Supporting Investment in Knowledge Capital, Growth and Innovation



OECD

Supporting Investment in Knowledge Capital, Growth and Innovation

OECD
BETTER POLICIES FOR BETTER LIVES

This work is published on the responsibility of the Secretary-General of the OECD. The opinions expressed and arguments employed herein do not necessarily reflect the official views of the Organisation or of the governments of its member countries.

This document and any map included herein are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Please cite this publication as:
OECD (2013), *Supporting Investment in Knowledge Capital, Growth and Innovation*, OECD Publishing.
http://dx.doi.org/10.1787/9789264193307-en

ISBN 978-92-64-19309-3 (print)
ISBN 978-92-64-19330-7 (PDF)

The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

Photo credits: Cover © Guskova Natalia /Shutterstock.com.

Corrigenda to OECD publications may be found on line at: *www.oecd.org/publishing/corrigenda*.

© OECD 2013

You can copy, download or print OECD content for your own use, and you can include excerpts from OECD publications, databases and multimedia products in your own documents, presentations, blogs, websites and teaching materials, provided that suitable acknowledgment of the source and copyright owner is given. All requests for public or commercial use and translation rights should be submitted to *rights@oecd.org*. Requests for permission to photocopy portions of this material for public or commercial use shall be addressed directly to the Copyright Clearance Center (CCC) at *info@copyright.com* or the Centre français d'exploitation du droit de copie (CFC) at *contact@cfcopies.com*.

Foreword

At the start of 2011 the OECD began work on a two-year project entitled *New Sources of Growth: Knowledge-based Capital*. While this programme of work has numerous intellectual antecedents, its immediate inspiration was a finding highlighted in the OECD's *Innovation Strat*egy, published in 2010, that many innovating firms do not invest in R&D. Instead, their innovation efforts are driven by investments in a broader range of intangibles assets, from software and large data sets to designs, firm-specific human capital and new organisational processes. These intangible assets are referred to in this book as knowledge-based capital (KBC). The work on KBC has set out to: provide evidence of the economic value of KBC as a new source of growth; and to improve understanding of current and emerging policy challenges.

The analysis presented here has been undertaken against a backdrop of sluggish macro-economic conditions, weak labour markets and burgeoning public debt in many OECD economies, all of which add urgency to the search for new sources of growth. Furthermore, rapidly ageing populations, combined with natural resource constraints, mean that the future of growth in advanced economies will increasingly depend on productivity-raising innovation. It is clearly essential, therefore, to deepen understanding of the sources of innovation and identify the main features of good policy practice.

The work on KBC has drawn on expertise from across the OECD Secretariat. Supported with financial resources from the Secretary-General's Central Priority Fund, the Directorate for Science, Technology and Industry led the two-year effort, and will continue to lead work in this area during 2013-2014. Other partner Directorates have been the Directorate for Financial and Enterprise Affairs, the Centre for Tax Policy and Administration, the Economics Department and the Statistics Directorate.

Three high-level events were organised during the project, all aimed at developing and testing analytic and policy ideas with academics, policymakers and practitioners. These events benefitted greatly from the inputs of partner organisations. The conference *New Building Blocks for Jobs and Economic Growth* was held in Washington DC on 16-17 May 2011, and opened by Ben Bernanke, Chairman of the Federal Reserve Board of Governors. The event was co-organised with the Athena Alliance, the Conference Board, and the Board on Science, Technology and Economic Policy (STEP) of the National Academies. Particular appreciation is expressed for the organisational and analytic support given by Ken Jarboe. The second event was a workshop - *A Policy Framework for Knowledge-Based Capital* – in Washington DC on 3-4 December 2012. This workshop was co-organised with the MIT Sloan School Center for Digital Business, in association with the STEP Board of the National Academies. Brian Kahin of MIT was critical to the success of this event and provided important intellectual input to the KBC project. Finally, a concluding project conference - *Growth, Innovation and Competitiveness: Maximising the Benefits of Knowledge-based Capital* – was held at the OECD Headquarters, Paris, on 13-14 February 2013. Further information on these events, including many presentations and video links, can be had at www.oe.cd/kbc.

Owing to the cross-Directorate character of the work on KBC, the different chapters of this publication were discussed and declassified by various OECD Committees, including the Committee for Industry, Innovation and Entrepreneurship (which had oversight responsibility for the project); the Committee for Information, Computer and Communications Policy; the Committee for Scientific and Technological Policy; the Committee on Statistics; the Committee on Fiscal Affairs; the Corporate Governance Committee; and the Economic Policy Committee. The comments and inputs formulated by delegates to these OECD official bodies are gratefully acknowledged.

The Synthesis report containing the main policy messages was discussed by the OECD Executive Committee and OECD Council and was presented at the OECD's Ministerial Council Meeting of May 2013. The Synthesis report is also available at www.oe.cd/kbc.

Many OECD staff contributed to the work on KBC and to this book. Alistair Nolan managed the project, under the guidance of Andrew Wyckoff (Director, Directorate for Science, Technology and Industry) and Dirk Pilat (Deputy-Director).

Mr. Nolan edited this book and wrote the Introduction and the Synthesis Report. Chapter 1 (Knowledge-based capital, innovation and resource allocation) - was authored by Dan Andrews and Chiara Criscuolo. Chapter 1 also draws on the research and comments of numerous analysts and OECD colleagues, including (in alphabetical order): Maria Bas (CEPII), Federico Cingano (Bank of Italy), Hélène Dernis, Carlo Menon, Peter Gal, Filipe Silva, Ben Westmore, Karen Wilson and Marco Da Rin (University of Tilburg). Valuable comments were also had from Eric Bartelsman, Jørgen Elmeskov, Giuseppe Nicoletti and Jean-Luc Schneider. Catherine Chapuis and Irene Sinha provided statistical and editorial support. Chapter 2 (Taxation and knowledge-based capital: policy considerations in a globalised economy) was written by Steven Clark, with guidance from Stephen Matthews. Chapter 3 (Competition policy and knowledge-based capital) was authored by Jeremy West. Chapter 4 (Measuring knowledge-based capital) was written by Mariagrazia Squicciarini and Marie le Mouel, with comments from Alessandra Colecchia, Colin Webb, Fernando Galindo Rueda and Nadim Ahmad, and with support from Hélène Dernis. Chapter 5 (Knowledge-based capital and upgrading in global value chains) was authored by Naomitsu Yashiro, with comments from Koen de Backer and Norihiko Yamano. Chapter 6 (Knowledge networks and markets) was written by Fernando Galindo-Rueda, with input from Gili Greenberg. Alissa Amico wrote Chapter 7 (Corporate reporting and knowledge-based capital). And Chapter 8 (Exploring data-driven innovation as a new source of growth: mapping the policy issues raised by "big data') was authored by Christian Reimsbach-Kounatze, with important contributions from Brendan Van Alsenoy.

Preparation of the project's empirical and policy conclusions benefitted from advice provided by an international panel of independent experts. In this connection, thanks are expressed to: Tony Clayton, Chief Economist, Intellectual Property Office, United Kingdom; Carol Corrado, Senior Advisor and Research Director, The Conference Board, United States; Professor Kyoji Fukao, Institute of Economic Research Hitotsubashi University, Tokyo; Professor Jonathan Haskel, Imperial College Business School, London; Professor Charles Hulten, University of Maryland and National Bureau of Economic Research, and Senior Fellow to The Conference Board; Richard Johnson, CEO Global Helix LLC and Chairman, Technology Committee, OECD Business and Industry Advisory Council; Professor Paloma Sanchez, Autonomous University of Madrid; and Professor Beth Webster, Director, Intellectual Property Research Institute of Australia.

Doranne Lecercle copy edited the text and Janine Treves provided support with overall presentation. Florence Hourtouat and Sarah Ferguson provided secretarial support throughout. Julia Gregory and Joseph Loux prepared the final manuscript for publication.

The material presented in this book was produced by the OECD during 2011 and 2012. As described above, much policy-relevant research on KBC remains to be done. During 2013 and 2014 work will continue, with the specific aims of improving measurement, better understanding policies to help create economic value from data, analysing the role of intellectual property rights, and continuing the assessment of the interactions between tax policies and corporate investment in KBC. Further information on the work on KBC will be available at the OECD website (www.oe.cd/kbc).

Table of contents

Abbreviations **13**

Executive summary **17**

Introduction and overview: Supporting investment in knowledge-based capital **21**

The rise of knowledge-based capital 22
Policy analysis and conclusions 29
References 51

Chapter 1. Knowledge-based capital, innovation and resource allocation **55**

The KBC-innovation-reallocation nexus 57
Investment in KBC, reallocation and productivity growth 61
The role of public policy 71
Policy reform options for increasing KBC and innovation 97
Notes 108
References 113

Chapter 2. Taxation and knowledge-based capital **127**

Policy context and project objectives 129
Market failure and productivity arguments for tax relief for R&D 132
Evidence and elements of cross-border tax planning 133
Metrics and main findings from the QETR model 135
Notes 150
References 154

Chapter 3. Competition policy and knowledge-based capital **155**

Competition and innovation 156
Competition and intellectual property 162
Competition policy in the digital economy 169
Conclusions 174
References 176

Chapter 4. Measuring knowledge-based capital **179**

The framework developed by Corrado, Hulten and Sichel 181
Recent advances and the work of the OECD 184
Investments in knowledge-based assets are important and growing 202
Building on recent work to advance the KBC measurement agenda 205
Notes 208
References 210

Chapter 5. Knowledge-based capital and upgrading in global value chains **215**

Deriving more value from GVCs: The upgrading of GVC activity 216
How does KBC support upgrading in GVCs? 227
An empirical analysis 236
Policy considerations 240
Notes 246
References 248

Chapter 6. Knowledge networks and markets 253

Knowledge flows and open innovation strategies 255
The role of knowledge networks and markets 261
Markets for intellectual property rights 270
Knowledge flows through mobile knowledge workers: Potential barriers 281
Concluding remarks and measurement implications 286
Notes 288
References 290

Chapter 7. Corporate reporting and knowledge-based capital 295

Collection and management of IA information 297
Disclosure of information on intangibles 301
Uses of intangibles reporting 305
Political economy of reform 306
Policy options 310
Annex 7.A1. Methods of measuring intangibles 312
Notes 315
References 316

Chapter 8. Exploring data-driven innovation as a new source of growth: Mapping the policy issues raised by "big data" 319

Understanding data and the drivers of their generation and use 320
The increasing use and value of data across the economy 325
Mapping the policy opportunities and challenges 334
Conclusion 343
Notes 344
References 349

Figures

Figure 0.1. Business investment in KBC and tangible capital, United States, 1972-2011 (% of adjusted GDP) 24
Figure 0.2. Business investment in KBC and tangible capital, 2010 (% of market sector value added) 24
Figure 0.3. ICT investment and KBC are positively correlated, 1995-2007 28
Figure 0.4. Business investment in KBC and the size of the venture capital industry 32
Figure 1.1. The KBC-innovation-reallocation nexus and public policies 58
Figure 1.2. Multi-factor productivity drives cross-country differences in GDP per capita 62
Figure 1.3. Business R&D, patenting and MFP performance 62
Figure 1.4. Managerial quality differs across countries with important implications for productivity 64
Figure 1.5. Investment in KBC varies significantly across countries 65
Figure 1.6. Knowledge-based capital and spillover effects 66
Figure 1.7. OECD countries differ in their ability to allocate labour to the most productive firms 67
Figure 1.8. Knowledge-based capital deepening and efficiency of resource allocation 68
Figure 1.9. The distribution of firm employment growth 69
Figure 1.10. Do resources flow to more innovative firms? 70
Figure 1.11. Patenting activity by young firms 71
Figure 1.12. Investment in KBC and selected public policies 72
Figure 1.13. Product market regulation and the distribution of managerial practices across firms 75

Figure 1.14. Framework policies and resource flows to patenting firms, 2002-10 76
Figure 1.15. Allocative efficiency and framework policies 77
Figure 1.16. More flexible EPL is associated with a more dynamic distribution of firm growth in R&D-intensive industries 80
Figure 1.17. Direct government funding of business R&D (BERD) and tax incentives for R&D 82
Figure 1.18. R&D tax incentives versus direct support to business R&D, 2004 and 2009 . 82
Figure 1.19. More generous R&D fiscal incentives are associated with a more static distribution of firm growth in R&D-intensive industries 85
Figure 1.20. Index of patent protection 90
Figure 1.21. Investments in alternative funding mechanisms, 2009 95
Figure 2.1. Direct government funding of business R&D (BERD) and tax incentives for R&D 130
Figure 2.2. Cash dividends of US MNEs on outbound FDI, repatriated under the one-time dividend received/corporate tax deduction provision, 2004-06 133
Figure 2.3. Cash dividends of US MNEs by industry of parent and by industry of CFC repatriated under the 2004-06 dividend received deduction 134
Figure 2.4. Foreign production: Transfer of KBC to offshore IP holding company, licence to conduit, sub-licence to manufacturing subsidiary 143
Figure 4.1. Investment in R&D and OC: Comparing estimates from INNODRIVE, COINVEST and INTAN-Invest, 1995-2006 186
Figure 4.2. Generality of patents: Average index, by country of applicant, patents filed at the European Patent Office, 2000-04 191
Figure 4.3. Number of USPTO design patents granted, by application year and origin of applicant, 1998-2011 192
Figure 4.4. Managerial OC employment, non-managerial OC employment, and other employment in the United States, 2003-2011 194
Figure 4.5. Investment in organisational capital, United States, 2003-11 195
Figure 4.6. Investment in organisational capital at the sectoral level, United States, 2003, 2007 and 2011 195
Figure 4.7. Organisational capital investment per person employed (headcounts), United States, yearly average by industry, 2003-11 196
Figure 4.8. Sectoral OC investment compared to value added, United States, yearly average, 2003-11 197
Figure 4.9a. Duration of EPO patents granted in manufacturing industries, for applications filed in 1978-91 200
Figure 4.9b. Duration of EPO patent granted in services industries, for applications filed in 1978-91 201
Figure 4.10. KBC investment as share of market-sector adjusted value added, 1981-2010202
Figure 4.11. Investment intensity in KBC and tangible capital, as percentage of adjusted value added, 2010 203
Figure 4.12. Change in business investment from 2008 to 2010, in percentage points 204
Figure 5.1. The share of domestic value added in exports of electrical and optical machinery, 1995-2009 217
Figure 5.2. Country share in global value-added in exports of electrical and optical machinery, 1995-2009 218
Figure 5.3. The distribution of the unit sales value of an iPad (USD 499) 218
Figure 5.4. The composition of processing trade by domestic Chinese firms 224
Figure 5.5. China's exports by end-use, 2010 225
Figure 5.6. World exports of commercial knowledge-intensive services (USD billion) 226
Figure 5.7. A resource-based view of GVC upgrading 229
Figure 5.8. Knowledge-based capital and the competitiveness of manufacturing firms in Japan 235

Figure 5.9. Knowledge-based capital (KBC) and GVC upgrading in firms in Japan 236
Figure 5.10. Knowledge-based capital and domestic value added embodied in electronics exports (14 European economies and the United States, year 2009) 239
Figure 6.1. Modes of innovation and knowledge sourcing for European innovation-active firms, 2008 257
Figure 6.2. US internal revenue service royalties by industry and royalty revenue shares, 2002-08 272
Figure 6.3. Patents sold, licensed and not used commercially 273
Figure 6.4. Revenues of specialist licensing firms, 2009 275
Figure 8.1. The data value chain and life cycle 320
Figure 8.2. Estimated worldwide data storage 321
Figure 8.3. Monthly global IP traffic, 2005-16 322
Figure 8.4. Average data storage cost for consumers, 1998-2012 323
Figure 8.5. Sequencing cost per genome, 2001-11 323
Figure 8.6. Data intensity of the United States economy, 2003-12 326
Figure 8.7. Stylised electricity sector value chain with energy and data flows 332

Tables

Table 0.1. Classification of the forms of KBC and their effects on output growth 23
Table 0.2. The protection of knowledge-based capital by intellectual property rights 40
Table 1.1. The classification of KBC and its possible effects 56
Table 1.2. Country and period coverage in the empirical analysis 74
Table 1.3. Differences in R&D tax incentives schemes across selected countries, 2013 83
Table 1.4. Characteristics of R&D tax incentive schemes with respect to refunds and carry-over provisions 86
Table 1.5. Tax and equity policy instruments to support the market for early-stage financing 96
Table 1.A1.1. Structure of the differences-in-differences estimator and data sources 101
Table 1.A1.2. Firm level productivity growth and framework policies: Baseline results 102
Table 1.A1.3. Firm level productivity growth and framework policies in ICT-intensive sectors 103
Table 1.A2.1. Venture capital and early-stage financing: The role of public support 107
Table 2.1. Summary R&D tax wedge and AETR* results 139
Table 3.1. Long-run effects on proxies for innovation of a one standard deviation increase in various factors[1] 159
Table 4.1. Investment in KBC – available macroeconomic level estimates 185
Table 4.2. Investment in KBC at the sectoral level – available estimates 188
Table 4.3. Estimated sectoral service lives and linear depreciation rates for organisational capital 199
Table 5.1. Examples of "hidden champions" 219
Table 5.2. Upgrading of GVC activity 222
Table 5.3. Classification of knowledge-based capital and generated value 228
Table 5.4. Upgrading of GVC activity and relevant KBC 234
Table 5.5. KBC stock per hour worked by person engaged (14 European economies + United States) 238
Table 5.6. Estimated coefficients of the interaction of industry-level knowledge intensity with KBC stock 240
Table 5.A1.1. Knowledge intensity of 18 industries (**hUS, i**) 245
Table 6.1. Modes of knowledge sourcing and innovation 258
Table 6.2. The relationship between modes of innovation and business performance, European firms, 2006-08 259

Table 6.3. Different types of knowledge exchange agreements and examples 262
Table 6.4. A proposed typology of knowledge networks and markets..... 264
Table 6.5. Countries in which NCAs are lightly or not enforced 284

Boxes

Box 0.1. Treating spending on knowledge-based capital as investment..... 23
Box 0.2. Estimating business investment in knowledge-based capital in China, Brazil and India 25
Box 0.3. KBC as financial security: recent developments and policy opportunities 32
Box 0.4. Business process innovation: An example of knowledge spillovers in the airline industry..... 36
Box 0.5. Design: A form of KBC that drives innovation and growth..... 36
Box 0.6. Intellectual property rights - current policy concerns..... 41
Box 1.1. The significant scope for misallocation of KBC 57
Box 1.2. Empirical approaches 73
Box 1.3. Compulsory licensing in OECD countries 91
Box 1.4. Treatment of intangible assets in International Accounting Standards (IAS) . 92
Box 2.A1.1 The hurdle rate of return and R&D tax wedge 148
Box 3.1. The OECD's Competition Assessment Toolkit (2010) 160
Box 3.2. Competition enforcement to foster innovation: The case of AT&T..... 160
Box 3.3. Avoiding patent ambushes: Options for standard-setting organisations..... 166
Box 4.1. Details of the CHS measurement framework 183
Box 4.2. Bridging *Frascati Manual* (FM) and System of National Accounts (SNA) R&D figures 190
Box 5.1. China's upgrading in GVCs 224
Box 5.2. The role of design in the textile value chain..... 230
Box 5.3. The role of scientific knowledge and networks in the pharmaceuticals value chain 231
Box 5.4. Japanese survey on the forms of KBC that support the upgrading of GVC activities..... 234
Box 6.1. New online knowledge marketplaces: The case of platforms for inducement prize contests 266
Box 6.2. Patent thickets and patent pools..... 268
Box 6.3. Data on patent re-assignments and knowledge markets 274
Box 6.4. Measurement implications 287
Box 7.1. National guidelines on IA management and reporting 299
Box 7.2. International frameworks and guidelines..... 300
Box 7.3. The Global Reporting Initiative Framework 308
Box 8.1. Data-driven science and research 327
Box 8.2. Data proliferation and implications for official statistics 330
Box 8.3. OECD Technology Foresight Forum 2012: Harnessing data as a new source of growth - Big data analytics and policies 334
Box 8.4. Basic principles of national application of the OECD (1980) privacy guidelines (part 2)..... 336
Box 8.5. Principles of the OECD (2008) Recommendation for Enhanced Access and More Effective Use of Public Sector Information 338
Box 8.6. Principle of OECD Guidelines for the Security of Information Systems and Networks 340
Box 8.7. Transmitting data: A regulatory barrier to machine-to-machine communication 342

Abbreviations

A4S	Accounting for Sustainability Project
ACCA	Association of Chartered Certified Accountants
AD	Alzheimer's disease
AETR	Average effective tax rate
AFNOR	Association Française de Normalisation
ANSI	American National Standards Institute
APCA	Association of Public Certified Accountants
ASEC	Annual Social and Economic
BBF	BioBricks Foundation
BEPS	Base erosion and profit-shifting
BERD	business expenditures on R&D
BIAC	Business and Industry Advisory Committee
BIS	United Kingdom Department for Business Innovation & Skills
BIOS	Biological Innovation for an Open Society
BPP	Billion Price Project
BRDIS	Business R&D and Innovation Survey
CAD	Computer-aided-design
CFC	Controlled foreign company
CHS	Corrado, Hulten and Sichel
CIS	Community Innovation Survey
CIT	Corporate Income Tax
CPS	Current Population Survey
CREST	Centre de Recherche en Economie et Statistique
CSA	Cost-sharing agreement
CSR	Corporate social responsibility
CTPA	Centre for Tax Policy and Administration
DID	Difference-in-difference
DIN	Deutsches Institut für Normung
EC2	Elastic Compute Cloud
EFFAS	European Federation of Financial Analysts Societies
ESG	Environmental, social and corporate governance
ETR	Effective tax rate
EPL	Employment protection legislation
EPO	European Patent Office
ETSI	European Telecommunications Standards Institute
FM	Frascati Manual
FMD	Floating Mobile Data
FRAND	Fair, reasonable and non-discriminatory
FDA	Food and Drug Administration

FDI	Foreign direct investment
FIEs	Foreign-invested enterprises
GAAP	Generally Accepted Accounting Principles
GFCF	Gross fixed capital formation
GRI	Global Reporting Initiative
GVC	Global value chain
GDP	Gross domestic product
HDD	Hard disk drives
HEC	Ecole des Hautes Etudes Commerciales
HS	Harmonized System
IA	Intangible assets
IASB	International Accounting Standards Board
ICAS	Institute of Chartered Accountants of Scotland
ICIO	Inter-country input-output
ICT	Information and communications technology
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IFRS	International Financial Reporting Standards
IIRC	International Integrated Reporting Committee
INPADOC	Worldwide Legal Status Database
INPI	National Industrial Property Institute
IP	Intellectual property
IPO	Intellectual property office /
IPO	Initial public offering
IPR	Intellectual property right
ISO	International Organisation for Standardization
IVSC	International Valuation Standards Council
JPO	Japan Patent Office
KBC	Knowledge-based Capital
KIBS	Knowledge-intensive-business-services
KNM	Knowledge network and market
KPI	Key performance indicators
KUL	Catholic University of Leuven
LEDs	Light-emitting diodes
M2M	Machine-to-machine
MD&A	Management Discussion and Analysis
METI	Ministry of Economy, Trade and Industry (Japan)
METR	Marginal effective tax rate
MFP	Multi-factor productivity
MGI	McKinsey Global Institute
MNE	Multinational enterprise
NACE	Nomenclature statistique des activités économiques dans la Communauté européenne
NAICS	North American Industrial Classification
NCA	Non-compete agreements
NCIX	National Counterintelligence Executive

NES	Nintendo Entertainment System
NESTA	National Endowment for Science, Technology and the Arts
NESTI	OECD National Experts on Science and Technology Indicators
NFC	Near Field Communications
NLM	National Library of Medicine
OC	Organisational capital
ODM	Original design manufacturing
OEM	Original equipment manufacturer
OKM	Online knowledge marketplaces
O*NET	Occupational Information Network
OS	Operating system
OSS	Open source software
PA	Patent aggregator
PAE	Patent assertion entities
PATSTAT	Patent Statistical Database
PD	Parkinson's Disease
PMR	Product market regulation
PSI	Public Sector Information
RBOC	Regional operating company
R&D	Research and development
SDBS	Structural Demographic Business Statistics
SEP	Standards-essential patents
SES VC	Seed and early-stage VC
SKA	Square kilometre array
SME	Small and medium-size Enterprise
SNA	System of National Accounts
SOE	State-owned-enterprise
SPV	Special purpose vehicle
SSD	Solid-state drives
SSO	Standard setting organisation
STAN	Structural analysis database
TiVA	Trade in value added
TFP	Total factor productivity
UCC	Uniform Commercial Code
UNPRI	United Nations Principles for Responsible Investment
USPTO	United States Patent and Trademark Office
VAX	Value added in exports to actual exports
VC	Venture capital
WICI	World Intellectual Capital Initiative
WIPO	World Intellectual Property Organisation
WTO	World Trade Organisation
XBRL	eXtensible Business Reporting Language

Executive summary

Innovation is a key to business success, but where innovation comes from is changing. Today's firms are looking beyond research and development (R&D) to drive innovation. They invest in a wider range of intangible assets, such as data, software, patents, designs, new organisational processes and firm-specific skills. Together these non-physical assets make up knowledge-based capital (KBC).

Business investment in KBC has been increasing faster than investment in physical capital such as machinery and buildings for a number of years in many OECD countries. Indeed, in some countries business investment in KBC now significantly exceeds investment in physical capital and overall investment in KBC has been relatively resilient during the global crisis.

But how much do KBCs contribute to growth, and could it do even more? This report aims to provide evidence of the economic value of knowledge-based capital, and to help meet the policy challenges it raises in the areas of innovation, taxation, entrepreneurship, competition, corporate reporting and intellectual property.

Key findings

- Business investment in KBC helps boost growth and productivity. Studies for the European Union and the United States show business investment in KBC contributing 20% to 34% of average labour productivity growth.
- KBC is transforming what makes firms competitive. For instance, in the automotive sector, software is increasingly prominent in the cost of developing new vehicles, with high-end vehicles relying on millions of lines of computer code.
- Countries that invest more in KBC are also more effective in reallocating resources to innovative firms. As a share of gross domestic product (GDP), the United States and Sweden invest about twice as much in KBC as Italy and Spain, and patenting firms in the United States and Sweden attract four times as much capital as similar firms in Italy and Spain.
- Overall tax relief for R&D, when factoring in cross-border tax planning by Multinational Enterprises (MNEs), could well be greater than governments foresaw when their R&D tax incentives were designed. Countries may be losing tax revenue on the output from subsidised R&D and also losing out on domestic knowledge spillovers associated with production. We also need to recognise the risk that increasing countries' reliance on tax incentives to boost R&D could increase the amount of foregone tax without a commensurate rise in innovation.
- Furthermore, firms that are not part of a multinational group of companies – often small and young firms – may be placed at a competitive disadvantage, relative to MNEs, in undertaking and exploiting R&D. In addition, more data are needed to estimate the amounts of income being shifted to low and no-tax countries through MNE tax planning involving KBC.

- Industries founded on KBC raise new issues for competition policy, particularly in the digital economy, where competition differs in some respects from other sectors.
- Intellectual property rights (IPR) are an increasingly important framework condition for investing in KBC. But IPR rules have not always kept pace with technological change – many copyright systems, for instance, were designed for a world of paper and print and may inhibit new digital services.
- Across countries, there is a positive correlation between the market value of firms and investment in KBC. But corporate financial reports provide limited information on companies' investments in KBC. This may hinder corporate finance and impair corporate governance.
- A fuller understanding of innovation and growth, and better policy, require better measurement of KBC and common measurement guidelines.
- Growing business investment in KBC amplifies the importance of getting human capital policies right. Human capital is the foundation of KBC: software, for example, is essentially an expression of human expertise translated into code.
- The rise of KBC also has profound implications for employment and earnings inequality. A KBC-based economy rewards skills and those who perform non-routine manual and cognitive tasks, but may also reward investors (who ultimately own much of the KBC) over workers.

Key policy recommendations

- Getting the key framework conditions right for investment in KBC is essential and can be a low-cost step for policy makers in fiscal terms. Appropriately crafted framework conditions are important for the creation and retention of high-value jobs in global value chains (GVCs).
- Well-functioning product and labour markets, and systems of debt and early-stage equity finance, are essential to encourage KBC investment. Bankruptcy laws that do not overly penalise failure are also important. Reducing the stringency of bankruptcy legislation from the highest to the average level in the OECD could raise capital flows to patenting firms by around 35%.
- Policy makers should adopt an enlarged concept of innovation, beyond the conventional view in which R&D is pre-eminent. Other forms of KBC, such as design, data and organisational capital, should also be policy targets.
- Policy should make it easier for firms to develop and commercialise new ideas by lowering the costs of failure and encouraging firms to experiment with potential growth opportunities.
- Improved design of R&D tax credits, such as greater targeting to stand-alone firms without the cross-border tax planning opportunities available to MNEs should be implemented, alongside reducing the unintended tax relief for MNEs on KBC use.
- Governments can take steps to facilitate companies' reporting of investments in KBC. In the near-term, countries are encouraged to develop additional measures via satellite accounts so as to maintain the international comparability of GDP.

- Competition policy should: properly account for competition among platform providers; eliminate unnecessarily anti-competitive product market regulation; and effectively enforce competition law, which will protect and encourage innovation.
- Creating economic value from large data sets is at the leading edge of business innovation. OECD governments must do more to implement coherent policies in the fields of privacy protection, open data access, information and communications technology (ICT) infrastructure and ICT skills.
- In economies increasingly based on knowledge assets, IPR systems must be coupled with pro-competition policies and efficient judicial systems. Steps should also be taken to address the erosion of patent quality (whether patents reflect genuinely novel innovations, for example). There is a need for greater mutual recognition and comparability across IPR systems internationally.

Introduction and overview: Supporting investment in knowledge-based capital

Achieving higher and sustained growth is essential for OECD economies. Business investment in knowledge-based capital (KBC) is increasing and is already a significant source of growth. But KBC is poorly measured and its many policy implications require further assessment. This chapter provides an overview of the OECD's recent work on KBC and, specifically, how KBC pertains to resource allocation and innovation, tax policy, competition policy, measurement, global value chains, knowledge networks and markets, corporate reporting, and "big data".

Today, the importance of growth can barely be overstated. The protracted nature of the global crisis, sluggish macro-economic conditions in many OECD economies, weak labour markets and burgeoning public debt all increase the importance of finding new sources of growth. Furthermore, rapidly ageing populations, combined with natural resource constraints, mean that the future of growth in advanced economies will increasingly depend on productivity-raising innovation. This book draws together the latest evidence and thinking on the role of knowledge-based capital (KBC) in growth and the policy opportunities available to governments.

The rise of knowledge-based capital

What is knowledge-based capital?

Knowledge-based capital comprises a variety of assets. These assets create future benefits for firms but, unlike machines, equipment, vehicles and structures, they are not physical. This non-tangible form of capital is, increasingly, the largest form of business investment and a key contributor to growth in advanced economies.

One widely accepted classification groups KBC into three types: computerised information (software and databases); innovative property (patents, copyrights, designs, trademarks); and economic competencies (including brand equity, firm-specific human capital, networks of people and institutions, and organisational know-how that increases enterprise efficiency) (Corrado, Hulten and Sichel, 2005). Table 0.1 sets out the different forms of knowledge capital and how they affect output growth.

Business investment in knowledge-based capital is increasing

Historically, business investment in KBC was not accurately measured in national income or corporate accounts (Box 0.1). However, beginning in the early 2000s, and focusing initially on the United States, researchers have applied direct expenditure methods to assess overall business investment in KBC, and then used these measures in growth accounting studies (growth accounting ascribes an economy's growth to increases in the volume of factors used – usually capital and labour – and the increase in the productivity of those factors). Since then, a significant research effort has expanded the number of countries covered by growth accounting analyses.

The research now available shows that most advanced economies have become progressively intensive users of KBC. In the United Kingdom, for instance business investment in KBC is estimated to have more than doubled as a share of market sector gross value added between 1970 and 2004. In Australia, since 1974-75, average annual growth of investment in KBC has been around 1.3 times that of investments in physical assets such as machinery, equipment and buildings (Barnes and McClure, 2009). And in Japan, the ratio of investment in KBC to GDP has risen throughout the past 20 years (Fukao et al, 2008). In the United States, the country with the longest time series, research shows business investment in KBC rising almost continuously for at least 40 years (Figure 0.1). Indeed, in both the United States and a number of other countries for which data are available, the business sector is now seen to invest as much, or more, in KBC as in traditional tangible capital (Figure 0.2).

Table 0.1. Classification of the forms of KBC and their effects on output growth

Type of KBC asset	**Mechanisms of output growth for the investor in the asset**
Computerised information	
Software	Improved process efficiency, ability to spread process innovation more quickly, and improved vertical and horizontal integration.
Databases	Better understanding of consumer needs and increased ability to tailor products and services to meet them. Optimised vertical and horizontal integration.
Innovative property	
Research & Development	New products, services and processes, and quality improvements to existing ones. New technologies.
Mineral explorations	Information to locate and access new resource inputs - possibly at lower cost - for future exploitation.
Copyright and creative assets	Artistic originals, designs and other creative assets for future licensing, reproduction or performance. Diffusion of inventions and innovative methods.
New product development in financial services	More accessible capital markets. Reduced information asymmetry and monitoring costs.
New architectural and engineering designs	New designs leading to output in future periods. Product and service quality improvements, novel designs and enhanced processes.
Economic competencies	
Brand-building advertisement	Improved consumer trust, enabling innovation, price premia, increased market share and communication of quality.
Market research	Better understanding of specific consumer needs and ability to tailor products and services.
Worker training	Improved production capability and skill levels.
Management consulting	Externally acquired improvement in decision making and business processes.
Own organisational investment	Internal improvement in decision making and business processes.

Source: left column, Corrado, C.A, Hulten, C.R and Sichel, D. (2005), *Measuring Capital and Technology: An Expanded Framework.* in C. Corrado, Haltiwanger, J. and Sichel, D. (eds), *Measuring Capital in a New Economy*, National Bureau of Economic Research and University of Chicago Press.

Box 0.1. Treating spending on knowledge-based capital as investment

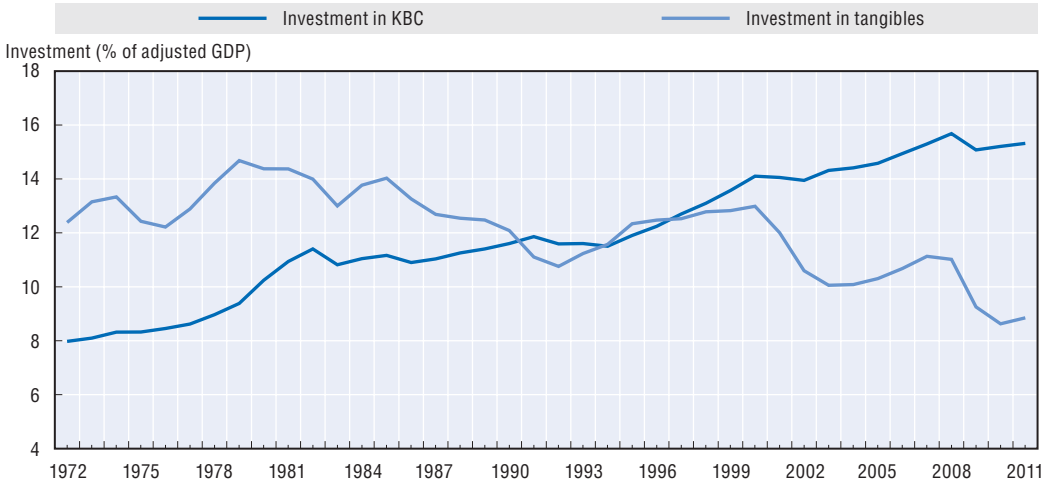
When businesses invest to integrate databases and organisational processes, spending on hardware typically only represents some 20% of total costs. The remaining costs are for organisational changes such as new skills and incentive systems. Most of these costs are not counted as investment, even if they are as essential as the hardware. Treating spending on different forms of KBC as investment accords with the views of many in the business community who attribute fundamental aspects of corporate success to spending on such things as marketing, data, design and business process re-organisation.

Both firm and national income accounting have historically treated outlays on KBC as intermediate expenditure and not as investment. By accounting convention, if an acquired intermediate good contributes to production for longer than the taxable year, the cost of the good is treated as investment. Evidence suggests that the different forms of KBC should be treated as investment from an economic viewpoint. Research from the United Kingdom has estimated the productive lives of specific types of KBC as follows: firm-specific training (2.7 years); software (3.2); branding (2.8); R&D (4.6); design (4); and business process improvement (4.2) (Haskel, www.coinvest.org.uk). New OECD research shows that firms expect investments in organisational capital to last on average 4 to 6 years in services, and between 7 and 10 years in manufacturing.

Spending on software and mineral exploration is currently treated as investment in the national accounts, and a number of countries have capitalised, or are in the process of capitalising, R&D. However, the growing literature on KBC suggests that, conceptually, other types of KBC could be treated as investment.

The growth of business investment in KBC is also more than a story about research and development (R&D). For example, in France, between 1995 and 2010, business spending on R&D remained unchanged at 1.9% of value added. But spending on non-R&D-related KBC increased from 7.4% to 10.6% of value added. Many other countries present a similar pattern. Overall, private R&D stocks generally represent no more than 20-25% of total private stocks of KBC.

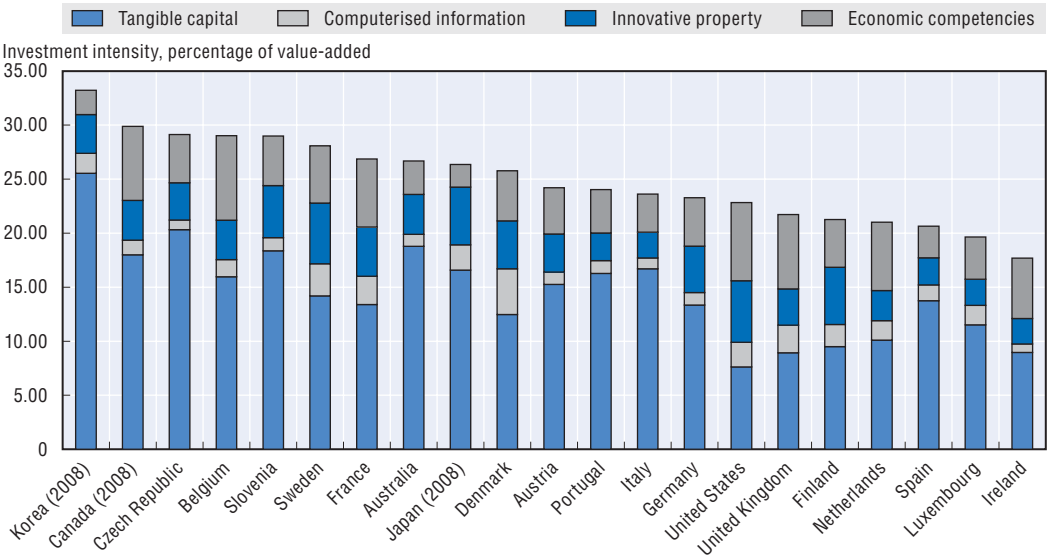
Figure 0.1. Business investment in KBC and tangible capital, United States, 1972-2011 (% of adjusted GDP)



Note: Estimates are for private industries excluding real estate, health and education.

Source: Unpublished update on Corrado, C.A. and C.R. Hulten (2010), "How do you Measure a 'Technological Revolution?", *American Economic Review: Papers & Proceedings 100* (May 2010): 99–104.

Figure 0.2. Business investment in KBC and tangible capital, 2010 (% of market sector value added)



Note: Figures refer to the market economy, which excludes real estate, public administration, health and education, with the exception of Korea, where figures refer to the whole economy.

Source: Based on INTAN-Invest (www.intan-invest.net, KBC investment for EU27 and United States), OECD Main Science and Technology Indicators (www.stastats.oecd.org, Korea, Luxembourg and Portugal market-sector value added and Korea tangible investment), National Accounts from Eurostat (http://ec.europa.eu/eurostat, Austria, Denmark, Finland, France, Ireland, Italy, Luxembourg, Netherlands, Spain and Sweden tangible investment), Australian Innovation System Report (2012, KBC investment), National Accounts from the Australian Bureau of Statistics (www.abs.gov.au, value added and tangible investment), the Japanese Industrial Productivity (JIP) Database (www.rieti.go.jp/en/database/JIP2011/ all data for Japan), Chun et al. (2012) (Korea KBC investment), and Baldwin et al. (2012, all data for Canada), accessed June 2013.

Many emerging economies are also increasing their investments in KBC

Emerging economies account for an increasing share of global investment in innovation (Box 0.2). Business investment in KBC has become a priority in many emerging economies. Policies usually focus on education and R&D, coupled with efforts to develop linkages between multinational enterprises (MNEs) and local firms and in some cases with measures to strengthen intellectual property rights (IPRs).

Box 0.2. Estimating business investment in knowledge-based capital in China, Brazil and India

Hulten and Hao (2011) measure investment in KBC in China. Recent economic reforms in China aim to raise income by capturing more value added via technology. This will require large-scale investment in KBC. Moreover, certain features of the economic transition in China require the creation of particular forms of KBC. For instance, the privatisation of state-owned enterprises requires investments in organisational capital and new business models.

Severe data constraints hamper measurement of KBC in China. Nevertheless, the authors estimate that investments in KBC were equivalent to 7.5% of GDP for the total economy in 2006, increasing from 3.8% in 1990. Spending on R&D accounts for only 18% of total investment in KBC; this suggests that narrowly focused innovation indicators will ignore much of total spending on innovation.

China's rate of investment in KBC is comparable to estimates for France and Germany, but behind those of Japan, the United Kingdom and the United States. However, it is uncertain whether this investment will translate into technological leadership. Half of KBC investment in China goes to just two categories: software and architectural and engineering design. Both are tied to investments in tangible capital (ICT and residential structures). A more focused measure of organisational and product/process innovation might exclude them. In this case, the adjusted KBC investment rate for China would only be 3.6% of GDP (2006). This is well below the corresponding adjusted rate of 8.6% for the United States, or 6.8% and 6.6% for Japan and the United Kingdom, respectively. Furthermore, in China, the ratio of investment in KBC to investment in tangible capital is around 0.3. By contrast, in Finland, France, the United Kingdom and the United States this ratio is near to, or above, 1.

World Bank (2012) estimates that business investment in KBC in Brazil averaged around 4% of GDP between 2000 and 2008. This is not much below investment in tangible assets, which varied between 4% and 9% of GDP over the same period. Business investment in KBC has also been increasing, from 3% of GDP in 2000 to 5% in 2008, although investment in tangible assets has risen more rapidly. In India, business investment in KBC in 2007 was recently estimated at 2.7% of GDP. Around 30% was contributed by R&D (Hulten, Hao and Jaeger, 2012).

Why is business investing more in knowledge-based capital?

There are a number of possible explanations for the growing intensity of business investment in KBC:

- With rising educational attainment, OECD economies have accumulated a larger stock of human capital. The stock of human capital in turn enables and complements the production and use of KBC (for instance, patents are a means of securing the intellectual property associated with innovations emanating from human capital).
- Many products are themselves becoming more knowledge-intensive. For instance, in the automotive sector, it is estimated that 90% of the new features in cars have a significant software component (innovative start-stop systems, improved fuel

injection, on-board cameras, safety systems, etc.). Valuable trade secrets now lie in the electronic controls that regulate the operation of motors, generators and batteries. Hybrid and electric vehicles require huge volumes of computer code: the Chevrolet Volt plug-in hybrid uses about 10 million lines of computer code. And a major part of the development costs for entirely new vehicles is also software-related (while manufacturers guard the exact figures closely, estimates of around 40% are not uncommon).

- In a context of global integration of markets and deregulation, sustained competitive advantage is increasingly based on innovation, which in turn is driven, in large part, by investments in different forms of KBC. For instance, levels of patenting, R&D, information technology (IT) and management quality have risen in firms more exposed to increases in Chinese imports (Bloom, Draca and Van Reenen, 2011).

- The fragmentation and geographic dispersion of value chains – as well as the increased sophistication of production processes in many industries – have raised the importance of KBC, in particular organisational capital (Wal-Mart's computerised supply chains, Merck's multiple R&D alliances).

- Businesses have made major investments in new information and communication technologies (ICTs). These have required complementary investments in forms of KBC such as new business process skills.

- New ICTs may make some types of KBC more valuable to firms. For example, when consumers can buy on line, rather than face to face, a brand and a reputation for reliable service gain in importance. For instance, although at least one Internet bookseller offers lower prices than Amazon 99% of the time, Amazon retains its large market share because of its reputation for customer service (Brynjolfsson and Smith, 2000).

Knowledge-based capital is essential to investment and growth

Aggregate business investment in KBC is positively correlated with income per capita. As a share of GDP, the business sector in higher-income economies invests proportionally more in KBC (although this correlation does not establish a causal relationship). And recently gathered data suggest that, at least in the early phase of the global economic crisis, business investment in KBC either grew faster than, or did not decline to the same extent as, investment in physical capital.

Growth accounting studies covering various periods show a positive relationship between business investment in KBC and macroeconomic growth and greater productivity. For instance, it is estimated that between 1995 and 2007 at least 33.7% of labour productivity growth in the United States was due to investments in KBC. And over the same period, across fourteen EU countries, investment in KBC is calculated to have accounted on average for at least 19.9% of labour productivity growth (Corrado, Haskel, Jona-Lasinio and Iommi, 2012). In Canada, GDP and annual labour productivity growth would likely have been 0.2 percentage points higher between 1976 and 2000 if KBC had been included in the national accounts as investment (Baldwin, Gu and Macdonald, 2011).

Growth accounting, however, does not explain what causes growth. Nor does it explain the complementarities between the different types of KBC. Econometric methods

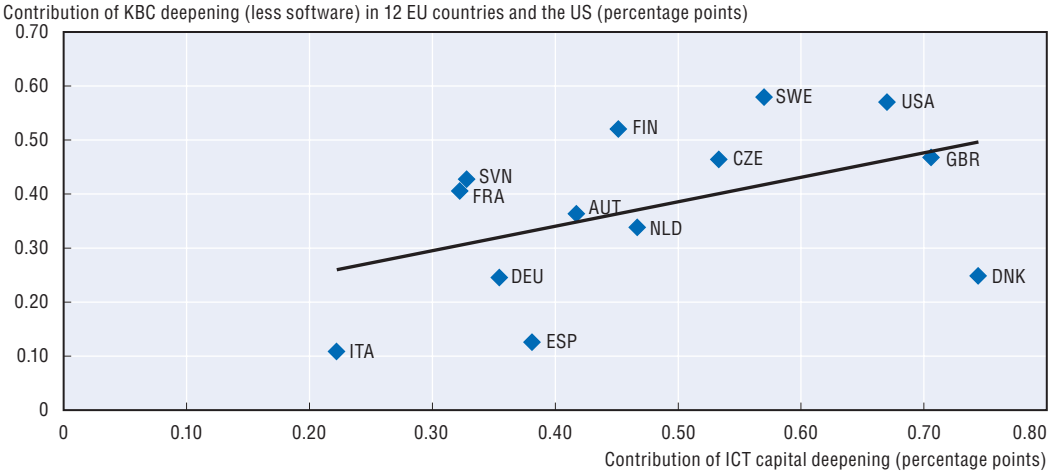
have therefore been used to reveal the positive, and significant, impacts of various forms of KBC – such as R&D, the use of data analytics and management practices – on productivity:

- Countries differ significantly in the extent to which the business sector invests in R&D. These differences are closely linked to productivity performance at the macro level (see **Chapter 1**). R&D not only enlarges the technological frontier, it also enhances firms' ability to absorb existing technologies. Micro-econometric studies often find private rates of return to R&D in the range of 20-30%. This is generally higher than the returns to physical capital, which is consistent with the higher risk associated with KBC.
- With respect to data as an economic asset, research shows that firms in the United States that base significant decisions on data analytics have levels of output and productivity 5-6% higher than would be expected given their other investments and use of information technology (Brynjolfsson, Hitt and Kim, 2011).
- Managerial quality also affects firm productivity and varies widely across OECD countries. This dispersion affords significant opportunities for productivity growth in some countries. For instance, as shown in **Chapter 1**, raising managerial quality from the median level (roughly corresponding to New Zealand in the sample) to the level of the United States could increase average productivity in manufacturing by as much as 10%.

There are also important complementarities between ICT capital investment and organisational capital, another form of KBC (see Figure 0.3). This is because firms typically need to adopt ICT as part of a wider – and more costly – set of mutually reinforcing organisational changes to obtain the greatest benefit. The link between organisational capital and ICT is particularly significant because cross-country differences in aggregate growth in OECD countries largely depend on the performance of ICT-intensive sectors and because better management practices can raise the productivity of ICT capital (van Ark, O'Mahony and Timmer, 2008). In fact, at least half of the US-Europe difference in labour productivity growth between 1995 and 2004 has been attributed to superior management practices in the United States (Bloom, Sadun and Van Reenen, 2012).

An economy that facilitates business investment in KBC is also likely to provide an environment supportive of advanced manufacturing, a major policy concern in many OECD economies. For instance, in Australia in 2005-06, spending on KBC in manufacturing stood at almost 65% of tangible investment, but in the services sector, it only reached 50%. In Germany, manufacturing accounts for nearly 50% of all investment in KBC, a share much higher than manufacturing's contribution to GDP. Furthermore, sustainable competitive advantage often comes from a complex, and often challenging, integration of different types of KBC (such as when firms integrate simulations of product designs and models of workplace organisation with large computerised data sets so as to introduce products more quickly and efficiently).

Figure 0.3. ICT investment and KBC are positively correlated, 1995-2007



Source: Corrado, C. A., J. Haskel, and C. Jona-Lasinio (2013). "Knowledge Spillovers, ICT and Productivity Growth", Mimeo (July). Paper presented at the 4th ICTNET workshop (London, April 2012), the 2nd World KLEMS meeting (Cambridge, Mass., August 2012), and ZEW (Manheim, Germany, May 2013).

Inherent properties of KBC are growth-enhancing

Two properties of KBC have particularly positive implications for growth. First, unlike physical capital, investments in many forms of KBC – R&D, organisational change, design – yield knowledge that can spill over to other parts of the economy. That is, firms that do not invest in KBC can only be partially excluded from benefits created by firms that do. For this reason, policy must provide adequate incentives for private investment in KBC.

While it is difficult to estimate knowledge spillovers, empirical studies focused on R&D have generally found them to be quite widespread. Research at the country level has also identified spillover effects from design, brand equity, organisational capital and training (although industry-level analysis is needed to consider these findings definitive) (Corrado, Haskel and Jona-Lasinio, forthcoming). Furthermore, new research shows a stronger positive correlation between KBC investment and MFP growth than between tangible capital investment and MFP growth (see **Chapter 1**). MFP rises faster when workers use more KBC than when they use more tangible capital. This suggests knowledge spillovers from KBC.

Second, KBC can spur growth because the initial cost incurred in developing some types of knowledge – often but not exclusively through R&D – does not need to be incurred again when that knowledge is used again in production. Indeed, once created, some forms of KBC – such as software and some designs – can be replicated at almost zero cost (they can also be used simultaneously by many users - this is known as "non-rivalry"). This can lead to increasing returns to scale in production, the property that makes ideas and knowledge an engine of growth. Scale economies of this sort can also be reinforced by positive network externalities. These occur when the benefit from a network rises with the number of users. Such externalities are particularly prevalent in the KBC-intensive digital economy (where, for example, the value of a platform, such as Apple's Operating System, increases with the number of users of the platform).

It should be added however that while R&D exhibits properties of partial excludability and non-rivalry, other forms of KBC may have a smaller impact on growth (and have also been less studied). For instance, firm-specific human capital and much of brand equity are highly excludable and rivalrous.

Policy analysis and conclusions

Framework conditions need to fit the realities of the knowledge economy

Because business investment in KBC underpins much of the knowledge economy it is affected by many areas of policy. As overall business investment in KBC increases, and because of KBC's intangible nature, some policy settings require readjustment. Framework conditions provide the fundamental economic context for investment in KBC and for the efficient reallocation of resources to new sources of growth, including those based on KBC.

It is essential for policies to be well suited to this new situation and to conform to good practice in such areas as taxation, entrepreneurship, competition, corporate reporting and intellectual property. The same holds for policies that enable the exploitation of data as an economic asset. The rise of KBC also amplifies the importance of policies towards education and training. Attention must likewise be given to complex regulatory issues that address data privacy and security. Indeed, as new technologies based on KBC develop, new regulatory challenges are likely to arise.

Many current policy settings, as well as systems of accounts (both corporate reports and national statistical accounts), are best suited to a world in which physical capital predominates. Getting these framework conditions right, while a challenge, is essential for growth in the 21st century and can be relatively inexpensive in fiscal terms. More than new government spending, smarter and better-focused rules and incentives for businesses should be the first priority for many countries.

Policy should facilitate efficient resource allocation, which is positively correlated with KBC use

As emphasised in **Chapter 1**, the allocation of economic resources to their most productive uses is a critical determinant of growth. The principal reallocation mechanisms are firm turnover (entry and exit), shifts in resources across firms and reallocation within firms. Reallocation is a frequent phenomenon in OECD countries: on average, about 15-20% of all firms and more than 20% of jobs are created or destroyed each year. However, the efficiency of resource allocation varies considerably from country to country. Countries that are more successful at channelling resources to the most productive firms also invest more in KBC.

To develop and commercialise new ideas, firms also require a range of tangible resources to develop prototypes, develop marketing strategies and eventually produce at a commercially viable scale. New OECD evidence reveals important cross-country differences in the extent to which labour and capital flow to innovative firms. For example, the degree to which labour flows to patenting firms in the United States and Sweden is estimated to be twice as large as in Italy. And countries with more stringent regulations in product and labour markets tend to invest less in KBC.

Efficient labour adjustment is also important

By raising labour adjustment costs, more stringent employment protection legislation (EPL) slows the reallocation process. However, by contrast, employment protection also raises workers' commitment and firms' incentives to accumulate firm-specific human capital. In line with this trade-off, evidence on the impact of EPL on innovation and productivity is somewhat mixed. Nevertheless, **Chapter 1** highlights that EPL has important effects on the form of the innovation process. For instance, new OECD evidence shows that in environments of greater technological change, stricter EPL lowers productivity growth by reducing firms' willingness to experiment with uncertain growth opportunities. Countries with stringent EPL tend to have smaller innovative sectors associated with intensive ICT use, and MNEs tend to concentrate more technologically advanced innovation in countries with weaker EPL. And in sectors with significant reallocation needs – measured by job layoffs, firm turnover and ICT intensity – reallocation is more efficient under less stringent EPL. Stringent EPL is also associated with lower R&D expenditure in sectors with higher rates of patenting.

An environment supportive of entrepreneurship, trade and investment is critical

Entrepreneurial activity is essential to the process of reallocating labour and all forms of capital to their most productive uses. However, entrepreneurial dynamics vary from country to country. In particular, the size of entering and exiting firms tends to be smaller in the United States than in Europe. Successful young firms also tend to expand more quickly in the United States, where firm productivity within industries also tends to be more dispersed (with more productive firms likely to account for a larger share of employment). One interpretation of these findings is that entrants in the United States engage in more experimentation and "learning by doing". Cross-country differences in entrepreneurial activity tend to be largest in new and high-technology sectors, where the use of KBC is likely to be most intensive.

Investment in KBC is also found to be positively correlated with debtor-friendly bankruptcy codes. Bankruptcy regimes that severely penalise "failed" entrepreneurs, whether by more readily forcing liquidation or by limiting entrepreneurs' ability to start new businesses in the future, are likely to reduce the willingness to take risks and thereby limit the supply of new ideas. Across countries and over time, more debtor-friendly bankruptcy codes are associated with greater intensity of patent creation, patent citations and faster growth in innovative industries (Acharya and Subramanian, 2009).

Liberalising barriers to international trade and investment also stimulates aggregate productivity by increasing knowledge diffusion and technology transfer across borders and by encouraging more efficient resource allocation (indeed, because, as noted earlier, investments in some forms of KBC are easily scalable, having a larger market size is beneficial). Recent evidence from a sample of European firms shows that the removal of product-specific quotas following China's WTO accession triggered a significant increase in R&D, patenting and productivity (Bloom, Draca and Van Reenen, 2011). And as **Chapter 1** reports, increased exposure to trading partners' R&D stocks (a proxy for the stock of foreign knowledge) from the level of Spain (around the OECD average in 2005) to the level of Canada (the 75th percentile) could boost patents per capita by around 20% in the long run.

As knowledge is partly embodied in, and can spill over from, imported intermediate goods, reductions in tariffs on intermediate inputs are associated with significant productivity growth in downstream manufacturing sectors. Across the services sector in OECD countries, more stringent restrictions on foreign direct investment (FDI) are

associated with lower allocative efficiency. Indeed, the analysis in **Chapter 1** suggests that lowering restrictions on FDI from the relatively high levels of Poland to those of Germany could increase aggregate productivity by around 2%.

Good conditions for the financing of KBC-intensive firms are also needed

It is widely held that young entrepreneurial firms face a financing gap. This gap is partly bridged by specialised financial intermediaries such as venture capitalists and business angels who scrutinise firms before providing capital and monitor – and sometimes mentor – them afterwards. Many early-stage investments occur in KBC-intensive firms. Indeed, for a sample of OECD countries and over a number of years, there is a positive correlation between aggregate business investment in KBC and the size of the venture capital sector (Figure 0.4). Countries with more developed seed and early-stage VC are also more effective at channelling capital and labour to young innovative firms, while a number of studies show that the supply of venture capital can have a positive, sizeable and independent impact on innovation and economic growth (Kortum and Lerner [2000]; Samila and Sorenson [2011]).

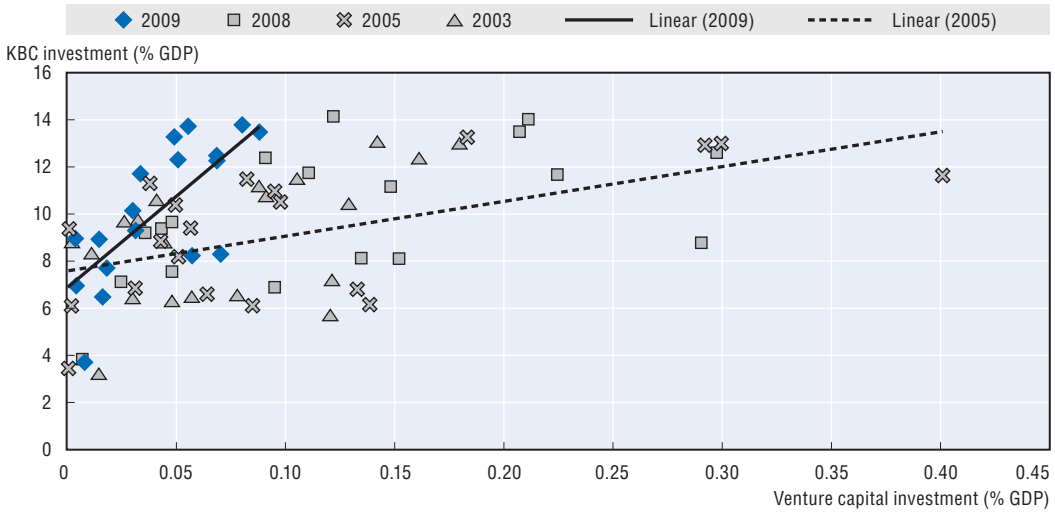
Nevertheless, countries differ significantly in the supply of seed and early-stage finance. This raises the question of whether differences in policy settings exacerbate rigidities in the financing of investments in KBC. A number of policy areas matter here, including: tax arrangements (tax deductions on investments, tax relief on capital gains and special provisions concerning the rollover or carry forward of capital gains and losses); regulations governing the types of institutions that can invest in seed and early-stage venture capital, such as pension funds (venture capital activity in the United States increased significantly following the removal of restrictions on pension fund investments in 1979); the availability to venture capitalists of viable exit strategies (e.g. initial public offerings); and bankruptcy arrangements (regimes that provide strong exit mechanisms and do not excessively penalise business failure can foster the development of VC).

Policy makers often attempt to nurture the market for seed capital through a range of direct and indirect supply-side policy initiatives. Indeed, most OECD countries have some type of government equity finance programme, such as direct public VC funds, "funds of funds" and co-investment funds, whereby public funds match those of private investors. In Europe, over half of all early-stage venture capital finance is provided by publicly supported co-investment funds. Such programmes, especially funds of funds and co-investment funds, have grown in importance over the past five years. While fiscal incentives are less common, 17 OECD countries use tax incentives of some sort. Evidence on the impact of supply-side policy interventions for early-stage finance is relatively scarce, and mainly relates to the performance of public VC funds. Government-supported VC firms risk coming under pressure to consider not only financial returns, but also policy goals relating to specific sectors, regions and social groups. However, empirical evidence suggests that government funding is most effective when disciplined by private VC management and pursues commercial objectives.

Demand-side policies can also be important in fostering early-stage equity investment. For instance, new OECD evidence which explores the determinants of VC investment in the clean technology sector suggests that regulations that aim to create a market for these technologies are associated with a higher level of VC investment, while fiscal incentives for investment in these technologies are ineffective. This likely reflects the frequent changes in the availability and generosity of such measures and further underscores the importance of a predictable policy environment for the financing of innovative ventures.

Figure 0.4. Business investment in KBC and the size of the venture capital industry

Selected OECD countries



Source: KBC estimates from sources in Figure 0.2. Venture capital data from the 2007, 2009 and 2011 editions of OECD's "Science, Technology and Industry Scoreboard", OECD Publishing, Paris, doi: http://dx.doi.org/10.1787/20725345

While far from a mature phenomenon, there have been some relatively recent innovations in KBC-based lending and investment. For instance, royalty-based financing has been used in the pharmaceuticals and biotechnology sectors. And one major publishing company funded an expansion of its business through a deal secured by its rights to the works of composers. In the United States, royalty-based financing is estimated to have been worth some USD 3.3 billion in 2007-08 (Ellis, 2009). Other transactions have been based on prospective revenues from products still at a pre-commercial stage of development. While still rare, KBC is also used as loan collateral. Governments can facilitate such developments in various ways, from monitoring the broader array of securities laws and regulations and how they affect KBC-based financing, to ensuring a robust market for intellectual property and institutional arrangements that minimise uncertainty as to ownership claims for KBC (Box 0.3).

Box 0.3. KBC as financial security: Recent developments and policy opportunities

The development of intellectual property as a source of loan collateral is part of a process of long-term economic transformation (Cuming, 2006). Historically, immovable property was the most valuable type of property, and mortgage laws were developed as financial systems emerged. With the rise of manufacturing, legal systems were reformed to permit the use of machinery and inventory as security. The increasingly central role of intangible assets in modern services-based economies will require new rules governing the use of intangible property as collateral. The problem is that intellectual property has distinctive valuation risks that affect the attractiveness of its use as collateral. These risks include the fact that: some intellectual property rights have limited life spans; a patent right might be made worthless as a result of novel innovations achieved by others; an intellectual property right can be lost through failure to pay renewal fees; some intellectual property rights only have potential value (for instance, a new software that has not yet been commercialised); some intellectual property may have limited marketability beyond its current ownership because its value is contingent on being combined with other assets; trademarks cannot generally be treated as independent collateral; and there may be uncertainty about the existence of copyright, which does not require registration.

…/…

Box 0.3. KBC as financial security: Recent developments and policy opportunities *(continued)*

However, there have been innovations in recent years in intangibles-based lending and equity investment. For instance:

- Royalty financing arrangements are increasingly used as sources of securitisation. The deals take a variety of forms. Some use existing royalty streams (the so-called "Bowie Bonds", issued in 1997, were backed by the stream of royalty payments generated by the catalogue of David Bowie's music). In 2006, XOMA Corporation, a human antibody therapeutics company, obtained a loan facility with Goldman Sachs' Specialty Lending group, secured by the latter's rights to payments from sales of three of the company's brand-name drugs. Other transactions have been based on prospective revenues from products still at a pre-commercial stage of development.
- In 1999, Citizens & Farmers Bank in Virginia issued the first M•CAM-insured intangible asset collateralised loan to the manufacturer of specialty infant formula bottle liners (M•CAM is a financial services firm specialising in intangible assets). This transaction set the precedent for a programme that offered intangible asset collateral insurance through a partnership between Bank of America, SwissRe and M•CAM.
- A 2007 survey in the United States showed that 18% of small high-technology companies in New England had used patents as collateral to obtain financing (Venkatachalam, 2007). The music publishing company Boosey and Hawkes funded an expansion of its business through a deal secured by its rights to the works of composers.
- Between 1997 and 2007, the share of secured syndicated loans collateralised by intangible assets in all secured loans rose from 11% to 24% in the United States (Loumioti, 2011).

Various areas of policy and institutional development could help promote an environment conducive to intangibles-based financing. These include:

- Regulations on corporate financial and accounting disclosure that help to reduce vagueness in identifying and quantifying internally generated intangible assets;
- The development of international valuation standards for intangible assets, through processes that engage the many relevant entities, from ratings agencies to large investors.
- Monitoring of the broader array of securities laws and regulations and how they affect intangible-based financing (possibly in unintended ways).
- Policies that facilitate a robust market for intangible assets, such as licensing, sales and auctions, to allow for their liquidation when necessary.

Institutional arrangements that minimise uncertainty as to ownership of intangibles. Uncertainty can be significant and have more than one source. In the United States, with respect to patents, legal claims covered by state-level laws can lead to geographic differences in court decisions (Jarboe and Furrow, 2008).

Government efforts to facilitate the development of patent litigation insurance (e.g. preventing fraudulent products and promoting financially sound products). For example, the Danish Patent and Trademark Office has encouraged the creation of patent litigation insurance for SMEs.

Government loan and loan guarantee programmes that might include provisions for purchasing intangible assets. The programmes might also be designed to explore with banks how to use facilities to finance intangibles-based firms. In China, for instance, at the end of 2008, the Beijing Intellectual Property Office created a programme to help SMEs borrow against their intellectual property.

The efficiency of resource allocation affects employment outcomes from business investment in KBC

Given the current state of data availability on KBC, drawing linkages to employment outcomes is not straightforward. But a number of observations are relevant. Firstly, as Chapter 1 shows, important cross-country differences are apparent as regards impacts on employment of increases in the patent stock. For example, a 10% increase in the firm-level stock of patents – one part of KBC – is associated with about a 2% increase in employment in firms in the United States, but only 0.6% in Japan and 0.4% in Finland. In other words, good framework conditions will help the KBC-intensive firms that can create jobs to do so.

Furthermore, because business investment in KBC is rising, new firms are more intensive users of KBC than in the past. At the same time, young and high-growth firms make a disproportionate contribution to employment growth. Previous OECD work has shown that young firms account for a substantial share of radical innovation. A new OECD project demonstrates that young firms are also an important source of employment growth. The project, called DYNEMP, currently covers thirteen countries and uses countries' business registers to quantify the extent to which firms with different characteristics (in terms of age, size and sector of activity) contribute to job creation and destruction, and how firm entry, growth and exit affect employment. Early results show that during the period 2001-11 businesses less than five years of age accounted on average for 18% of total employment but generated 47% of all new jobs created. Furthermore, during the financial crisis, the majority of jobs destroyed generally reflected the downsizing of large mature businesses, while most job creation was due to young small and medium-sized enterprises. While policies to foster job creation must consider the needs of firms of all sizes, these data indicate the importance of a policy context that enables entrepreneurship. Future research is needed to establish at the micro-level the relationships between young job-creating firms and their KBC investments.

In addition, while more evidence is needed, the environment for investment in KBC is also likely to play a role in determining which countries retain or move into the high-wage segments of different industries. For example, in 2006, the iPod accounted for 41 000 jobs, of which 14 000 in the United States and 27 000 elsewhere. But US workers, largely engaged in forms of KBC such as design, R&D, software and marketing, earned a total of USD 753 million, while those abroad (almost double their number), mostly engaged in manufacturing of parts, components and their assembly, earned USD 318 million (Linden, Dedrick and Kraemer, 2009).

Policy makers should take a broader view of innovation

A policy message that derives from many chapters in this book is that policy makers need to adopt a view of innovation that is broader than R&D. Forms of KBC, such as data, new business processes (Box 0.4) and design (Box 0.5), also drive innovation and value creation and may be affected by specific barriers and policies. One implication of this broader perspective might be a renewed emphasis on programmes such as technical extension services that facilitate the diffusion of various forms of KBC to firms. Historically, such programmes played a major role in diffusing new agricultural technologies. Extension programmes in manufacturing, some with a broader focus than technology, have also been extensively evaluated.

In adopting a policy perspective that goes beyond R&D, well-designed support measures are needed, including: frameworks that foster collaboration to innovate, for instance between firms and public research organisations; and well-crafted direct support that facilitates KBC investments in areas of highest social return (such as through innovation prizes and competitively awarded grants). Demand-side policy, which has typically received less attention than supply-side policy, could also support KBC investments in ways that simultaneously help to meet public needs (this is particularly so for innovation-oriented competitive public procurement).

Beyond the essential attention to framework conditions, public policies to increase business investment in KBC must of course be based on evidence that businesses would otherwise under-invest in KBC. Firms' ability to internalise fully the returns from investments in KBC varies depending on the type of asset. The strongest evidence for private under-investment exists for R&D-related spending. But positive externalities – which could lead to socially suboptimal investment – also exist for design and other forms of KBC (many businesses find their designs copied, a sign that some spillover of value is occurring). There is a need for more evidence on the scale of such positive externalities.

A wider perspective on innovation's drivers may require the redesign of some long-standing innovation programmes. For example, most OECD governments operate programmes that facilitate business access to research or technology-related advice and information, often from universities and public research organisations. These schemes – such as innovation vouchers, know-how funds and technical extension services – tend to focus on technological information and typically create links to academics in science, technology, engineering and mathematics (STEM) disciplines. Work on KBC suggests that an exclusive focus on STEM disciplines is too narrow. In fact, businesses require information and advice relating to many forms of KBC and interact with academics for a variety of reasons. In the United Kingdom, for instance, nearly a third of all academics in the arts and humanities are engaged with business in some way, as are nearly half of academics in the creative arts and media (Hughes, Kitson, Probert, Bullock and Milner, 2011). As well as knowledge related to STEM disciplines, businesses may want assistance with marketing, sales and support services, as well as human resource management, logistics and procurement. This suggests that a move from STEM to STEAM, as some researchers have proposed (the "A" refers to "Arts") would be appropriate.

Policy stability – keeping uncertainty to a minimum – is also important. As described in **Chapter 1**, new OECD evidence shows that in countries that have often reversed R&D tax policy, the impact of R&D tax credits on private R&D expenditure is greatly diminished.

Establishing targets for innovation policy has both advantages and disadvantages, but if governments do use innovation targets – such as the Lisbon Agenda's 3% of GDP guideline for national R&D spending – these should include the wider innovation indicators provided by KBC.

Box 0.4. Business process innovation: An example of knowledge spillovers in the airline industry

Southwest Airlines has introduced many significant innovations in the airline industry, such as boarding passengers without assigned seats and frequent-flyer programmes. For decades after the company's creation, in 1971, Southwest consistently achieved the lowest average cost per seat-mile among US airlines. Its stockmarket return has also been one of the highest of all S&P 500 companies. While these innovations were central to its success, many were not patented. Other airlines have replicated Southwest's innovations – including RyanAir, Easy Jet and Go in Europe as well as Air Asia in the Far East – often on the basis of passive or easily accessed knowledge flows (from travelling on Southwest planes to participation in "best practice" events organised by Southwest). Southwest also developed key innovations by learning from others. For instance, Southwest sent staff to the Indianapolis 500 to observe pit crews fuel and service race cars because the pit crews performed the same functions as aircraft maintenance crews, but faster. New ideas gleaned in this way and from other sources eventually contributed to a 50% reduction in Southwest's aircraft turnaround time.

Source: Criscuolo, C., Haskel, J. and Slaughter, M. (2005), Global Engagement and the Innovation Activities of Firms, NBER Working Paper 11479 (www.nber.org/papers/w11479).

Box 0.5. Design: A form of KBC that drives innovation and growth

A design is a plan or representation of the look, function or workings of a product or system. Product design affects functionality and the consumer's attachment to the product. Beyond physical appearance, design is often integral to all stages of the business process, from manufacture, brand development and marketing to after-sales service (in a global context, design can help to differentiate products to meet the requirements of different local markets). The impacts of design are not limited to physical products. For instance, the design of graphical user interfaces is increasingly important. Design also plays a major role in services, such as online purchasing or airport check-in. There is substantial quantitative and qualitative evidence that design plays important roles in innovation and firm performance and that overall business spending on design is large. For instance:

- One study of the United Kingdom suggests that spending on design might almost equal business spending on R&D (NESTA, 2012).
- A number of world-beating products owe at least part of their success to different facets of design. For tablet computers and smartphones some of the most prominent intellectual property conflicts in recent years have focused on design.
- Research published in 2010 indicated that the iPhone had then added around USD 30 billion to the value of the Apple Corporation, only 25% of which was attributable to patentable technology stemming from R&D. Much of the rest was attributable to Apple's innovations in design, marketing and management (Korkeamäki and Takalo, 2010). Incorporating design into the early stages of new product development has been shown to result in stronger corporate financial performance (Gemser, Candi and van den Ende, 2011).
- Design can allow firms to pull away from cost-based competition (for example, design enabled Sony to charge a 25% higher price for its Walkman than competitors) (Czarnitzki and Thorwarth, 2009).
- Design competencies can help companies in traditional industries such as textiles, apparel and furniture to succeed. Italy has long had a successful furniture industry largely based on small and medium-sized firms with competitive advantages in design.

…/…

Box 0.5. Design: A form of KBC that drives innovation and growth *(continued)*

- 67% of exporters in New Zealand have identified design as central to their commercial success (Gertler and Vinodrai, 2006).
- In 2007, almost half of businesses in the United Kingdom believed that design contributes to increased market share and turnover (Design Council, 2007). And in 2004, among firms in the United Kingdom that saw design as integral to their business, nearly 70% had introduced a new product or service in the previous three years (compared to just 3% of companies for which design played no role) (Design Council, 2004).
- Design expenditure has been shown to have a positive association with Dutch firms' sales of new products. (Marsili and Salter, 2006).

Industrial design filings have risen strongly in recent years. The World Intellectual Property Organization (WIPO) estimates that design filings grew by 16% worldwide in 2011, after 13.9% growth in 2010. Much of this growth reflects increased design filings in China (WIPO, 2012).

The Europe 2020 Flagship Initiative – Innovation Union includes design among its ten priorities. Further afield, China, India, Korea and Singapore have all enacted design policies and consider design to have strategic economic importance.

Appropriate tax treatment of KBC can stimulate investment and growth in cost-effective ways

Chapter 2 focuses on the structure of corporate income tax regimes and how they affect incentives for investment in KBC and tax revenues. Evidently, many tax policies affect innovation and growth, as described in previous OECD publications such as *Tax Policy Reform and Economic Growth* (2010). However, the work in **Chapter 2** focuses on new effective tax rate indicators and an assessment of the effects of corporate income tax on KBC investment decisions of multinational enterprises (MNEs). A key message is that the tax treatment of not only R&D expenditure but also returns to R&D must be taken into account in assessing the overall scale of tax relief for R&D and the design of R&D tax incentives.

Whether through R&D tax credits or special tax allowances, many OECD countries offer significant tax incentives for business spending on R&D. The number of countries providing tax incentives for business spending on R&D, and the generosity of such measures, is rising. Indeed, in some countries R&D tax incentives are the principal policy instrument used to foster innovation. For instance, in Canada in 2010, the R&D tax credit accounted for around 70% of all public support for business R&D. Ensuring that such resources are used cost-effectively is clearly essential.

MNEs typically operate as integrated global businesses and are able (within the limits of the law) to plan their tax affairs to take advantage of differences in tax rates and regimes across tax jurisdictions. Notwithstanding tax rules designed to protect the tax base in many countries, MNEs are often able largely to avoid corporate income tax on returns to R&D, for example by using offshore intellectual property holding companies. A particular difficulty for tax authorities is to establish arm's-length prices for transfers of KBC within a MNE. There are obvious risks, for instance, that managers of an MNE may attempt to mis-represent the value of patents transferred to an offshore company in order to minimise the firm's global (host and home country) tax burden. Also, owing in part to pressures to provide internationally competitive tax treatment, countries are often

reluctant to impose "controlled foreign company" (CFC) rules that would tax on a current basis (rather than deferred or exempt basis) royalty income received by offshore holding companies of resident MNEs.

Owing to limited data, it is difficult to estimate the global scale of profit shifting to no-/low-tax countries through MNE tax planning involving KBC, but the magnitudes involved appear to be significant. For example, the potential annual revenue cost from income shifting by US-based MNEs may be as high as USD 60 billion, with possibly half of this due to aggressive transfer pricing of KBC-related transactions (Gravelle [2009]; Clausing [2011]).

Conventional methods for assessing effective tax rates on investment in many forms of KBC largely ignore the international dimension of tax regimes and the tax planning behaviour of MNEs. **Chapter 2** reports the OECD's work to develop a new model for assessing the overall tax burden on R&D and for understanding how domestic and international tax policies influence business decisions to undertake R&D, where to hold KBC (such as patents) arising from successful R&D, and where to undertake production exploiting KBC. Key empirical findings from the new model are that:

- In many countries, overall tax relief for R&D (particularly that of MNEs) may be greater than governments intended when they first designed tax incentives for R&D expenditure.
- No-/low-tax rates and favourable tax regimes encourage MNEs to locate economic ownership of KBC (and receipt of income in the form of royalties) in offshore holding companies. In addition, limited taxation of foreign royalty income tends to encourage the use of KBC in foreign production and particularly in host countries with relatively low corporate tax rates. Such location decisions could have a number of negative consequences for the domestic economy: the country providing tax incentives for R&D might collect little tax on the commercialisation of the subsidised R&D; if KBC is held offshore and used in foreign production, there may be an important loss of domestic spillovers from R&D (e.g. knowledge gained from embedding KBC in production technology); and domestic employment may be negatively affected by tax policies that encourage the use of KBC in foreign production. Furthermore, global output may also be lower if investments are made in KBC not where they are most productive but where the tax arrangements afford the highest post-tax profitability.
- Compared to MNEs, "stand-alone" R&D performers (firms that are not part of a MNE group, and thus without foreign affiliates to engage in cross-border tax planning) may be placed at a competitive disadvantage. The absence of a level playing field may make it more difficult for such firms to compete with MNEs, which may inhibit knowledge creation. Yet such firms may have particular strengths as R&D performers (e.g. in creating radical innovations).

The analysis provides a case for targeting R&D tax credits to SMEs, in particular those that are not part of a multinational group. Such an approach is further supported by OECD analysis reported in **Chapter 1** which shows that the productivity impacts of fiscal incentives for R&D are unclear, possibly because they may favour incumbents at the expense of more dynamic young firms. If countries do not choose to target R&D tax credits, they may decide instead to consider steps to curtail profit shifting by MNEs so as to level the playing field (without reducing innovation activity). Forthcoming OECD

work on base erosion and profit shifting (BEPS) will provide a collaborative framework for developing appropriate reforms to international tax systems.

The analysis also points to the potential benefits of international co-operation to limit unintended tax relief for R&D (and its use in production) stemming from cross-border tax-planning, and possible inefficiencies arising from R&D support through tax credits and patent boxes.

Industries founded on knowledge-based capital create challenges for competition policy

Because competition is a key driver of innovation and growth, it is an important factor in the development of KBC-intensive sectors. **Chapter 3** addresses the question of whether competition policy is fully applicable in KBC-intensive markets and, if it is, whether it needs to be adjusted to account for differences between KBC-intensive markets and other kinds of markets.

Chapter 3 gives particular attention to the functioning of the "digital economy" (an umbrella term to describe markets focused on digital technologies that typically involve the trade of information goods or services via electronic commerce). The digital economy has brought new, rapidly expanding industries and business models. Indeed, never before have leading firms grown so large so quickly, and new businesses are challenging incumbents in novel ways. Claims of dominance and abusive or otherwise restrictive practices are frequent and have led to major legal disputes. Simply understanding how competition operates in the digital economy can be difficult.

Features of the digital economy that are especially significant for competition include: rapid change and constant innovation; the prominent role of IP in business strategies; economies of scale for information products; interoperability issues (given that many high-technology products are composed of complex systems of components that need to interface with each other and, in some cases, with external networks); and the importance of networks and the effects of network economies. Furthermore, many markets in the digital economy are global in scope. This can lead to jurisdictional or territorial difficulties. For example, in a given market it may be difficult to identify a physical entity that is legally representative of the party responsible for suspected anticompetitive behaviour. Moreover, an anticompetitive practice may affect several jurisdictions, thereby raising the question of which agency should take enforcement action.

When companies in the digital economy become very successful, many, even thousands, of other businesses may depend on their products or platforms. An example is Apple's iPhone and the thousands of software companies that have developed iPhone applications. As such companies can have huge market valuations, competition authorities may be tempted to focus on competition issues specific to individual platforms. However, unlike other sectors, the most meaningful competition in the digital economy may take place between platforms, which can be created by companies with very different business models. For example, Apple, Google, and Microsoft all compete in the market for mobile phone operating systems. Apple does not license its Operating System (OS) to handset manufacturers but reserves it for its own brand. Google offers handset manufacturers free licences to the Android system, while Microsoft licenses its mobile OS but charges users a fee. In such contexts, competition *among* platforms may be more important to innovation and consumer welfare than competition *within* platforms. It is important therefore that competition policy properly account for inter-platform competition.

Beyond the digital economy, it is clear that competition is central to innovation, even if discussion continues on the precise circumstances under which it has the greatest effect. OECD studies show that one of the most effective ways to boost business R&D is to eliminate unnecessarily anticompetitive product-market regulations (PMR). Indeed, the effect on business R&D of reducing these regulations could be greater than what has been achieved by reinforcing IPRs or by granting subsidies for private R&D. New OECD evidence – reported in **Chapter 1** - shows that a modest reduction in PMR in the energy, transport and communications sectors – corresponding to Germany's reforms in 2005, or the difference in regulation between Australia and Austria in 2008 – could result in a 5% increase in the stock of business R&D and a 3% rise in patents per capita in the long run. Product-market reforms can also increase incentives for firms to incorporate foreign technologies. Product-market regulations also affect the ability of successful firms to attract the complementary tangible resources needed to implement and commercialise new ideas. For example, as described in **Chapter 1**, reducing the stringency of regulations on business services from the high level in Italy to the OECD average (i.e. France) could raise the extent to which labour and capital flow to innovative firms by around 30% and 60% respectively.

While there is no clear consensus on the degree of competition that generates the most innovation, support is accumulating for the idea that the relationship is similar to an inverted "U", with moderate levels of competition stimulating more innovation than low or high levels. The great majority of enforcement activity by competition authorities occurs in relatively concentrated markets with low levels of competition that are likely to become less competitive in the absence of enforcement. The inverted-U theory implies that enforcement actions increase innovation by moving markets closer to moderate levels of competition. Effective enforcement of competition law stimulates innovation by protecting and encouraging competition in markets where there is the greatest potential for innovation to increase.

For knowledge-based capital, protection of intellectual property rights are a key framework condition

Various chapters of the book raise the issue of intellectual property rights (IPRs). IPRs afford legal protection of rights to intellectual property embedded in different types of KBC. These rights include patents (mainly new products and new processes), copyrights (mostly software, databases and artistic creation), trademarks (brand or logo) and design rights. Table 0.2 summarises the forms of KBC that can be protected by different types of IPR across OECD member countries (although the scope of protection varies from country to country. For example, patents can be used to protect business methods in the United States, but nowhere else).

The exact size of the IP marketplace is difficult to estimate, because most transactions are based on confidential agreements. However, trade statistics suggest that growth in the value of technology royalty payments is well above the growth rate of GDP. In the United States, active corporations reported gross royalty receipts of USD 171 billion in 2008, up from USD 116 billion in 2002 (see **Chapter 6**).

Table 0.2. The protection of knowledge-based capital by intellectual property rights

Type of investment	Legal forms				
	IPR				Other (trade secrets, contracts, etc.)
	Patents	Copyright	Design rights	Trademark	
Software	X	X	X		
Databases		X			X
Research & development	X		X		
Artistic originals		X	X		
Design	X	X	X		
Market research		X		X	X
Business process	X	X			X
Training					

Source: Clayton, UK Intellectual Property Office (unpublished).

The increasing importance of markets for intellectual property has also given rise to companies whose main activity is the monetisation of IP, principally through licensing. As **Chapter 6** describes, US data for this sector indicate total revenues of USD 20 billion in 2010, a 4% nominal increase from 2009, at a time of widespread economic contraction. Figures for individual EU countries indicate particularly high growth rates: in Germany, revenues of these businesses increased in current price terms by nearly 25% in 2010.

The primary aim of IP is to preserve incentives to innovate and to disclose innovation-related information by granting exclusive, but time-limited and scope-limited, rights to the use of a new product, process or artistic creation. In the case of patents, inventors are granted the right to prevent others from using their invention in exchange for public disclosure of technical information about the invention. Such public disclosure can be important for further technological advances, as follow-on innovators may learn from the patented invention. More broadly, IPR systems aim to encourage the creation of knowledge-based assets, create conditions for exploiting those assets, facilitate the diffusion of knowledge and ideas, and enable markets for funding innovation (for instance when patents serve as collateral or signals/certifications for investors).

However, there are now widespread concerns about the efficiency of IPR systems (Box 0.6). A number of OECD countries have begun comprehensive reviews of their IPR regimes, and debates on IPR have assumed new prominence in the economics press.

Box 0.6. Intellectual property rights - current policy concerns

There are significant differences countries' IPR regimes. Nevertheless, a number of themes recur in current policy debates:

- Fears, particularly in the United States, over the possible erosion of patent quality (notably the accuracy of the patent claim and whether the patent is genuinely novel or non-obvious). OECD data indicate that patent quality across the OECD area has eroded steadily over the last decade (with "quality" measured by indicators of patent family size, patent generality and whether the patent represents a breakthrough invention) (OECD, 2011). Deterioration in quality may in part result from patent offices being overwhelmed by the growing number of patent applications. Technological advances in areas such as computer programmes and telecommunications, as well as the growth in applications from emerging economies, have driven strong growth in patenting activity.

…/…

Box 0.6. Intellectual property rights - current policy concerns *(continued)*

- The rise of overlapping webs of IPRs, so-called "patent thickets". These may obstruct entry in some markets.
- The growing problem of so-called "patent assertion entities" (PAEs). PAEs are firms that do not make, own or provide their own products or services. Instead, they purchase patents and file resource-consuming lawsuits against companies alleged to have infringed those patents. They now bring the majority of US patent lawsuits, but are much less active in Europe. Examination of the impact of litigations prompted by PAEs – which tend to be in IT industries – has found evidence of a loss of social welfare and reduced innovation incentives.
- The extension of the patentable domain into the area of business methods. Overly broad patents, it is feared, could retard follow-on innovation, limit competition and raise prices through unnecessary licensing and litigation.
- Concerns over the effects on innovation and competition of specific operational features of patent systems such as patent disclosure notice (how well a patent informs the public of what technology is protected) and patent remedies (judicially awarded damages that should replicate the market reward that the patent holder loses because of patent infringement).
- In an ever more integrated global economy, the need to move to greater mutual recognition and compatibility of intellectual property systems internationally (for instance to ensure that examination decisions in patent offices treat local and foreign inventors equally).
- Concerns that while appropriate protection of copyright is crucial, digital technology makes enforcement extremely difficult. There are also fears that in an era of routine copying of text, data and images, copyright law may hinder the emergence of new kinds of Internet-based firms. It may also make scientists and other researchers reluctant to use text- and data-mining techniques.
- A broader concern that SMEs can face capacity constraints in their ability to negotiate intellectual property systems. Capacity-constrained SMEs may be particularly affected by cross-country differences in regimes and dispute resolution mechanisms.

The complementarity of patent protection and competition is highlighted by new OECD evidence of a positive relationship between the strength of patent regimes and the number of patent applications per capita, but only in countries with sound competition policies (see **Chapter 1**). Similarly, increases in patenting have a stronger association with MFP growth when anticompetitive product market regulations are lower, as it is easier to bring new ideas to market and exploit knowledge spillovers when barriers to entry are low. In sectors with higher patenting intensity, lower barriers to firm entry are also associated with higher allocative efficiency. However, while strengthening IPR increases the number of patents, it is unclear whether this reflects increased innovation or simply more widespread use of patents.

In addition to patents, the OECD's work on KBC also draws attention to the importance of design rights. Design rights protect aspects of a product's appearance (rather than its function). Differences across countries in the propensity to register design rights may reflect different legal traditions, culture and design rights systems. For instance, France and Germany have historically had more registration of designs than the United Kingdom (Moultrie and Livesey, 2011). Compared to the United Kingdom, Germany appears to be more aware of design-related intellectual property. The cost of enforcement also appears to be lower, and there is a general perception that courts will protect design rights. Infringement of design rights in the United Kingdom is dealt with

under civil law and, in contrast to Germany, does not include criminal sanctions. With its strong and relatively inexpensive legal enforcement, Germany also has many private initiatives to protect design. France has a simplified registration process for products with short product cycles.

Internationally, little systematic is known about the relative efficacy of different frameworks to protect design rights and provide incentives for investment in design. More analysis is needed to understand how differences among firms in terms of design registration affect differences in their economic outcomes. Much design investment is undertaken by small firms with comparatively limited capacities to enforce their design rights, a situation aggravated by the fact that the value of most individual design rights is relatively small. It would be important to understand how policy can enable designs to be monetised effectively, especially by small firms.

Governments must invest in better measurement of innovation, investment and growth

Chapter 4 focuses on the measurement of KBC. While KBC is central to growth, the development of international comparative data is in its infancy. Measurement of investment in KBC is rife with assumptions that require further testing and empirical refinement. Government support for proper measurement of KBC is needed to improve understanding of the sources of employment and productivity growth and the design of evidence-based policies. As **Chapter 4** describes, achieving consistent and high-quality estimates of investment for the assets that compose KBC will require sustained effort over many years. In this, there are several key challenges, opportunities and areas of progress, as briefly outlined here.

- In recent years, a number of international initiatives have estimated investment in KBC. Efforts to harmonise national-level estimates have led to the publication of comparable macro-level data under the INTAN-Invest umbrella for the EU27 countries plus Norway and the United States. At present, 34 OECD and non-OECD countries have reported estimates of aggregate investment in KBC based on a common framework.

- Uncovering the role of KBC in growth requires greater understanding of the investment behaviour of individual firms and industries. Efforts have been made to obtain industry-level estimates of KBC for 17 countries. While these initiatives provide policy-relevant information, they need to be scaled up and their comparability enhanced.

- A number of KBC-related assets have been overlooked in past definitional and measurement work. These forms of KBC – such as firm-specific training and design – are not included in official statistics. Plans exist to produce international measurement guidelines for design by 2014.

- The measurement of organisational capital (see Table 0.1) involves several assumptions. A main assumption relates to the share of management time used to effect lasting changes in a firm's productivity. In this connection, an experimental methodology proposed by the OECD has gone beyond a focus on managers, identifying the tasks of any employee that contribute to the long-term functioning of the business. As **Chapter 4** describes, this novel focus suggests that firms' investments in organisational capital may be almost twice as large as previously thought.

- The importance of organisational capital also depends on the number of years over which firms reap its benefits. The OECD has found that organisational capital is much longer-lived than previously thought. Firms expect such investments to yield benefits for on average 4 to 6 years in services and 7 to 10 years in manufacturing.
- Measurement of innovative property has progressed steadily in recent decades. However, for R&D there are a number of official data collections and distinct measurement approaches. The OECD has recently provided guidelines to facilitate international harmonisation and benchmarking.
- Measuring KBC by focusing on the cost of inputs, such as R&D, ignores the value of the output of R&D. To address this, measures of the "quality" of firms' innovative property – in particular the technological and economic value of patented inventions – have been constructed by the OECD using information contained in patent documents. Such indicators are generally comparable across countries and over time.
- Obtaining consistent industry-level depreciation rates for R&D investments has proved challenging, and there is no commonly agreed methodology. In the past, estimated R&D depreciation rates ranged between 12% and 29% for the business sector overall, and between 11% and 52% for specific industries. OECD work using patent renewal data suggests that R&D may be much more long-lived than previously thought, with an aggregate 8% annual depreciation.
- Assessing how KBC relates to productivity and growth also requires more refined information on asset prices, so as to accurately capture the quantity of the assets purchased. For instance, in countries and fields where specialised researchers are in short supply, an increase in R&D expenditures may simply reflect the higher salaries that firms might have to pay to retain researchers, rather than an increase in the number of scientists hired.

If measurement systems fail to keep up with changes in the knowledge economy, policy debate may focus on a few, easier-to-measure, indicators that do not reflect the rich variety of mechanisms that exist for producing, exchanging and using KBC.

Knowledge-based capital helps to capture value in global value chains

Chapter 5 examines the role of KBC in business engagement in global value chains (GVCs). The development of GVCs has changed the nature of global competition. Economies and firms no longer only compete for market share in high value-added industries. They increasingly compete for high value-added activities in GVCs. The value created in a GVC is usually unevenly distributed among its participants. The distribution of value is found to depend on the ability of participants to supply sophisticated, hard-to-imitate products or services. Increasingly, the supply of such products or services stems from forms of KBC such as brands, basic R&D and design, and the complex integration of software with organisational structures. Policy makers in OECD and many emerging economies understand the need to develop KBC so as to enter higher-value segments of GVCs. As the Secretary General of the China Industrial Overseas Development and Planning Association has remarked, "Our clothes are Italian, French, German, so the profits are all leaving China…We need to create brands, and fast."

The much-studied example of the iPhone shows how KBC can determine the geographical pattern of value creation in a GVC. The largest share of the value created by the iPhone accrues to providers of distribution and retail services in the United States and to Apple, mainly to its innovations in design, marketing and supply-chain management. For each iPhone 4 sold, at a retail price of USD 600, Apple earns around USD 270, while Korean firms supplying core components earn USD 80, and Chinese enterprises that undertake the assembly earn USD 6.5, a mere 1% of the total value.

New OECD research reported in **Chapter 5** also shows that a country's KBC is significantly and positively correlated with its export specialisation, particularly in industries that are skill-intensive and source many inputs from abroad. In other words, the more a country invests in KBC, the more likely it is to develop a comparative advantage in international trade in such industries. Among the different forms of KBC, the category "economic competencies" seem to have the largest impact on these results. Economic competencies are also among the types of KBC that are hardest to replicate. They include firm-specific skills such as management, brand equity and organisational processes and structures. Such forms of KBC are usually firm-specific, non-tradable and built up through in-house accumulation over time. Toyota provides an example of hard-to-replicate organisational capital. It excels as a global car manufacturer, owing in part to a deeply entrenched process of continuous incremental innovation – or *kaizen* – rather than radical innovation. It is estimated that Toyota implements around a million new ideas a year, most of them from workers. Other car manufacturers have found this system extremely difficult to duplicate, even though they have the financial resources to do so.

Knowledge networks and markets are growing, and better evidence must be generated for policymaking

As **Chapter 6** shows, rising investment in KBC and the unprecedented accumulation of information and IP rights have driven a widespread search for mechanisms to help individuals, businesses and organisations navigate increasingly complex innovation systems. Knowledge networks and markets (KNMs) comprise the set of systems, institutions, social relations, networks and infrastructures that enable the exchange of knowledge and associated IP rights. KNMs provide services ranging from facilitation of search and matching with relevant counterparties, to evaluation, implementation and enforcement of agreements. **Chapter 6** thus examines a range of innovation-specific institutions and policies relevant to the accumulation and use of KBC, and which are complementary to broader framework conditions (such as tax and competition policies).

There are several types of KNM and a number of approaches to classifying them. For instance, KNMs are typically thought of as being intended to facilitate the transfer of disembodied knowledge. But within this function, one may find KNMs ranging from searchable registers and repositories of existing data and information, to platforms for sourcing new solutions to *ad-hoc* problems and challenges (such as platforms for identifying consultants to assist with new R&D projects). Standard economic statistics are only beginning to encompass the market for ideas. In some countries, corporation tax data on licensing incomes provide evidence on the growth of knowledge markets that complements the picture emerging from a wide range of *ad hoc* studies and data on international transactions in IP. New statistical data on specialist IP firms and intermediaries show that the value of their services is relatively small in comparison with the investment made in KBC, but appears to be increasing. Comparison between the United States and European countries suggests that European markets are significantly less developed.

Several KNMs respond to challenges and opportunities arising from open innovation strategies adopted by firms. Survey data reveal that business innovation strategies are typically linked to specific approaches for knowledge sourcing and collaboration. Open sourcing strategies are not exclusive to R&D-active firms, but these firms typically exhibit a different pattern of collaboration as compared with other firms. A more complete description of business innovation strategies requires further evidence on how internally developed knowledge is used by other parties (an issue not addressed in most official surveys). The transfer of knowledge, even through the most "open" and "free" mechanisms, is critically dependent on the existence of enforceable IP rights, because these mitigate the risk that knowledge will be misappropriated.

As Chapter 6 describes, the IP marketplace has witnessed some important recent developments, including the emergence of patent assertion entities (sometimes known as "patent trolls") (see also Box 0.5). Government-sponsored IP funds, typically involving patents, are another addition to the range of intermediaries operating in the IP market place and to the portfolio of policy instruments being considered by public authorities. Their stated rationale differs across countries, although they have the common objectives of improving the valorisation of IP, addressing patent thickets and providing innovation actors with a defence against disruptive litigation. But the case for this type of instrument is by no means uncontested. The use of public funds to invest in IP titles and the alignment of this practice with international treaties should be scrutinised (if implemented at all).

Employee flows – such as flows of researchers and recent graduates - are crucial for accumulating and using KBC. As **Chapter 6** describes, understanding of the impact of institutions and regulations on job mobility, knowledge transfer and business innovation is still incomplete. New data sources will likely need to be combined with traditional measures to gain further insight on policy relevant aspects of knowledge transfer through people. Limited evidence exists, for example, on the legal enforcement of contractual practices restricting a former employee's ability to work for a competitor or set up a new business. Evidence presented in **Chapter 6** suggests that enforcement practices for such agreements vary significantly across OECD economies. A number of countries and regions place restrictions on the enforcement of non-compete agreements, a practice which some observers have linked positively to entrepreneurship and innovation in specific sectors. However, the impact of these agreements is likely to vary across economies with different labour market institutions and innovation systems.

Knowledge markets, in particular those involving intellectual property rights, are particularly complex objects of policy analysis. The concept of KNMs is probably too broad to be usefully considered as a single, all-encompassing object of analysis. A wide range of approaches, using diverse data sources and multi-disciplinary research strategies, are needed to fully grasp the implications of policies in this area. For each type of knowledge network or market, policy makers should concentrate on identifying original causes of market failure and evaluating the appropriate mechanisms for dealing with them.

Better corporate reporting of KBC should be encouraged

As described in **Chapter 7**, corporate reporting has been a subject of vigorous debate in recent years, and views diverge on how to enhance its quality and usefulness to investors, analysts and financial institutions. While attention has focused on integrated reporting and environmental, social and governance (ESG) reporting, better reporting of corporate spending on, and benefits from, KBC is also important to the broader debate on improving the quality of corporate reporting.

Nevertheless, in terms of practice, corporate reporting of intangibles appears not to have changed significantly in recent years. Indeed, despite the fact that the value of many of the world's most successful companies resides almost entirely in their KBC (or "intangibles", the term used in the accounting profession), corporate reports provide only limited information on this. Privately held companies have no obligation to report on KBC, nor do publicly held companies, except when recognition is required in the context of mergers and acquisitions.

Some evidence suggests that industrial sectors more dependent on external finance grow faster in countries with higher-quality corporate disclosure regimes (Rajan and Zingales, 1998). And in sectors more reliant on external finance, R&D expenditure as a share of value added also grows faster in countries with higher-quality corporate disclosure (Carlin and Mayer, 2000). In addition, enhanced disclosure of KBC, in a manner that is consistent across companies and countries, could have a positive impact on corporate performance by improving internal controls and risk management, raising the quality of strategic decision making and increasing overall transparency for shareholders and other stakeholders.

Given that the prevailing accounting standards do not generally require recognition of KBC (except in specific cases), reporting depends almost entirely on management's interest to disclose this information, most often through narrative reporting. As a result, KBC is often described qualitatively and generally not assigned any financial value.

As **Chapter 7** describes, a variety of approaches to the collection and disclosure of KBC data exist. Some have been developed by governments but most by the private sector (e.g. the Intangible Assets Monitor and the World Intellectual Capital Initiative). However, implementation is voluntary and has not been widely taken up.

While most market participants see the value of enhanced disclosure of KBC, the question of how this should be achieved remains contentious. Corporate reporting requirements have grown significantly in complexity and length in recent years. The overall volume of information reported needs to be reduced and presented in a manner that best reveals value-adding assets and processes. There are a number of steps governments might take to improve the current situation:

- Policy makers can support disclosure through recommendations and guidelines or by backing private-sector initiatives. To date, few OECD governments have introduced guidelines on this topic. As a result, company reporting follows different frameworks, which limits comparability and consistency.
- Progress could also be made by establishing expenditure classifications – i.e. standards for reporting KBC on companies' profit and loss statements – that would promote consistency in data collecting and reporting. This would require the development of standards for reporting spending on KBC to become a part of the Generally Accepted Accounting Principles (GAAP). New and globally accepted classifications would allow firms to categorise in a consistent way the items of KBC-related expenditure that are currently treated as intermediate expenditures of undefined type.
- Policymakers could establish support mechanisms to facilitate reporting. Such measures might include support to young enterprises, for instance through coaching for data collection and reporting.

- Governments might introduce frameworks for auditors that would provide more assurance about disclosure of KBC. Currently, auditors lack a framework to provide an opinion on KBC that cannot be recognised in financial statements.
- Policy makers can also engage in international co-ordination with a view to cross-country comparisons of companies.

Better policy can help create economic value from data

Chapter 8 examines the growing role of data as an economic asset. The explosive growth of the Internet and particularly of digital technologies such as mobile networks, remote sensors and applications such as smart grids, has created vast fields of information, often loosely referred to as "big data". Data are now processed, shared and transferred around the clock and across the globe. As **Chapter 8** describes, global data creation is projected to grow by 40% a year, compared with 5% yearly growth in worldwide IT expenditure. Combined with powerful data analytics, "big data" offers the prospect of significant value creation, social benefits and productivity enhancement. For instance:

"Big data" could be used throughout health-care systems – from clinical operations to payment and pricing of services and R&D – with estimated potential total savings of more than USD 300 billion for US health care by 2020 (MGI, 2011). Additional benefits could be had from innovations such as the formulation of timely public health policies using real-time data, for instance by assessing epidemiological trends based on the public's web-search behaviour.

- In public utilities, "smart-grid" technologies can generate large volumes of data about energy consumption patterns. Globally, it is estimated that the use of data-driven smart grid applications could cut more than 2 billion tonnes of CO_2 emissions by 2020 (GeSI, 2008).
- In the transport sector, the ability to track the location of mobile devices makes it possible to monitor traffic to reduce congestion and save commuter time, and to provide new location-based services. Overall, estimates suggest that the global pool of personal geo-location data is growing by about 20% a year. By 2020, such data could provide USD 500 billion in value worldwide in the form of time and fuel savings (MGI, 2011).

In addition to being a data source, the public sector is also an important data user. By fully exploiting public-sector data, governments could significantly reduce their administrative costs. Examining Europe's 23 largest governments, one source estimates potential cost savings of 15% to 20%, with the potential to accelerate annual productivity growth by 0.5 percentage points over the next decade (see **Chapter 8**). Additional benefits could be achieved by improving access to public sector information (PSI).

"Big data" is a relatively new theme on the policy agenda, and optimal policy has not yet been determined. However, it is clear that to unlock the potential of big data OECD countries need to develop coherent policies and practices for the collection, transport, storage and use of data. These policies must address issues such as privacy protection, open data access, infrastructure and measurement. It is also clear that there are mismatches between the supply of and demand for skills in data management and analytics (data science). Employees will be needed who can combine expertise in computer science, data analytics, experimental method and other disciplines.

Business investment in KBC amplifies the importance of appropriate human capital policies

Human capital is a key underpinning of KBC. For instance, software, which represents a large share of R&D spending, is essentially an expression of human expertise translated into code. Over half of all R&D spending goes to wages for researchers and technicians. And patents are a legal device for securing the intellectual property associated with innovations emanating from people's ideas. The rapid evolution of different parts of the KBC-intensive economy inevitably generates skills shortages. For instance, research in the United States suggests a shortfall of some 1.5 million managers and analysts with adequate understanding of the business benefits of data (MGI, 2011). As the recovery gains momentum, skills shortages may increase. To the extent that workforce skills can rapidly adjust, so as to complement new technologies, aggregate growth will be enhanced without greatly exacerbating income inequality.

In a context of highly constrained public finances, and in countries where educational attainment is already high, efforts to improve the quality of education will often be a priority. Particularly important are policies that balance skills supply and demand efficiently (the OECD's *Skills Strategy* sets out a comprehensive assessment of good practice in this area).

Partnerships between public bodies and private businesses provide an opportunity to foster and deploy KBC-related skills. A supply of skilled workers is necessary but not sufficient. Curricula must produce workers that businesses want to hire. Employers can help take responsibility for workforce development within their sectors and develop solutions to meet rapidly evolving needs. For instance, in the United Kingdom, Jaguar Land Rover has created a network from among a range of universities to deliver tailored courses in science and engineering for its staff, as part of the company's Technical Accreditation Scheme. The aim is to provide Jaguar's employees with access to "the best courses from the best sources".

KBC has profound implications for earnings inequality, creating a significant policy challenge

One of the challenges associated with the rise of KBC is earnings inequality. OECD analysis finds that skill-biased technological change is the single most important driver of rising inequalities in labour income (OECD, 2011a).

A KBC-based economy rewards skills. But it is not just an occupation's skill level that determines its substitutability by technology. Whether an occupation involves routine or non-routine tasks also matters (Autor, Levy and Murnane, 2003). For instance, high-skill jobs can be displaced if they involve routine tasks. And some low-skill jobs, such as those of janitors and drivers, involve non-routine tasks that have been hard to replace. However, technological change is progressively increasing the number of non-routine tasks that can be performed by machines and software. Driverless cars, for instance, will soon become widely affordable, and are already licensed in a number of states in the United States.

A KBC-based economy may also reward investors (who ultimately own much of the KBC) over workers (in the United States, for instance, wages as a share of GDP are at an all-time low). Furthermore, rising investment in KBC can create winner-takes-all opportunities for a tiny few. Digital technologies allow small differences in skill, effort or quality to yield large differences in returns, in part because of the size of the market that

can be served by a single person or firm. For instance, while average incomes of writers of fiction may not have changed greatly in recent decades, a select few can become multi-millionaires. J.K. Rowling is the first author to earn a billion dollars, with income from books, films and video games reflecting the fact that globalisation and digitisation allow words, images and products to be readily obtained worldwide. A related phenomenon is the widening of the distribution of productivity across firms, particularly in sectors with heavy investments in ICT, and where an early success can be ramped up quickly and at low cost (Faggio, Salvanes and Van Reenen, 2010).

Technological change does not automatically lead to a loss of employment. Greater cost efficiency can lead to total output growth. This might create enough employment to offset the reduction in labour needed to produce each unit of output. Significant efforts will clearly be needed to understand more fully the effects of KBC on employment, the demand for skills and the distribution of returns from production.

References

Acharya, V.V. and Subramanian, K.V. (2009), "Bankruptcy Codes and Innovation", *Review of Financial Studies*, Vol. 22 (12), pp. 4949-4988.

Australia, (2012), "Australian Innovation System Report – 2012", Department of Industry, Innovation, Science, Research and Tertiary Education, Commonwealth of Australia, www.innovation.gov.au/innovation/policy/australianinnovationsystemreport/aisreport2012.pdf

Autor, D.H., Levy, F. and Murnane, R.J. (2003), "The Skill Content of Recent Technological Change: An Empirical Exploration", Quarterly Journal of Economics, 118(4), November 2003, 1279-1334.

Baldwin, J., W. Gu and R. Macdonald (2012), "Intangible capital and productivity growth in Canada", in *The Canadian Productivity Review Research Papers*, Statistics Canada, Ottawa, www.statcan.gc.ca/pub/15-206-x/15-206-x2012029-eng.htm.

Barnes, P. and McClure, A. (2009), "Investments in Intangible Assets and Australia's Productivity Growth", Australian Government Productivity Commission Staff Working Paper, Canberra, Australia.

Bloom, N., Sadun, R. and Van Reenen, J., (2012), "Americans Do IT Better: US Multinationals and the Productivity Miracle", *American Economic Review*, Vol. 102(1), pp. 167–201.

Bloom, N., Draca, M. and Van Reenen, J. (2011), "Trade Induced Technical Change: The Impact of Chinese Imports on Innovation", Diffusion and Productivity, mimeo. www.stanford.edu/~nbloom/TITC.pdf

Brynjolfsson, E., Hitt, L.M. and Kim, H.H. (2011), "Strength in Numbers: How Does Data-Driven Decisionmaking Affect Firm Performance ?", Available at SSRN: http://ssrn.com/abstract=1819486 or http://dx.doi.org/10.2139/ssrn.1819486.

Brynjolfsson, E. and Smith, M. (2000), "Frictionless Commerce? A Comparison of Internet and Conventional Retailers", *Management Science,* 46, no.4: 563-585.

Carlin, W. and Mayer, C. (2000), "Finance, Investment and Growth", *Working Paper*: University of Oxford.

Chun, H., K. Fukao, S. Hisa and T. Miyagawa (2012), "Measurement of Intangible Investments by Industry and Its Role in Productivity Improvement Utilizing Comparative Studies between Japan and Korea", *RIETI Discussion Paper Series* 12-E-037, www.rieti.go.jp/jp/publications/dp/12e037.pdf.

Clausing, K.A. (2011), "The Revenue Effects of Multinational Firm Income Shifting", *Tax Notes*, March 28, 2011.

Corrado, C. A., J. Haskel, and C. Jona-Lasinio (2013). "Knowledge Spillovers, ICT and Productivity Growth", Mimeo (July). Paper presented at the 4th ICTNET workshop (London, April 2012), the 2nd World KLEMS meeting (Cambridge, Mass., August 2012), and ZEW (Manheim, Germany, May 2013).

Corrado, C.A, Haskel, J., Jona-Lasinio, C. and Iommi, M. (2012), "Intangible Capital and Growth in Advanced Economies: Measurement Methods and Comparative Results", Working Paper, June 2012, available at www.intan-invest.net.

Corrado, C.A. and C.R. Hulten (2010), "How do you Measure a 'Technological Revolution?", *American Economic Review: Papers & Proceedings 100* (May 2010): 99–104.

Corrado, C.A., Hulten, C.R. and Sichel, D.E. (2005), "Measuring Capital and Technology: An Expanded Framework", in Corrado, C., Haltiwanger, J. and Sichel, D. (eds), *Measuring Capital in the New Economy*, 11-45. Studies in Income and Wealth, Vol.65. Chicago: The University of Chicago Press.

Criscuolo, C., Haskel, J. and Slaughter, M. (2005), Global Engagement and the Innovation Activities of Firms, NBER Working Paper 11479 (www.nber.org/papers/w11479).

Cuming, R.C.C. (2006), "Pledges of Intellectual Property Rights Under Chinese Law", presentation made at the Symposium on Intellectual Property Financing, Xiangtan, China, September 25-28.

Czarnitzki, D. and Thorwarth, S. (2009), "The Design Paradox: The Contribution of In-house and External Design Activities to Product Market Performance", *ZEW Discussion Papers*, No. 09-068.

Design Council (2007), "The Value of Design, Factfinder Report". Available at www.designfactfinder.co.uk:8080/design-council/pdf/TheValueOfDesignFactfinder.pdf.

Design Council (2004), "Design in Britain, 2004-2005". Available at: www.design-council.org.uk.

Ellis, I. (2009), "Maximizing Intellectual Property and Intangible Assets; case Studies in Intangible Asset Finance", Athena Alliance (www.athenaalliance.org).

Faggio, G., Salvanes, K. and Van Reenen, J. (2010). "The Evolution of Inequality in Productivity and Wages: Panel Data Evidence", Industrial and Corporate Change, Oxford University Press, vol. 19(6), pages 1919-1951, December.

Fukao, K., Miyagawa, T., Mukai, K., Shinod, Y. and Tonogi, K. (2008), "Intangible Investment in Japan: New Estimates and Contribution to Economic Growth", www.euij-tc.org/news/events_2007/20080719/Fukao.pdf.

Gemser, G., Candi, M and van den Ende, J. (2011), "How Design Can Improve Firm Performance", *Design Management Review*, Vol. 22 (2), pp. 72–77.

Gertler, M.S. and Vinodrai, T. (2006), "Better by Design? Capturing the Role of Design in Innovation", paper presented at "Blue Sky II: What Indicators for Science, Technology and Innovation Policies in the 21st Century?", OECD and Statistics Canada, Ottawa, 25-27 September. www.oecd.org/dataoecd/10/45/37450179.pdf.

GeSI (2008), SMART 2020: Enabling the low carbon economy in the information age. Available at: www.smart2020.org/_assets/files/02_Smart2020Report.pdf

Gravelle, J.G. (2009), "Tax Havens: International Tax Avoidance and Evasion", Congressional Research Service Report for Congress, 7-5700, R40623, July 9, 2009.

Hughes, A., Kitson, M. and Probert, J. with Bullock, A. and Milner, I. (2011), "Hidden Connections: Knowledge Exchange Between the Arts and Humanities and the Private, Public and Third Sectors", Arts and Humanties Research Council, and the Centre for Business Research, Cambridge, United Kingdom.

Hulten, C.R. and J.X. Hao (2011), "The Role of Intangible Capital in the Transformation and Growth of the Chinese Economy", *NBER Working Paper* 18405, September 2012.

Hulten, C.R, J.X. Hao and K. Jaeger (2012), "The Measurement of India's Intangible Capital", paper prepared for the World Input-Output Data project, The Conference Board.

Jarboe, K.P. and Furow, R. (2008), "Intangible Asset Monetization: The Promise and the Reality", Working paper # 3, Athena Alliance (www.athenaalliance.org).

Korkeamäki, T. and Takalo, T. (2010), "Valuation of Innovation: The Case of iPhone", *MPRA Paper* No. 28042. Available at: http://mpra.ub.uni-muenchen.de/28042/

Kortum, S. and Lerner, J. (2000), "Assessing the Impact of Venture Capital on Innovation", *Rand Journal of Economics*, Vol. 31, pp. 674-692.

Linden, G., Dedrick, J. and Kraemer, K.L. (2009), "Innovation and Job Creation in a Global Economy: The Case of Apple's iPod", *Working Paper*, Personal Computing Industry Center, UC Irvine, January.

Loumioti, M. (2011), "The Use of Intangible Assets as Loan Collateral", Harvard Business School Job Market Paper. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1748675

Marsili, O. and Salter, A. (2006), "The Dark Matter of Innovation: Design and Innovative Performance in Dutch Manufacturing", *Technology Analysis & Strategic Management*, Vol. 18 (5), pp. 515-534.

MGI: McKinsey Global Institute (2011), "Big data: The Next Frontier for Innovation, Competition and Productivity", McKinsey & Company, June, www.mckinsey.com/~/media/McKinsey/dotcom/Insights%20and%20pubs/MGI/Research/Technology%20and%20Innovation/Big%20Data/MGI_big_data_full_report.ashx

Moultrie, J. and Livesey, F. (2011), "Design Rights: Case Studies", unpublished paper presented at the Design Rights Workshop (organised by the United Kingdom Intellectual Property Office and the United Kingdom Design Council), London – 21 September 2011.

NESTA (2012), "UK Innovation Index 2012", Available at www.nesta.org.uk/home1/assets/features/innovation_index_2012.

OECD (2007), *OECD Science, Technology and Industry Scoreboard 2007*, OECD Publishing.
doi: http://dx.doi.org/10.1787/sti_scoreboard-2007-en

OECD (2009), *OECD Science, Technology and Industry Scoreboard 2009*, OECD Publishing.
doi: http://dx.doi.org/10.1787/sti_scoreboard-2009-en

OECD (2011), *OECD Science, Technology and Industry Scoreboard 2011*, OECD Publishing.
doi: http://dx.doi.org/10.1787/sti_scoreboard-2011-en

OECD (2011a), *Divided We Stand: Why Inequality Keeps Rising*, OECD Publishing. doi: http://dx.doi.org/10.1787/9789264119536-en

Rajan, R.G. and Zingales, L. (1998), "Financial Dependence and Growth", *American Economic Review*, Vol. 88(3), pp 559-586.

Samila, S. and Sorenson, O. (2011), "Venture Capital, Entrepreneurship and Economic Growth", *Review of Economics and Statistics*, 93(1), pp. 338-349.

van Ark, B., O'Mahony, M. and Timmer, M.P. (2008), "The Productivity Gap Between Europe and the United States: Trends and Causes", *Journal of Economic Perspectives*, Vol. 22(1), pp. 25–44.

Venkatachalam, A. R. (2007), "Use of Patents in Securing Financing: A Survey of New

England Firms. Enterprise Integration Research Center", University of New Hampshire. Available at: http://wsbe2.unh.edu/files/Survey_Summary_FINAL.pdf

World Bank (2012), "Measuring Intangible Assets in an Emerging Market Economy: An Application to Brazil", *Policy Research Working Paper* 6142.

World Intellectual Property Organization (2012), "World Intellectual Property Indicators", WIPO Geneva.

Chapter 1.

Knowledge-based capital, innovation and resource allocation

Investment in knowledge-based capital (KBC) – assets that lack physical embodiment, such as computerised information, innovative property and economic competencies – has been rising significantly. This has implications for innovation and productivity growth and requires new thinking on policy. The returns to investing in KBC differ significantly across countries and are partly shaped by structural policies, which influence the ability of economies to reallocate scarce resources to firms that invest in KBC. Well-functioning product, labour and venture capital markets and bankruptcy laws that do not overly penalise failure can raise the expected returns to investing in KBC by improving the efficiency of resource allocation. The same is true for lower barriers to international trade and investment, which also stimulate innovation through greater market size and knowledge diffusion across borders.

While structural reforms offer the most cost-effective approach to raising investment in KBC, there is a role for innovation policies to raise private investment in KBC towards the socially optimal level(s). Indeed, R&D tax incentives and, as a finding that contrasts with previous research, direct support measures can be effective, but design features are crucial in order to minimise the fiscal cost and unintended consequences of such policies. Well-defined intellectual property rights (IPR) are also important to provide firms with the incentive to innovate and to promote knowledge diffusion via the public disclosure of ideas. However, such IPR regimes need to be coupled with pro-competition policies to ensure maximum effect while the rising costs of the patent system in emerging KBC sectors may have altered the trade-off inherent to IPR between the incentives to innovate and the broad diffusion of knowledge.

The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

Innovation-based growth, underpinned by investments in a broad range of knowledge-based capital (KBC), is central to raising long-term living standards. This is especially the case in advanced economies that are relatively close to the technological frontier, where future growth will increasingly need to come from improvements in multi-factor productivity (MFP) (OECD, 2012).

While investment in innovation has traditionally been proxied by indicators such as spending on research and development (R&D) and the purchase of capital embodying new technologies, innovation-based growth relies on a much broader range of KBC. These include employee skills, organisational know-how, databases, design, brands and various forms of intellectual property, and have been classified more formally under three broad categories: computerised information, innovative property and economic competencies (Corrado et al., 2005; Table 1.1).

Table 1.1. The classification of KBC and its possible effects

Type of KBC asset	Mechanisms of output growth for investor in the asset
Computerised information	
Software	Improved process efficiency, optimised vertical and horizontal integration
Databases	Better market segmentation and appropriation of consumers' rent. Optimised vertical and horizontal integration. The use of information to improve logistics and production efficiency.
Innovative property	
Research & Development	New products and services. Quality improvements to existing ones. Better ways of producing output. New technologies.
Copyright and license costs	Knowledge diffusion (inventions and innovative methods).
New product development in the financial industry	More accessible capital markets. Reduced information asymmetry and monitoring costs.
New architectural and engineering designs	Fixed cost leading to production in future periods. Quality improvements, novel designs, enhanced processes.
Economic competencies	
Brand-building advertisement	Price premium. Increased market share. Changes in consumers' preferences.
Market research	Targeted products and services. Increased market share.
Workers' training	Improved production capability of workers. Increased skill levels.
Management consulting	Faster and better decision making. Improved production processes.
Organisational capital	Faster and better decision making. Improved production processes.

Source: Based on the classification in Corrado et al. (2005), "Measuring Capital and Technology: An Expanded Framework", in *Measuring Capital in the New Economy*, C. Corrado, J. Haltiwanger and D. Sichel (eds.), *Studies in Income and Wealth*, Vol. 65, The University of Chicago Press, Chicago, IL.

There are important differences among OECD economies in investment in – and returns to – KBC and innovative capacity. These cannot be explained solely by differences in specialisation patterns. Differences at the country level are associated with diverging patterns of firm performance, with some countries better able to channel resources to innovative and high-growth firms than others. In this context, a key question is the extent to which national institutions and international arrangements can facilitate the reallocation of resources to new sources of growth based on KBC. This chapter therefore explores how public policies shape patterns of resource allocation and investment in KBC, and the role of reallocation mechanisms in promoting the growth of innovative firms. More broadly, these issues have relevance for emerging economies aiming to move up the global value chain.

The chapter is organised as follows. A stylised framework first depicts conceptually how public policies shape incentives to accumulate KBC and innovate, as well as the efficiency of resource allocation and the links between innovation and reallocation. Next, some stylised facts on KBC and innovation at the aggregate level are presented, along with some links to firm performance within countries, including indicators of the efficiency of resource allocation. Existing and new OECD empirical evidence on how public policies shape the KBC-innovation-reallocation nexus are then reviewed; new OECD empirical research undertaken for this project is described in Box 1.2. Finally, the chapter offers some general policy conclusions.

The KBC-innovation-reallocation nexus

Recent research emphasises the growing importance of KBC as a source of productivity gains, and the contribution of efficient resource allocation to this process (Andrews and de Serres, 2012). Owing to the non-rivalrous nature of knowledge, the costs incurred in developing new ideas – typically through R&D – are not incurred again when these are combined with other inputs to produce goods or services. This combination can lead to increasing returns to scale, an important property that makes ideas and knowledge an engine of growth (Jones, 2005). Realising this growth potential depends on the ability to reallocate labour and capital to their most productive uses. Efficient mechanisms to reallocate tangible resources take on heightened importance, given that KBC is prone to misallocation (Box 1.1).

Box 1.1. The significant scope for misallocation of KBC

Given the limitations of market mechanisms for allocating intangibles, KBC is prone to misallocation. The heterogeneous nature of KBC – e.g. patents are far from homogenous – is a key barrier to the efficient allocation of KBC. Efficient outcomes would require transparent environments with opportunities to trade with a wide range of potential transactors (thick markets), thereby creating the pre-conditions for effective matching (Roth, 2008). However, because the prices of transactions in the secondary market for patents are often not publicly disclosed, the resulting information asymmetries undermine the development of a more liquid market. The extent to which transactions in the secondary market allocate patents to more productive uses is also unclear, especially in the IT sector. Moreover, the bilateral environment in which the details of a licence are negotiated lacks a transparent price discovery process to reveal the "fair" price of the patent and may lead to a poor match. For these reasons, facilitating transactions in the market for patents is difficult and the market is subject to significant transaction costs (Gambardella, 2008; Eisenberg and Ziedonis, 2010).

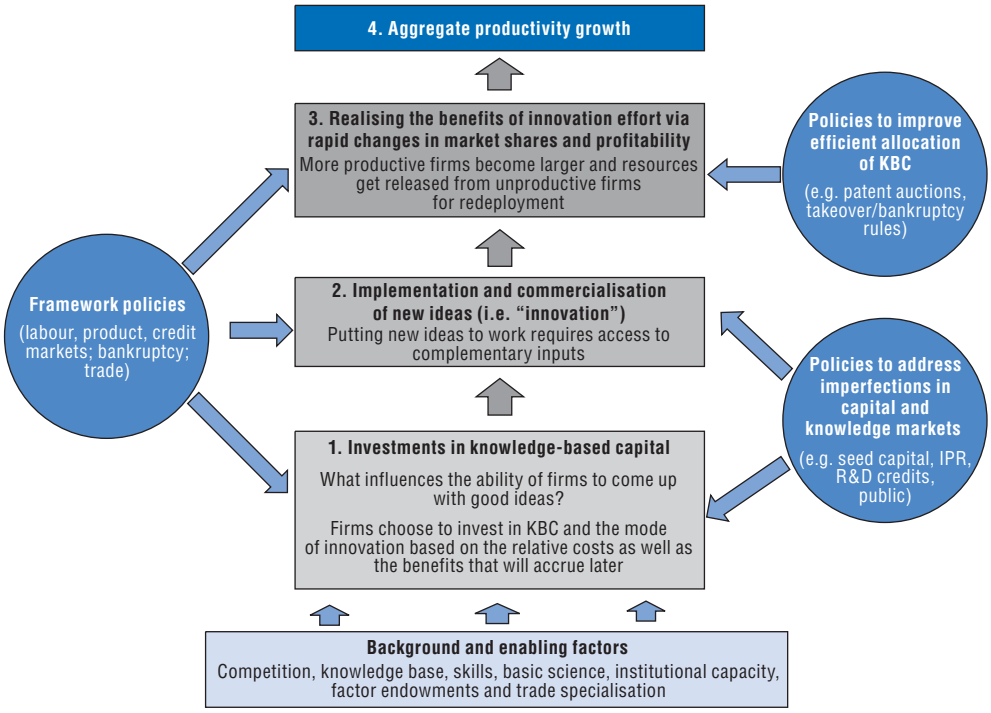
Tacit knowledge is embodied in individuals and therefore lacks separability; this undermines its transferability. The mechanisms for allocating tacit, human-capital based, or even codified but not legally protected KBC, are even less efficient. Firms have two main options: corporate takeovers or selective recruitment (poaching) of specialists. However, both of these strategies entail important risks. For instance:

- A company acquiring an entity in which most intangible assets are human capital-based has to retain the employees of interest (and their teams) in the post-acquisition environment. This is risky given the capital outlays involved and the fact that the acquiring company has less than perfect control of the targeted asset, since it is embedded in individuals.
- Accessing external sources of KBC via the selective recruiting of specialists is complicated by the usual obstacles to labour mobility – e.g. binding non-compete covenants and pension and health care portability – and the need for recruiting firms to possess at least some internally generated technological knowledge in order to assess these external sources effectively and to absorb the acquired knowledge.

Efficient resource allocation in a knowledge-based economy

Figure 1.1 sketches the key elements of the KBC-innovation-reallocation nexus. The basis of the framework is three inter-related building blocks, broadly aligned with the different stages of the innovation process: the development of new ideas (or adaptation of foreign technologies); the implementation and commercialisation phase; and reaping the benefits of new ideas through changes in market share and profitability. Of course, the framework takes as given a number of enabling factors – such as workforce skills – which are clearly crucial to innovation but are beyond the scope of this chapter.[1]

Figure 1.1. The KBC-innovation-reallocation nexus and public policies



Source: Andrews and Criscuolo (2013), "Knowledge-Based Capital, Innovation and Resource Allocation: A Going for Growth Report", *OECD Economic Policy Papers*, No. 4, OECD Publishing, doi: http://dx.doi.org/10.1787/5k46bh92lr35-en

Implementing new ideas (stage 2) can take the form of new processes or new organisations that allow the firm to produce more outputs with the same amount of inputs and increase multi-factor productivity, thus lowering marginal costs of production. Ultimately, firms are able to offer their outputs at a lower price and gain market shares through price competition (stage 3). Similarly, firms can introduce new goods or make quality improvements to existing goods and thus compete on quality (e.g. charging higher prices for their new or differentiated product without losing market shares). In the short to medium term, innovations increase a firm's profitability (Geroski et al., 1993), but as other firms also compete on quality, the profit margins gained by a firm from its innovation are likely to be steadily eroded in markets that function efficiently.[2]

Removing obstacles to experimentation with new products, processes and business models encourages investment in KBC by start-ups and by incumbent firms operating at the frontier that face competitive pressures, e.g. in order to exploit information and communication technology (ICT) and so-called "big data" efficiently. The competitive edge

gained in this way and the appropriation of any returns to successful innovations justifies their innovative efforts (Schumpeter, 1942). Competition pushes frontier firms to continue to innovate to stay abreast of new technological developments (Aghion and Howitt, 1992), while further from the frontier, investments in KBC are necessary to facilitate the adoption of the most productive technologies (Griffith et al., 2004). Firms that fail to do so may have to downsize or exit the market, releasing resources for use by firms with the most efficient technologies.[3] When resource allocation is more efficient (Olley and Pakes, 1996), the most productive firms will have the largest market shares and the largest gains in efficiency will be achieved when innovative firms rapidly gain market share at the expense of unsuccessful or stagnant competitors (Bartelsman and Hinloopen, 2005).

The ability to expand the tangible capital base and the workforce rapidly is particularly important in a knowledge-based economy. For firms that invest in KBC, the profitability of successful new ideas depends on the ability to exploit the strong returns to scale that characterise this type of capital (Bartelsman et al., 2010; Bartelsman and De Groot, 2004). For example, they may scale up innovative production methods (e.g. ICT-related business investments) that have proved successful in smaller-scale experiments (Brynjolfsson et al., 2008). Conversely, the ability to scale down operations rapidly – via divestitures of labour and capital – and to maximise salvage value makes exit easier in the event of failure (Bartelsman et al., 2008).[4] In this context, facilitating the expansion of successful innovative start-ups is particularly important for long-run growth, because firms that drive one technological wave often tend to concentrate simply on incremental improvements in the subsequent one (Benner and Tushman, 2002) and young firms possess a comparative advantage in commercialising radical innovations (Henderson, 1993; Tushman and Anderson, 1986).[5]

Openness to trade is also crucial because it leads to more innovation via market-size effects, tougher product market competition and larger knowledge flows. Larger market size stimulates investment in KBC by magnifying the expected profits in the event of successful ventures (Schmookler, 1966; Acemoglu and Lin, 2004). However, globalisation means that firms have to differentiate their goods or lower their costs in order to stay competitive (see below). It also promotes productivity-enhancing reallocation via the expansion of the most productive firms into foreign markets (via exports or by becoming multinationals) and the exit of low-productivity firms that are unable to compete in the global market or undertake the costs required to enter the foreign markets (Melitz, 2003; Melitz and Ottaviano, 2008; Melitz and Trefler, 2012). Finally, trade and foreign direct investment (FDI) are associated with increased flows of knowledge from global customers and suppliers (Crespi et al., 2008; Duguet and MacGarvie, 2005) and from the activities of multinational enterprises (MNEs).[6]

Misallocation and the role of policy

In practice, frictions are likely to arise from market failures related to knowledge and rigidities in factor markets. Specific features likely to distort investment in KBC include the following:

- Private investment in KBC may be below the socially desirable level if the non-rival and only partially excludable nature of some forms of KBC means that firms cannot fully appropriate the returns from their investments, as some knowledge will spill over to other firms.
- KBC is difficult to collateralise and its inherent riskiness reinforces traditional market failures in capital markets (e.g. information asymmetries), which may inhibit the implementation and commercialisation of new ideas, especially for KBC-intensive firms.

- The scale economies that arise from the non-rival nature of KBC can be reinforced by network externalities (i.e. the value of a product increases with the number of users). In extreme cases this may lead to a winner-takes-all outcome. Network effects create a natural monopoly or high barriers to entry and limit competition in areas in which competitive pressures might raise efficiency.

These features are the source of (still unresolved) inefficiencies in knowledge markets and thus place heightened importance on the efficient reallocation of tangible resources. Frictions for reallocating capital and labour are likely to lower the expected net benefits of innovative investment by making it more difficult for successful innovators to attract the resources they need to implement and commercialise new ideas. Moreover, if the innovative effort fails, rigidities may make downsizing and exiting more costly and make it difficult for entrepreneurs to move on and experiment with new ideas. More broadly, as new and young firms are an important source of new ideas, barriers to entry in domestic and international markets will lower the supply of KBC. They will also dampen competitive pressures on incumbents to generate KBC and raise the cost and/or lower the quality of the inputs required by innovative firms to expand.

Ease of reallocation influences firms' business strategies

Policies would appear to affect the different stages of the innovation process and productivity growth sequentially. However, firms' initial investments in KBC are likely to be shaped by their perceptions of the expected costs of implementing and commercialising new ideas and their ability to capitalise on the expected benefits or to exit at low cost (both of which depend on the ease of reallocation).[7] In particular, firms' innovation strategies will be influenced by their views on the extent of rigidities in the reallocation process. If they find that the costs of reallocation are high, entrepreneurs may focus on incremental innovations, rather than experiment with disruptive technologies, because it would be more difficult to realise the benefits of risky technologies if they succeed and contain losses if they fail (Bartelsman, 2004).

In addition, some entrepreneurs may choose not to enter the market because it may not appear profitable or sustainable to enter with just an incremental innovation (Shane, 2001; Bhide, 2000). The extent of specialisation in sectors that rely more on reallocation – such as more innovative or ICT-intensive sectors – may therefore vary across countries (Bartelsman et al., 2010), partly as a result of how different policy settings influence the nature of resource flows across incumbents and new entrants and thus the scale of production in these sectors.

Policies may have unintended consequences

An important implication of Figure 1.1 is that different policies affect different stages of the innovation process (Jaumotte and Pain, 2005a; OECD 2010) so that a range of policy tools may be required to encourage innovation. However, the policy instruments are likely to interact, raising the potential for policy complementarities and trade-offs.

Policies designed to address market failures in knowledge markets (e.g. R&D tax incentives) may unintentionally undermine an economy's reallocation dynamics. More generally, policies that might appear to be neutral in design (e.g. trade liberalisation) may have non-neutral impacts on firms because of the diversity of firms' characteristics, even within narrowly defined industries. Indeed, policies may unintentionally make the cost of inputs disproportionately lower for certain firms or shift the tax burden towards others. For example, regulations that impose a fixed cost on firms may disproportionately affect

young firms, which typically have fewer resources to absorb this cost. These considerations are particularly relevant for policies that affect the efficiency of labour and financial markets (to be discussed below).[8]

Side effects of the knowledge-based economy

Gearing public policy to maximise the growth potential of KBC may not have unambiguously positive effects and may lead to trade-offs with other policy goals. First, some forms of KBC may have undesirable side effects: firms may undertake expenditures on marketing and intellectual property rights (IPR) to create significant upfront costs and deter entry by other firms, or they may engage in rent-seeking behaviour (also an intangible investment from a firm's perspective) (Hunter et al., 2005). Second, while efficient reallocation raises returns to KBC, the shifting of resources entails costs for firms, workers and governments so that excessive reallocation is no more desirable than trapping resources in inefficient activities. Third, there may be a tension between policies that promote experimentation and raise the returns to innovation and equity concerns.

The knowledge-based economy rewards high-level skills. This is likely to reinforce rising income inequalities via skill-biased technological change. Technological progress has made some routine and medium-level work redundant, thereby displacing workers, while increasing the value of other "new economy" tasks (Autor et al., 1998). As part of these changes, firms have tended to introduce information technologies against a backdrop of organisational restructuring made possible by KBC (see the following section). This has shifted the mix of skills firms require towards non-routine tasks (e.g. organisational and management tasks; Bresnahan et al., 2002).

Rising investment in KBC can also create winner-takes-all opportunities for a very few (Brynjolfsson and McAfee, 2011). Digital technologies – which allow the replication of informational goods and business processes at near zero marginal cost – can allow the top provider to capture most, if not all, of its market, with only a tiny fraction accruing to the next best (even if they are almost as good). Besides generating disproportionately strong income growth at the very top end of the income distribution, such outcomes may undermine work incentives by detaching effort from reward and creating concerns from a competition policy perspective.

Finally, by codifying previously tacit knowledge, knowledge-based assets such as IPR and software have facilitated the decoupling of (codified) knowledge from the producer of that knowledge. With the caveats in Box 1.1 in mind, this has given owners of capital opportunities to trade and appropriate (part of) the rents from that knowledge, thereby creating tensions between owners of capital and owners of knowledge.

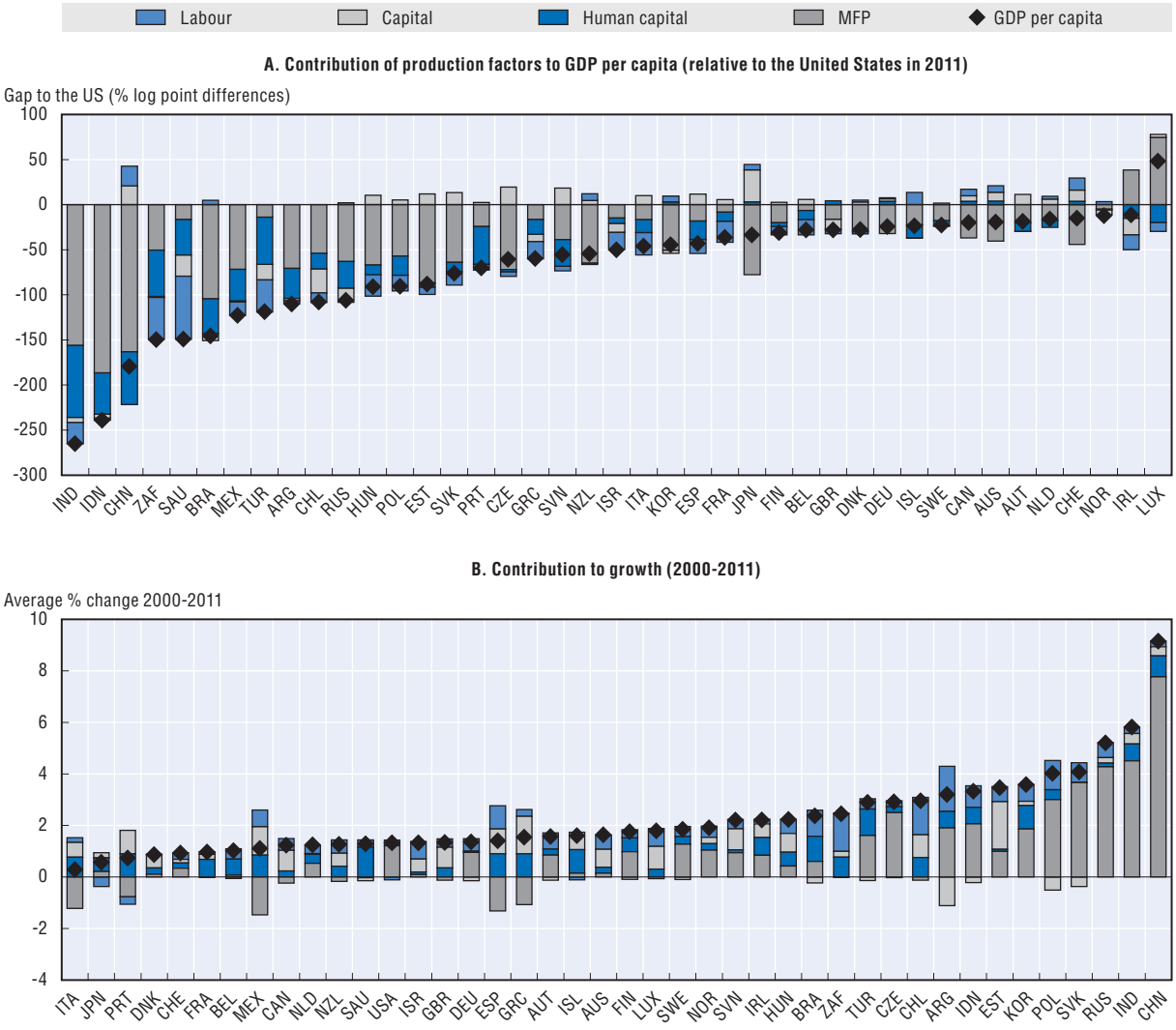
Investment in KBC, reallocation and productivity growth

Links with aggregate growth

Wide and persistent differences in the level of MFP account for the bulk of income per capita gaps across countries (Figure 1.2, Panel A; Easterly and Levine, 2001).[9] Countries that have succeeded in converging towards high-income countries in recent years have often done so on the basis of convergence in MFP and the stock of knowledge (Figure 1.2, Panel B). In theory, MFP reflects the efficiency with which inputs are used, via improvements in the management of production processes, organisational change, or R&D and innovation. It is therefore natural to examine the link between gaps in MFP growth and differences in countries' investment in KBC, which, as discussed below, tend to be significant.

Once estimated KBC is incorporated in growth accounting, the contribution of MFP growth to labour productivity growth tends to fall.[10] Over the period 1995-2006, incorporating KBC is estimated to reduce the contribution of MFP by close to one-half in Sweden; one-quarter in the United States and Finland; roughly one-fifth in France, the United Kingdom, the Czech Republic and Australia; and by one-tenth or less in Austria, Denmark, Germany and Japan (van Ark et al., 2009; OECD 2011a).

Figure 1.2. Multi-factor productivity drives cross-country differences in GDP per capita

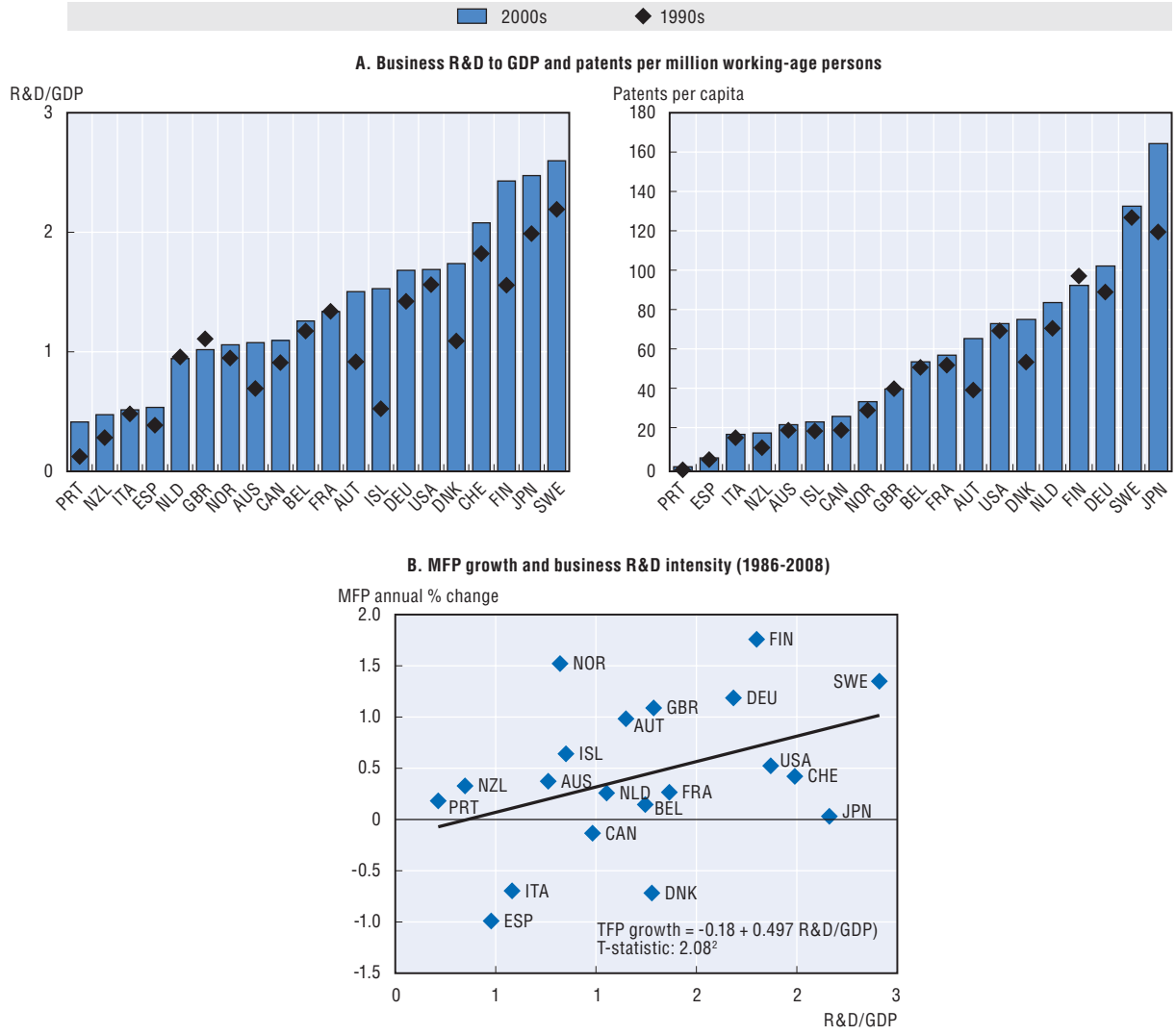


Source: Johansson et al. (2013), "Long-Term Growth Scenarios", *OECD Economics Department Working Papers*, No. 1000, OECD Publishing, doi: http://dx.doi.org/10.1787/5k4ddxpr2fmr-en.

There are important differences among countries in the contributions of MFP and KBC to growth of gross domestic product (GDP). This reflects both differences in the amount of investment in intangible assets and differences in the returns (i.e. marginal product) to these investments.[11] For example, there are persistent differences in the intensity of business R&D and patenting across countries even after controlling for differences in industrial structure, suggesting that variations in the use of KBC cannot be explained solely by

structural differences such as trade specialisation patterns (Figure 1.3).[12] These differences are important because business R&D intensity and patenting have been closely linked to productivity performance (Bloom and Van Reenen, 2002; Hall et al., 2010; Westmore, 2013). For economies far from the technology frontier, R&D is still necessary to facilitate the adoption of foreign technologies (Griffith et al., 2004).

Figure 1.3. Business R&D, patenting and MFP performance



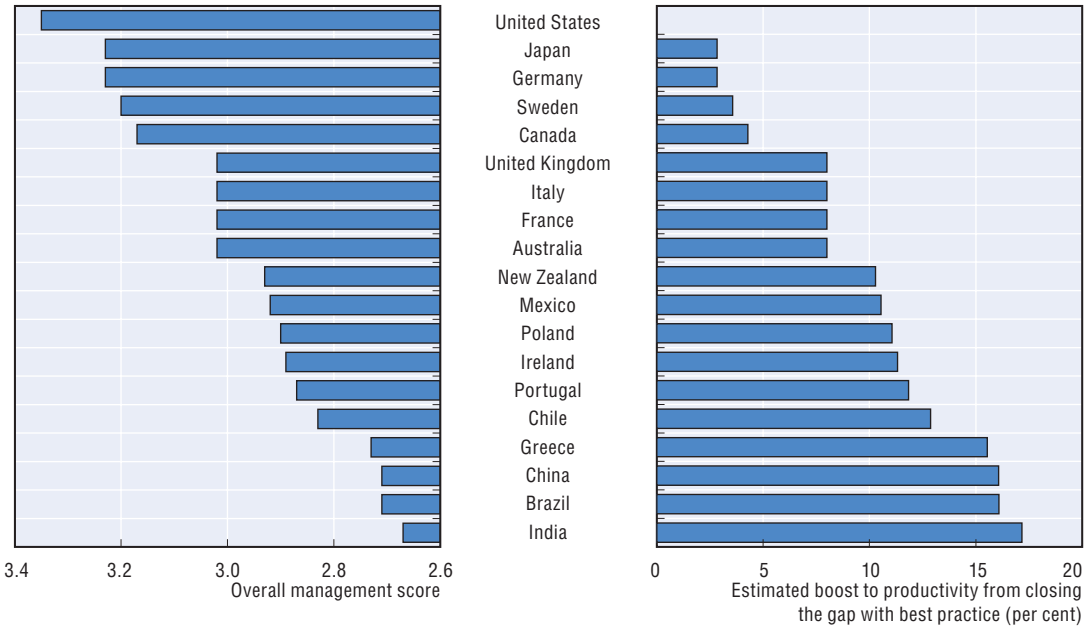
Notes: The patent measure is based on triadic patents, which refer to a series of patents for a single invention filed at the European Patent Office, the United States Patent and Trademark Office and the Japan Patent Office. The patents are a yearly average per million working age (15-64) members of the population. The value is an average per year for the 1990s and an average over the years with available data during the 2000s.

Source: OECD (2011a), *OECD Science, Technology and Industry Scoreboard 2011*, OECD Publishing, doi: http://dx.doi.org/10.1787/sti_scoreboard-2011-en; OECD Productivity Database; and OECD calculations, based on Johansson et al. (2013), "Long-Term Growth Scenarios", *OECD Economics Department Working Papers*, No. 1000, OECD Publishing, doi: http://dx.doi.org/10.1787/5k4ddxpr2fmr-en. See Westmore (2013) "R&D, Patenting and Growth: The Role of Public Policy", *OECD Economics Department Working Papers*, No. 1047, OECD Publishing, doi: http://dx.doi.org/10.1787/5k46h2rfb4f3-en for more details.

At the same time, estimates of managerial quality, based on interviews of middle management from randomly drawn samples of firms, also vary widely across OECD countries (Figure 1.4) and recent research find that managerial quality has a causal effect on firm productivity (Bloom et al., 2013a). For example, raising managerial quality from the median level (roughly corresponding to New Zealand in Figure 1.4) to the level in the United States could increase the average level of productivity in manufacturing by as much as 10% (Bloom et al., 2012a).

Figure 1.4. Managerial quality differs across countries with important implications for productivity

Average management quality score in the manufacturing sector; selected countries

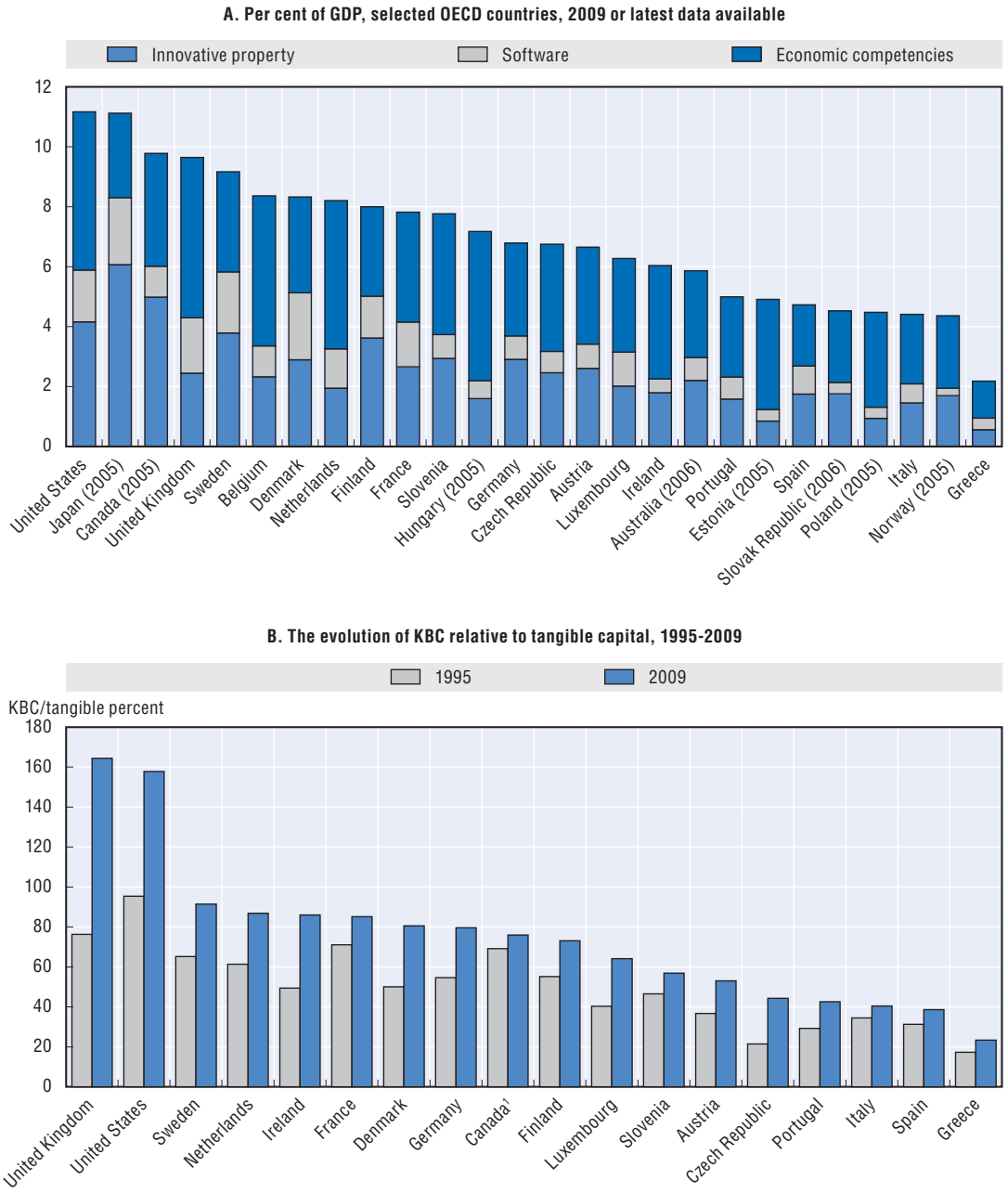


Notes: The overall management score is an average of responses to 18 survey questions that are designed to reveal the extent to which firms: i) monitor what goes on inside the firm and use this information for continuous improvement; ii) set targets and track outcomes; and iii) effectively utilise incentive structures (e.g. promote and reward employees based on performance). The estimates in the right panel are calculated from the difference in management score between each country and the United States and the estimated coefficient on the management score term in a firm-level regression of sales on management scores, capital and employment. The sample is based on medium-sized firms, ranging from 50 to 10 000 employees.

Source: OECD calculations based on the management scores and estimated coefficients in Bloom et al. (2012a), "Management Practices Across Firms and Countries", *NBER Working Paper*, No. 17850.

These cross-country differences in R&D, patents and managerial quality are reflected in broader estimates of KBC, which also include computerised information, creative property, design, brand equity and firm-specific human capital (Figure 1.5).[13] For example, English-speaking countries (particularly the United States), Japan and Sweden invest relatively heavily in KBC; this translates into a relatively larger contribution of intangible capital deepening to labour productivity growth (Figure 1.6). By contrast, the resources devoted to KBC and their contribution to productivity growth tend to be smaller in some continental and southern European economies (van Ark et al., 2008).

Figure 1.5. Investment in KBC varies significantly across countries



Notes: The estimates refer to the market sector and include each of the types of KBC listed in Table 1.1 and mineral exploration.
* Data for Canada in Panel B refer to 1998 and 2005.

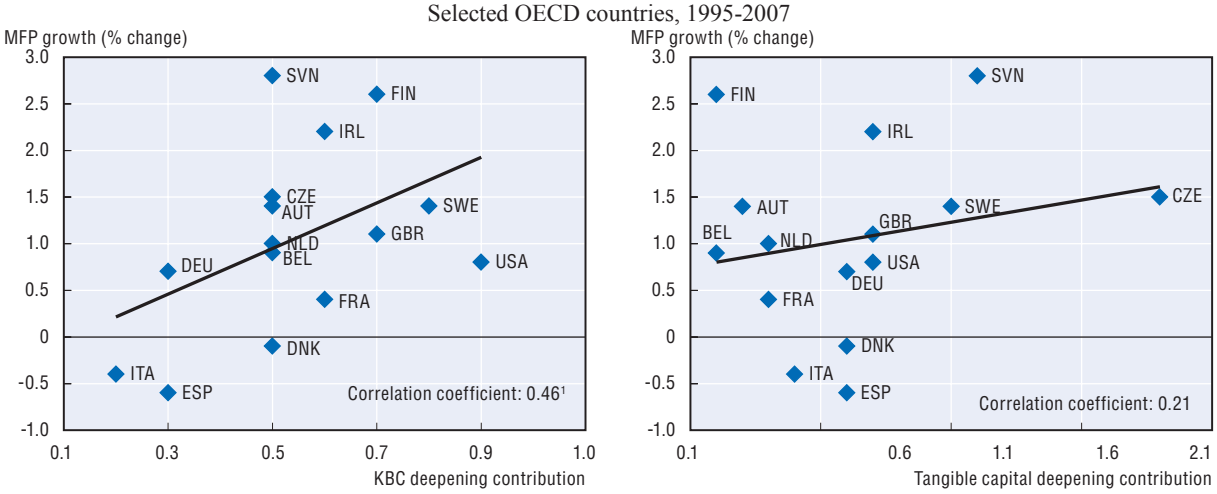
Source: Corrado et al. (2012), "Intangible Capital and Growth in Advanced Economies: Measurement Methods and Comparative Results", mimeo, INTAN-Invest.

Beyond their direct effect on capital accumulation, these cross-country differences matter because KBC is often only partially excludable so that privately created knowledge diffuses beyond its place of creation and creates wider benefits. While it is difficult to estimate knowledge spillovers, empirical studies that focus on R&D have generally found these effects to be relatively large (Hall et al., 2010; Australian

Productivity Commission, 2007). Furthermore, the positive association between the contribution of capital deepening and MFP growth is clearer for KBC than for tangible capital, which provides suggestive – albeit crude – evidence of such spillover effects (Figure 1.6).

Figure 1.6. Knowledge-based capital and spillover effects

Selected OECD countries, 1995-2007



Note: Labour productivity growth can be broken down into the contribution of capital deepening and the contribution of MFP. The chart plots the contribution of KBC/tangible capital deepening to labour productivity growth against the growth rate of MFP. The correlations are robust to individually dropping outliers, such as the Czech Republic, Finland and Slovenia. Unlike conventional growth accounting exercises (e.g. Figure 1.2), the MFP estimates are based on a value-added series that capitalises the full set of KBC indicators outlined in Table 1.1.

* denotes statistical significance at the 10% level.

Source: Corrado et al. (2012), "Intangible Capital and Growth in Advanced Economies: Measurement Methods and Comparative Results", mimeo, INTAN-Invest.

There are also important complementarities between organisational capital and investment in ICT capital. They are particularly significant because cross-country differences in aggregate growth in OECD countries depend to a considerable extent on the performance of key ICT-intensive sectors (van Ark et al., 2008). To extract the maximum benefit from ICT, firms typically need to adopt ICT as part of a "system" of mutually reinforcing organisational changes (Brynjolfsson et al., 1997), which will be easier to accommodate in firms with better organisational capital. In fact, Bloom et al. (2012b) attributed at least one half of the US-"Europe"[14] difference in labour productivity growth between 1995 and 2004 to superior management practices, which significantly raised the productivity of ICT capital in the United States. The findings are confirmed by a study of firm-level MFP growth for a broader sample of OECD countries (Andrews, 2013; see Annex 1.A1). For example, in sectors that use ICT intensively, increases in organisational capital intensity are associated with swifter firm MFP growth than in other sectors.

From macro to micro: KBC, innovation and resource allocation

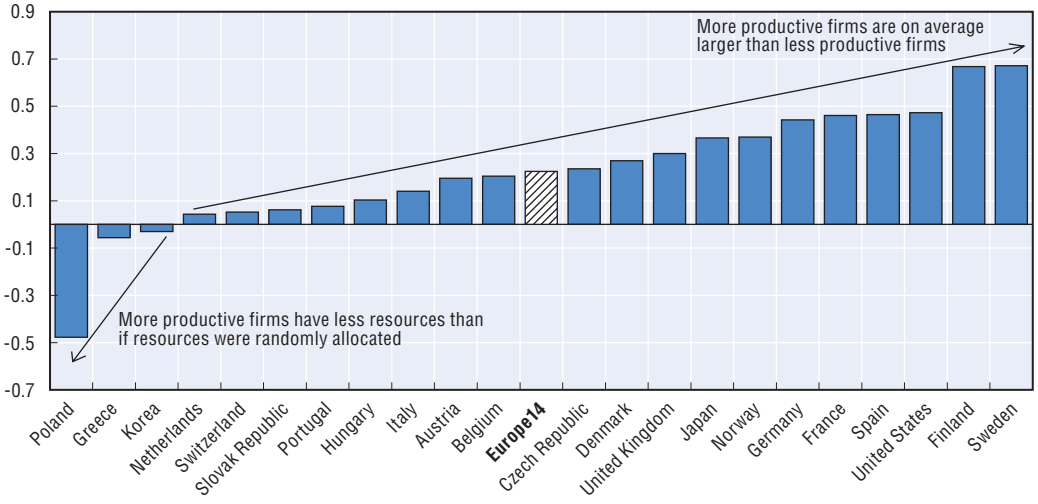
Differences in resource allocation are correlated with KBC use

Cross-country differences in KBC deepening at the aggregate level tend to coincide with diverging patterns of firm performance within countries, which reflect the scope and ease of reallocation and the prevalence of certain innovation strategies. Empirical evidence

suggests that some countries are more successful than others in channelling resources towards innovative and high-productivity firms. One consequence of this is that, other things being equal, the extent to which the most productive firms have the largest market shares – a metric that has been taken to represent the degree of allocative efficiency in an economy (Olley and Pakes, 1996) – also tends to vary across countries. For instance, new OECD estimates suggest that more productive firms are likely to account for a much larger share of manufacturing employment in the United States and some Nordic countries than in some continental European countries (Figure 1.7). Moreover, an emerging literature links these sizeable differences in allocative efficiency across countries to policy distortions, with important consequences for aggregate performance. For example, estimates suggest that if China and India aligned the efficiency of their resource allocation to that of the United States, manufacturing total factor productivity (TFP) could rise by 30-50% in China and 40-60% in India (Hsieh and Klenow, 2009).

Figure 1.7. OECD countries differ in their ability to allocate labour to the most productive firms

Covariance across firms between firm size and labour productivity; log points, selected OECD countries, 2005



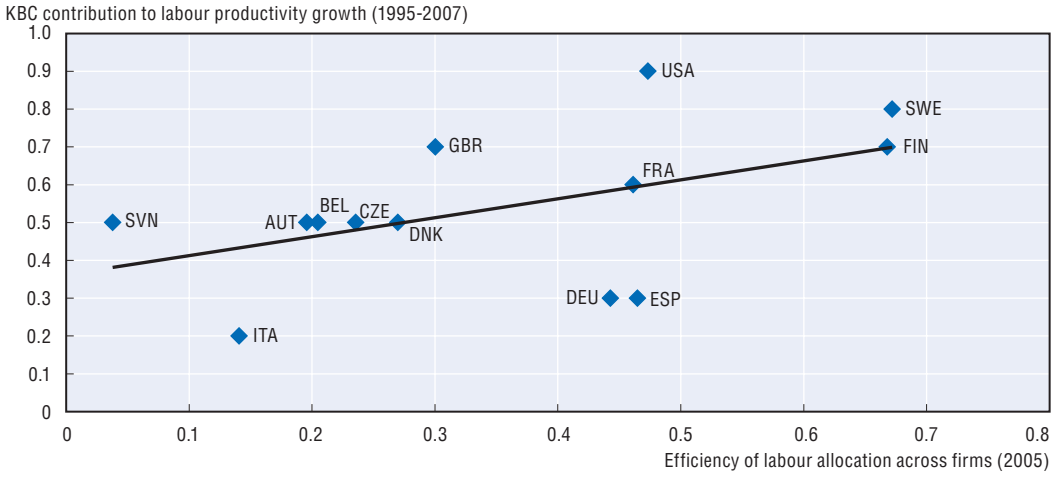
Notes: the estimates show the extent to which the firms with higher than average labour productivity have larger employment shares. In most countries, the covariance between productivity and employment share is positive, suggesting that the actual allocation of employment boosts manufacturing labour productivity, compared to a situation in which resources are allocated randomly across firms (this metric would equal zero if labour was allocated randomly). For example, manufacturing labour productivity in the United States is boosted by around 50% due to the rational allocation of resources. Europe-14 includes: Austria, Belgium, Czech Republic, France, Greece, Germany, Hungary, Italy, Netherlands, Portugal, Poland, Spain, Slovak Republic and Switzerland. The result is obtained by aggregating the respective allocative efficiency indicators by each countries share in manufacturing sector employment.

Source: Andrews and Cingano (2012), "Public Policy and Resource Allocation: Evidence from Firms in OECD Countries", *OECD Economics Department Working Papers*, No. 996, OECD Publishing, doi: http://dx.doi.org/10.1787/5k9158wpf727-en.

Countries that are more successful at channelling resources to the most productive firms also tend to invest more in KBC. As argued above, incentives to invest in KBC partly depend on perceptions about the ease with which labour and capital will flow to successful firms (can be reallocated from less productive to more productive firms) and ultimately result in a more efficient allocation of resources in an economy. Figure 1.8 provides *prima facie* evidence of a positive correlation between investment in KBC and the efficiency of allocation, based on the indicator introduced in Figure 1.7.[15] This evidence is confirmed by more formal empirical analysis, described below.

Figure 1.8. Knowledge-based capital deepening and efficiency of resource allocation

Selected OECD countries



Source: Details on the intangible capital and resource allocation estimates are contained in Figures 1.6 and 1.7, respectively.

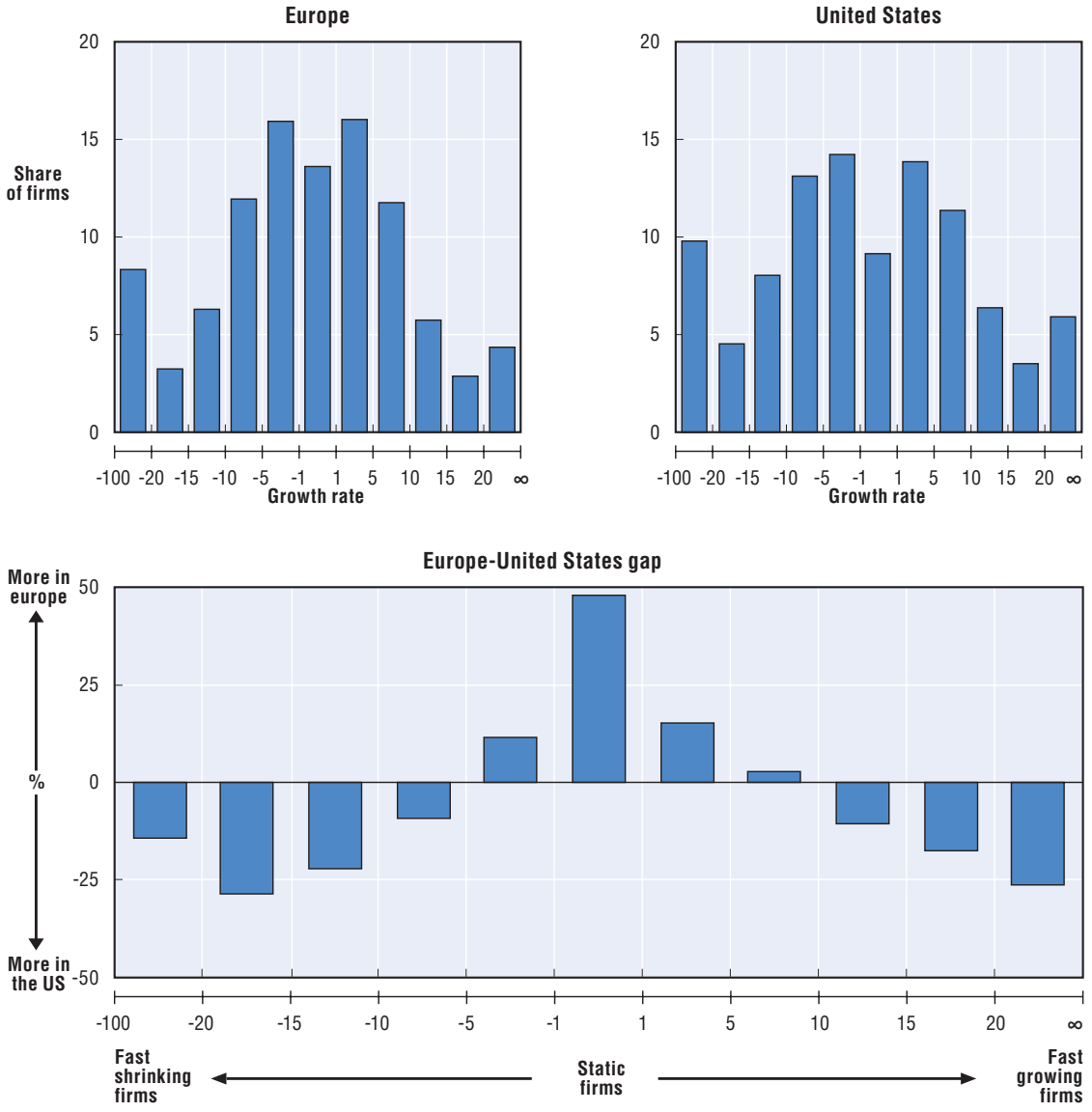
The extent to which innovative firms attract resources differs across countries

Cross-country differences in the post-entry performance of firms tend to be more marked than differences in entry and exit patterns (Bartelsman et al., 2003). In fact, there are large differences in the extent to which young firms grow over their life cycle (Hsieh and Klenow, 2012). For example, from birth to 35 years, employment in the typical (surviving) manufacturing plant increases by a factor of ten in the United States, of two in Mexico and actually declines in India, while productivity increases by a factor of eight in the United States, but only of two in India and Mexico. One interpretation of these findings is that firms with the potential to become larger are likely to face higher marginal input costs in some countries than others. This could occur if public policies are size-contingent or financial market frictions prevent efficient capital reallocation. Another interpretation is that a lack of market integration lowers the returns to innovation (Hsieh and Klenow, 2012).

Firm-level empirical studies also reveal important differences among higher-income countries. Entering and exiting firms tend to be smaller in the United States than in Europe and successful young firms tend to expand relatively more quickly in the United States than elsewhere (Bartelsman et al., 2012). This is consistent with the more dynamic distribution of firm growth in the United States, where successful firms grow faster and unsuccessful firms shrink faster than in Europe (Figure 1.9). Firm productivity within industries also tends to be more dispersed in the United States than in Europe (Bartelsman et al., 2004), though recent evidence points to important differences in productivity dispersion in Europe (Altomonte, 2010). These differences may be due to greater experimentation and "learning by doing" in the United States, given that the largest differences are in high-technology and emerging sectors where experimentation and intensive use of KBC are likely to be strong (Bartelsman et al., 2008). This suggests that institutional differences, which shape differences in the cost of reallocating resources, may explain why some European countries have been relatively slow to capitalise on the ICT revolution (Bartelsman et al., 2010; Conway et al., 2006), and enjoy the growth potential of KBC.[16]

Figure 1.9. The distribution of firm employment growth

United States and selected European countries; 2002-05

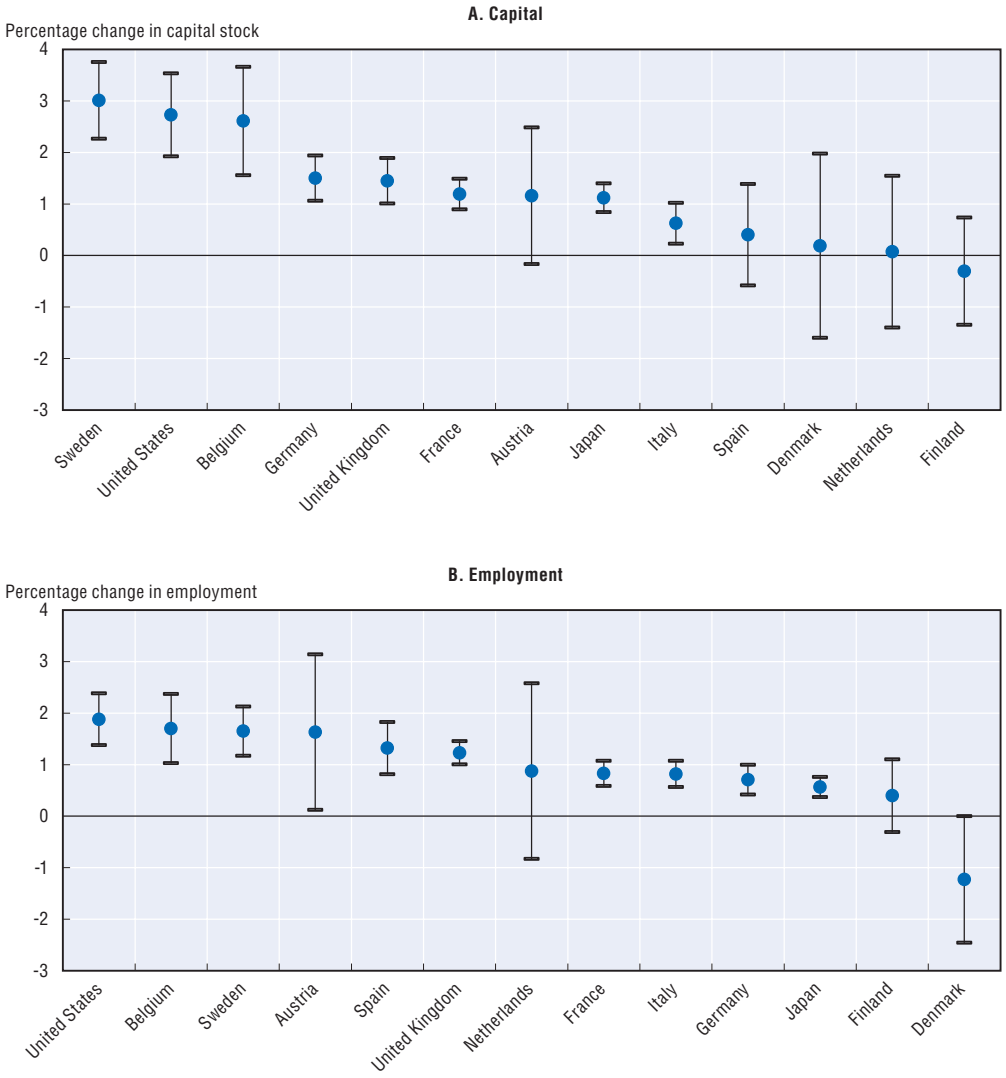


Notes: The figure compares the distribution of firm employment growth between the United States and the average of Austria, Denmark, Spain, Finland, Italy, Netherlands and Norway (countries for which data were available). The European countries in the sample have a larger share of static firms (growing between -5% and 5% a year) than the United States where more firms grow more than 5% or shrink more than 5% a year. The bottom panel shows the Europe-US differential in percentage terms. For example, the share of firms with employment growth above 20% is 5.9% in the United States and 4.3% in Europe, which translates into a differential of around -26%.

Source: Bravo-Biosca (2010), "Growth Dynamics: Exploring Business Growth and Contraction in Europe and the US", research report, NESTA and FORA, London, based on national business register data.

Figure 1.10. Do resources flow to more innovative firms?

Additional inputs attracted by a firm that increases its patent stock by 10%, selected OECD countries, 2002-10



Note: The black dot shows the country-specific point estimate and the grey bands denote the 90% confidence interval (the confidence interval varies across countries owing to differences in the number of observations). These estimates are obtained from the following baseline fixed effects regression specification:

$$\ln Y_{i,s,c,t} = \beta_1 \ln(PatS_{i,s,c,t}) + \eta_i + \mu_{s,c,t} + \varepsilon_{i,s,c,t}$$

where Y is the economic characteristic (employment or capital) for firm i, in sector s, in country c at time t and $PatS$ is the depreciated patent stock of firm i. The specification also includes firm fixed effects and industry*country*year fixed effects. To obtain the country-specific estimate, $PatS$ is interacted with various dummy variables for each country.

Source: OECD calculations based on firm-level data from the ORBIS-Patstat Database for the non-farm business sector. See Andrews et al. (2013), "Do Resources Flow to Innovative Firms? Cross-Country Evidence from Firm-Level Data" *OECD Economics Department Working Papers*, forthcoming, OECD, Paris.

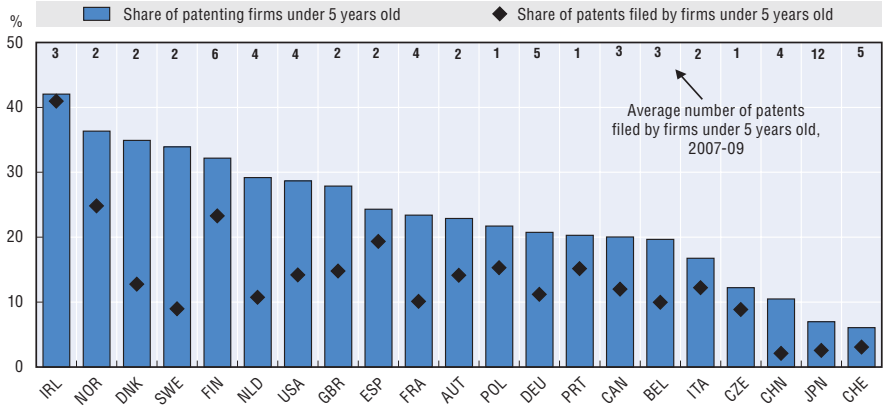
To implement and commercialise new ideas, firms require a range of complementary tangible resources to test ideas (e.g. to develop prototypes and business models), develop marketing strategies and eventually produce on a commercially viable scale (Figure 1.10). New OECD evidence (Andrews et al., 2013) uses longitudinal data to explore what happens to important economic variables when firms patent (see Box 1.2 for details). It

reveals important differences among countries in the extent to which capital and labour flow to innovative firms. For example, a 10% increase in the patent stock is associated with an increase in the typical firm's capital stock of about 3% in Sweden and the United States; 1.5% in the United Kingdom and Germany; and a 0.5% in Italy and Spain (Figure 1.10, Panel A). Similarly, patenting firms in the United States can attract labour roughly twice as easily as in the average OECD country (Figure 1.10, Panel B).[17]

Cross-country differences tend to be driven by younger firms. The sensitivity of capital to patenting is about five times greater in the United States than in Italy for young firms but only about double for older firms. Caution should be used when drawing conclusions from these differences owing to the limitations of the data. However, their significance is enhanced by the differences across countries in patenting by young firms (Figure 1.11), which are also more much more likely to file a radical patent than older firms (Andrews et al., 2013). Moreover, the resource flows associated with radical patents are around two times larger in Sweden and the United Kingdom than in Italy. One interpretation of these findings is that firms in countries in which reallocation costs are lower may be more willing to experiment with disruptive technologies than in those in which they are higher.

Figure 1.11. Patenting activity by young firms

Selected OECD countries, 2007-09



Note: Refers to patents filed at the European Patent Office and United States Patent and Trademark Office.

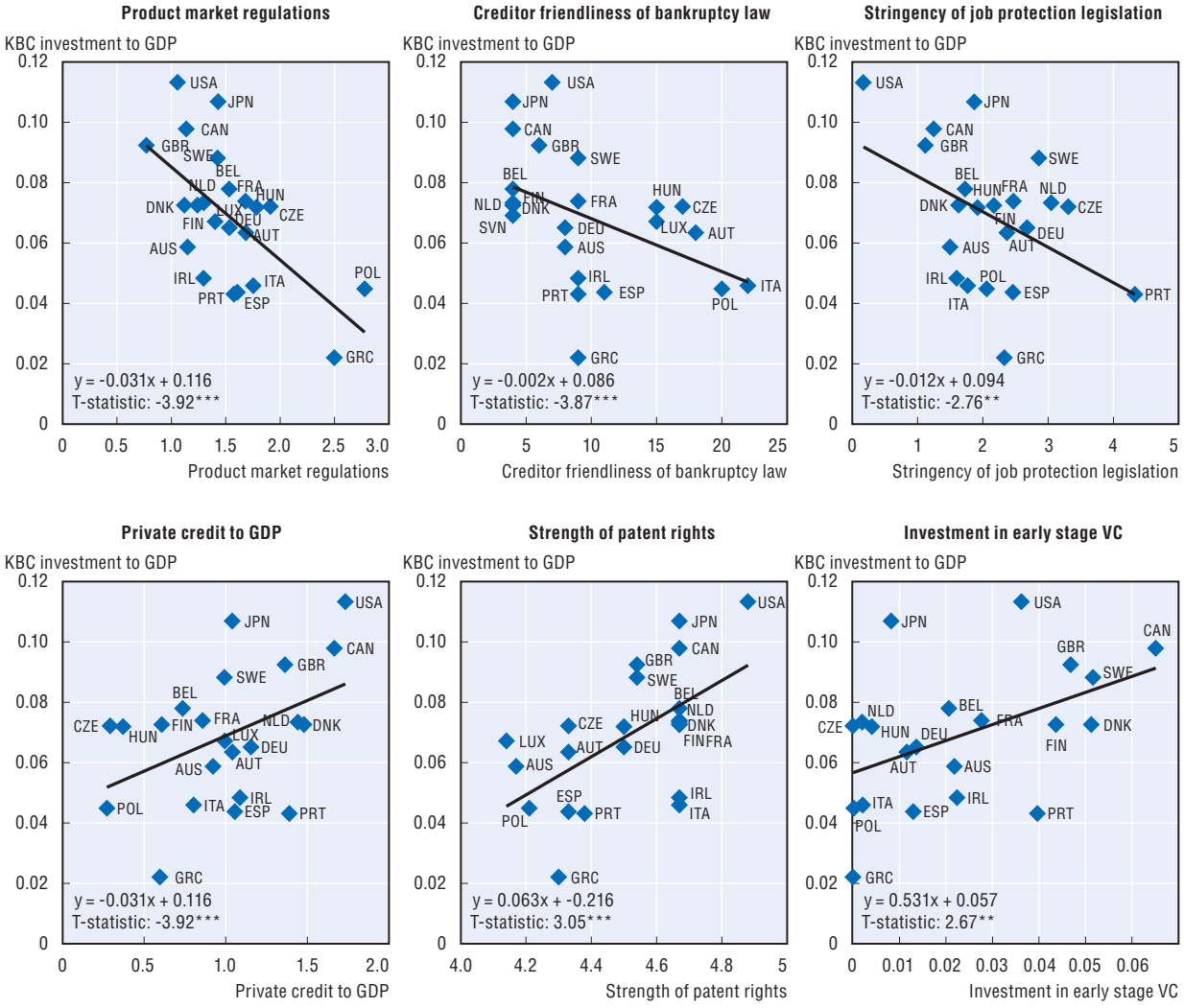
Source: OECD (2011a), *OECD Science, Technology and Industry Scoreboard 2011*, OECD Publishing, doi: http://dx.doi.org/10.1787/sti_scoreboard-2011-en.

The role of public policy

While a wide range of policy instruments may affect the KBC-innovation-reallocation nexus, this section focuses on a key subset of policies affecting the business environment and innovation using the framework developed above. For each policy considered, it examines the direct and indirect impact on the three building blocks: developing and adopting new ideas; implementing and commercialising new ideas; and reaping the benefits of new ideas through changes in market share and profitability. For illustrative purposes, Figure 1.12 shows some preliminary evidence on the links between selected public policies and investment in KBC from a recent study by Corrado et al. (2012). While the correlations are only suggestive (and subject to reverse causality), countries with less stringent regulations in product and labour markets and deeper financial markets tend to have higher rates of investment in KBC, while investment in KBC is positively correlated with debtor-friendly bankruptcy codes and higher seed and early-stage venture capital.

Figure 1.12. Investment in KBC and selected public policies

Share of GDP, selected OECD countries, 2005



Note: Intangible investment to GDP is measured in 2005, while the policy indicators refer to either 2003 (product market regulation [PMR], employment protection legislation [EPL], Bankruptcy Law and Private Credit to GDP) or 2005 (Patent rights and early stage venture capital [VC]).

Source: OECD calculations based on intangible capital estimates from Corrado et al. (2012), "Intangible Capital and Growth in Advanced Economies: Measurement Methods and Comparative Results", mimeo, INTAN-Invest; and policy indicators from: OECD (PMR, EPL and Early Stage VC); World Bank (Bankruptcy Law and Private Credit to GDP); and Park (2008; patent rights).

This section explores in greater depth the links between policies, investment in KBC (including innovation) and the underlying reallocation of resources using the empirical approaches described in Box 1.2. Given that the measures of KBC in Figure 1.12 are only available on a consistent basis for a limited set of countries and time periods, the policy analysis is based on partial measures of KBC – such as R&D and patents – and on MFP for which internationally comparable data are more readily available at the firm, sectoral and aggregate levels.[18]

Box 1.2. Empirical approaches

The empirical research on which this chapter is based exploits country-, sector- and firm-level data to explore how policies affect reallocation and innovation outcomes. While studies based on aggregate and sectoral data use OECD data, micro-aggregated analyses use country-specific business registers, and firm-level analyses uses commercial databases (e.g. ORBIS, ThomsonONE) matched with administrative patent data. These data have been harmonised to improve cross-country comparability (see Gal, 2013, for details with respect to ORBIS).[1] Details on the country and time coverage for each study are contained in Table 1.2.

Aggregate level analysis

Westmore (2013) uses cross-country error-correction (ECM) panel estimation to explore the policy determinants of R&D expenditure and patenting, an approach similar to that of Jaumotte and Pain (2005b). The links between R&D and patents and total factor productivity are identified, as is the extent to which policies shape the returns to knowledge. Overall, this research provides evidence on the average impact of policies on innovation but not on the channels through which policies operate.

Sectoral level analysis

The impact of framework and innovation-specific policies on R&D expenditure at the industry level, by embedding a differences-in-differences estimation strategy in the ECM approach employed in Westmore (2013). While the results are generally inconclusive, an effect of labour market regulations on R&D expenditure was found. See Appendix 2 of Andrews and Criscuolo (2013) for details.

Using a neo-Schumpeterian growth framework in which a sector's MFP growth is determined by the sector's distance from the productivity frontier as well as the growth at the productivity frontier, Bas et al. (2013) find that tariffs on intermediate inputs in upstream sectors affect productivity growth in downstream manufacturing industries. They also explore whether the estimated effects vary with a sector's distance to the productivity frontier and the technological content of the intermediate inputs.

Micro-aggregated and firm level analysis

Bravo-Biosca et al. (2013) use administrative firm-level data from national business registers to explore how public policies shape the distribution of firm growth. For each country-industry, indicators that depict the distribution of employment growth (e.g. the share of high growth, growing, static and shrinking firms) are related to country-level policies using a differences-in-differences estimator.

Andrews and Cingano (2012) use ORBIS data to construct an index of allocative efficiency at the sectoral level, which measures the extent to which firms with higher levels of labour productivity in an industry also have higher market (employment) shares (see Figure 1.11 for an example). In turn, these indicators are related to country-level policies in a differences-in-differences econometric framework and to sectoral policies in a narrower sample of services sectors.

Andrews (2013) explores the extent to which framework policies and innovation-specific policies affect MFP growth at the firm level, using a neo-Schumpeterian growth framework. The impact of country-level policies is identified using a differences-in-differences estimator, and the heterogeneous effects of policies are explored by allowing the impact of the policy to vary with a firm's distance to the productivity frontier. See Annex 1.A1 for details.

Using a fixed effects regression framework, Andrews et al. (2013) exploit firm-level panel data on key economic performance variables and patenting activity to explore the association of changes in the patent stock over time with flows of capital and labour to patenting firms (firms in ORBIS are matched to firms in PATSTAT). The role of policy in explaining the observed cross-country differences in the magnitude of these flows is explored by introducing interaction terms between the firm-level patent stock and framework policies. The paper also looks at differences in policy impacts according to the age of the firm.

Criscuolo and Menon (2013) explore the drivers and the characteristics of risk finance in the Cleantech sector, with a focus on the role of supply-side, demand-side and fiscal environmental policies. They use comprehensive commercial deal-level information on businesses seeking investment in this sector, matched with patent-level data and indicators of renewable policies and government R&D expenditures.

Da Rin et al. (2013) explore the contribution of supply-side policy initiatives to cross-country differences in the supply of seed and early-stage financing. They exploit information at the deal level from the ThomsonOne database and use a panel econometric specification to explore the correlation of policies with the volume of seed and early-stage financing and indicators of the structure of seed and early-stage financing (e.g. the age at which the firm receives financing). See Annex 1.A2 for details.

…/…

Box 1.2. Empirical approaches *(continued)*

Table 1.2. Country and period coverage in the empirical analysis

	Westmore (2013)	Bas et al., (2012)	Bas (2012)	Andrews & Cingano (2012)	Andrews (2013)	Andrews et al., (2013)	Bravo-Biosca et al., (2012)	Criscuolo & Menon (2013)	Da Rin, et al. (2013)
Australia	X	X	X					X	X
Austria	X	X	X	X	X	X	X	X	X
Belgium	X	X	X	X	X	X		X	X
Canada	X	X	X				X	X	X
Chile									X
Czech Republic		X		X	X	X		X	X
Denmark	X	X	X	X	X	X		X	X
Estonia									X
Finland	X	X	X	X	X	X	X	X	X
France	X	X	X	X	X	X		X	X
Germany	X	X	X	X	X	X		X	X
Greece			X	X	X	X			X
Hungary				X	X				X
Iceland			X						X
Ireland	X		X					X	X
Israel								X	X
Italy	X	X	X	X	X	X	X	X	X
Japan	X	X	X	X		X		X	X
Korea			X	X	X			X	X
Luxembourg									X
Mexico									X
Netherlands	X	X	X	X	X	X	X	X	X
New Zealand									X
Norway	X		X	X	X	X	X	X	X
Poland				X		X			X
Portugal	X			X	X	X			X
Slovak Republic				X	X	X			X
Slovenia									X
Spain	X	X	X	X	X	X	X	X	X
Sweden	X	X	X	X	X	X		X	X
Switzerland	X			X		X		X	X
Turkey									X
United Kingdom	X	X	X	X	X	X	X	X	X
United States	X	X	X	X	X	X	X	X	X
Number of countries	19	16	20	22	19	20	9	26	xx
Time period	1983-2008	1996-2007	1991-2009	2005	1999-2009	2002-2010	2002-2005	2005-2010	1995-2011

Note: Criscuolo and Menon (2013) also include Brazil, China, India, Hong Kong (China) and Singapore. Data for the United States are available for each exercise. However, when a differences-in-differences estimation framework is employed, the United States is excluded from the sample (except by Bravo-Biosca et al., 2013, who use an instrumental variable approach).

1. The empirical studies that use ORBIS data have benefited greatly from the efforts of Gal (2013), "Measuring Total Factor Productivity at the Firm Level using OECD-ORBIS", *OECD Economics Department Working Papers*, No. 1049, OECD Publishing, doi: http://dx.doi.org/10.1787/5k46dsb25ls6-en.

Framework policies have pervasive impacts on the KBC-innovation-reallocation nexus

Product market regulations

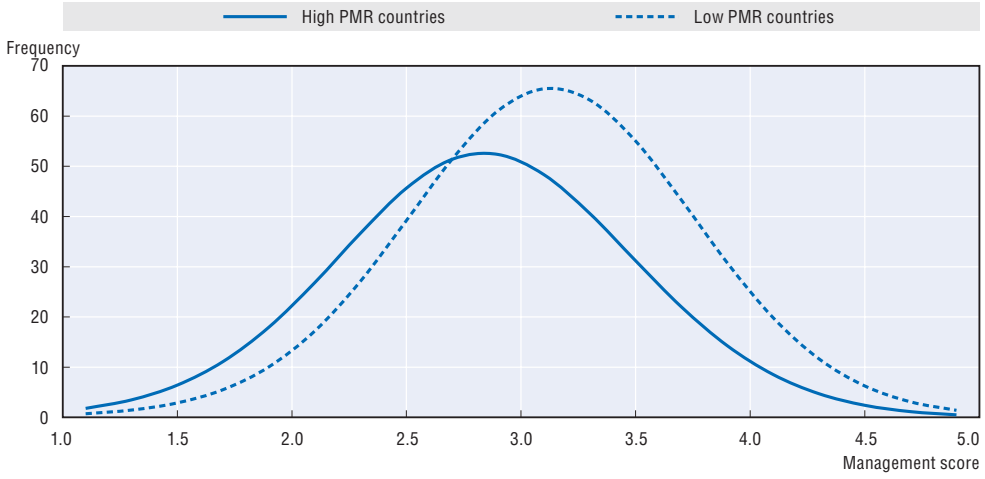
Product market regulations (PMR) have a pervasive impact at each stage of the innovation process, and empirical studies show a negative relationship between PMR and productivity at the aggregate level (Bouis et al., 2011) and at the firm and sectoral levels (Aghion et al., 2004; Bourlès et al., 2010) as well as an inverted U-shaped relationship between indicators of competition and innovation (Aghion et al., 2005).

PMR influence the formation of new ideas (Figure 1.1, stage 1) through their effects on innovative effort. Lower entry regulations increase the supply of new ideas by raising firm entry rates (Fisman and Sarria-Allende, 2010; Klapper et al., 2006; Ciccone and Papaioannou, 2007). This raises competitive pressure and increases pressure on incumbent firms to innovate. New OECD evidence shows that a modest reduction in PMR in the energy, transport and communications sectors – corresponding to the difference in regulation between Australia and Austria in 2008 – could result in a 5% increase in the stock of business enterprise R&D and a 3% rise in patents per capita in the long run (Westmore, 2013). This can be expected to raise annual MFP growth by around 0.1% but would take some time to materialise given the relatively sluggish adjustment of R&D to shocks. Similarly, the positive impact of knowledge spillovers from abroad on domestic patenting activity is significantly higher in countries in which barriers to entry for new firms are relatively low (Westmore, 2013). This suggests that reforms to PMR can raise incentives for firms to incorporate foreign technologies (Parente and Prescott, 2000; Holmes et al., 2008).

Product market reforms affect innovation and its implementation through improved managerial performance that enhances the ability of firms to undertake the internal reallocations required to implement new technologies and to sustain the innovation process. Pro-competition policies are likely to improve management performance by imposing greater market discipline, which truncates the tail of poorly managed (and unproductive) firms (Schmitz, 2005; Bloom and Van Reenen, 2010). The tail of poorly managed firms in countries with less stringent product market regulations, such as the United States, is smaller than in countries where product market regulations are generally more cumbersome (Figure 1.13).

Figure 1.13. Product market regulation and the distribution of managerial practices across firms

Increasing efficiency, manufacturing firms in selected countries, 2004-10

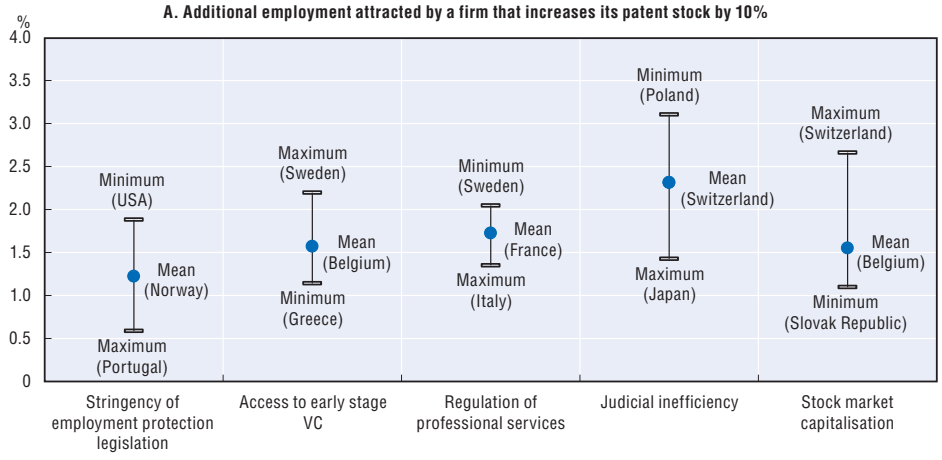


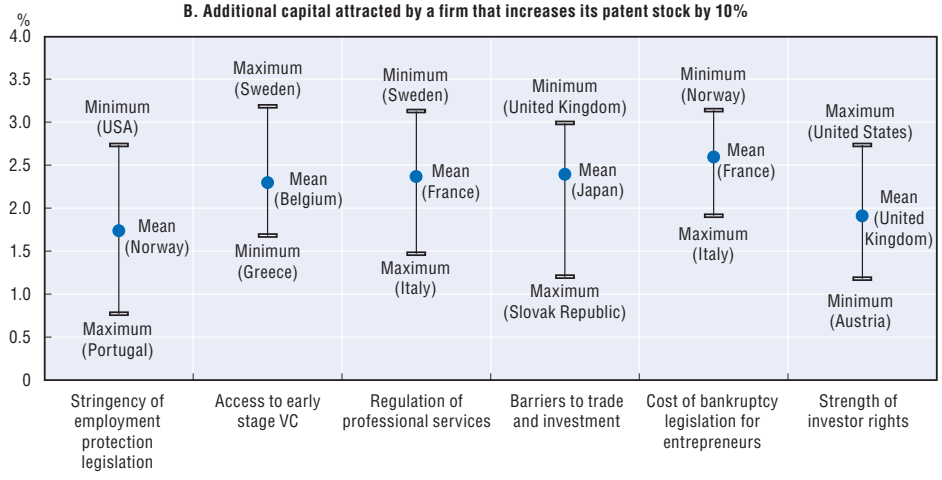
Notes: Countries are grouped according to their ranking in the overall OECD product market regulation index in 2008. Countries in the low PMR group include: Australia, Canada, Germany, Japan, New Zealand, Ireland, Sweden, United Kingdom and the United States. Countries in the high PMR group include: Brazil, Chile, China, France, Greece, India, Italy, Mexico, Poland and Portugal. Since the number of firms in the underlying dataset varies across countries, the management score distributions are scaled to a common number of firms in each country prior to aggregation. See Figure 1.4 for details on management score data.

Source: OECD calculations based on management score data from Bloom et al. (2012a), "Management Practices Across Firms and Countries", *NBER Working Paper*, No. 17850; and OECD PMR indicators.

Product market regulations also influence the ability of firms to attract the tangible resources they need to implement and commercialise new ideas (Figure 1.1, stage 2). Figure 1.14 shows how the estimated flow of resources to patenting firms (a concept first introduced in Figure 1.10) varies under different policy settings based on new OECD econometric modelling (Andrews et al., 2013). For example, a policy reform that would reduce the stringency of regulations affecting business services from the OECD average (i.e. France) to the low level in Sweden is associated with an increase in the size of innovative firms by 20% in terms of employment and 30% in terms of the capital stock.[19]

Figure 1.14. Framework policies and resource flows to patenting firms, 2002-10





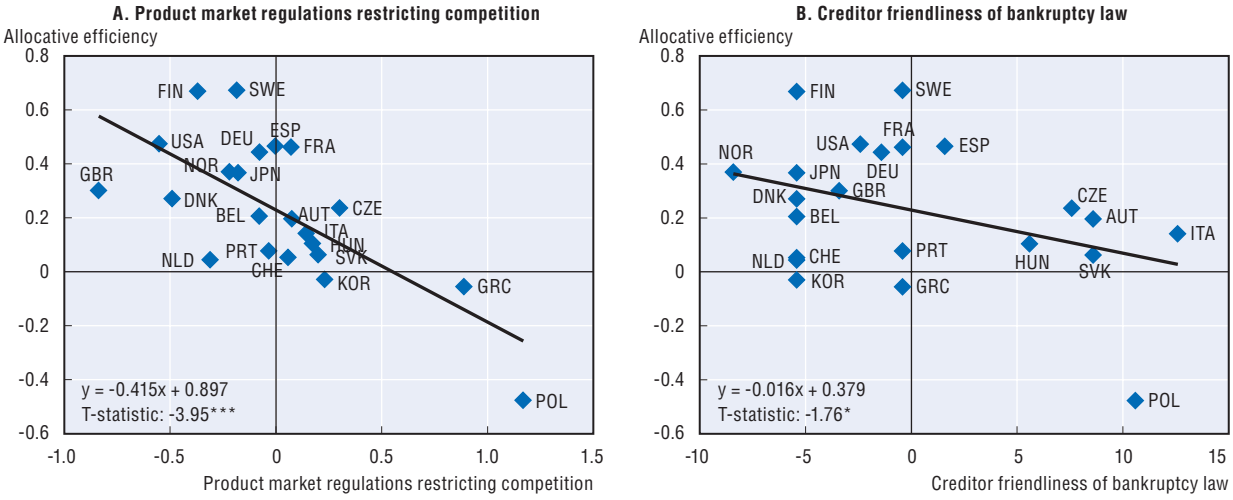
Note: The figure shows that the sensitivity of employment and capital to changes in the patent stock varies according to the policy and institutional environment. The estimates are obtained by including an interaction term between the patent stock (PatS) and policy variables in the baseline equation outlined in the notes to Figure 1.10. All policy terms are statistically significant at least at the 10% level. Panel A shows that the sensitivity of firm employment to patenting is three times larger when EPL is at the sample minimum (i.e. the United States), than when it is at the sample maximum (i.e. Portugal).

Source: OECD calculations based on matched ORBIS-PATSTAT data. See Andrews et al. (2013) for details. EPL is the OECD employment protection legislation sub-index of restrictions on dismissal of individual workers with regular contracts; regulation of professional services and barriers to trade and investment are sourced from the OECD PMR Index; stock market capitalisation is expressed as a percentage of GDP and is sourced from the World Bank along with judicial efficiency and strength of investor rights. Judicial efficiency refers to the cost of enforcing contracts, which measures the court costs and attorney fees as a percentage of debt value. Strength of investor rights takes into account the extent of corporate disclosure, directors' liability and ease with which shareholder can sue company officers. See Figure 1.12 for details on early-stage VC and bankruptcy legislation.

Product market regulations influence the ability of economies to capitalise on innovation via rapid changes in market shares of successful firms (Figure 1.1, stage 3). Across OECD countries, less stringent product market regulations tend to be associated with higher allocative efficiency in manufacturing sectors (Figure 1.15A), a relationship confirmed by econometric analysis (Andrews and Cingano, 2012). Inappropriate service regulations also have a sizeable negative effect on aggregate productivity, owing to the trickle-down effect of inefficiencies in resource allocation in the service sector. For example, a highly regulated country such as Spain would eventually experience a 4% increase in aggregate productivity if it reduced anti-competition barriers in the services sector to the level of Denmark. Reforms to regulation in the services sector tend to have stronger effects on resource allocation when labour and credit markets are more responsive. This indicates that the benefits of higher entry and competition are more fully realised when barriers that hinder the flow of labour and capital to their most productive use are also low (Andrews and Cingano, 2012).

Figure 1.15. Allocative efficiency and framework policies

Selected OECD countries, 2005



Note: Allocative efficiency measures the contribution of the allocation of employment across firms to manufacturing labour productivity in 2005 (see Figure 1.11). Product market regulation refers to the overall index of the OECD PMR for 2003. For details on the cost to close a business, see Figure 1.12.

Source: Andrews and Cingano (2012), "Public Policy and Resource Allocation: Evidence from Firms in OECD Countries", *OECD Economics Department Working Papers*, No. 996, OECD Publishing, doi: http://dx.doi.org/10.1787/5k9158wpf727-en.

Trade and investment restrictions

The liberalisation of barriers to international trade and investment stimulates aggregate productivity (Bouis et al., 2011) by raising the scope for knowledge diffusion and technological transfer across borders (Coe and Helpman, 1995), by encouraging more efficient resource allocation (Caves, 1985) and by expanding market size, which raises the returns to innovation, as discussed above.

With respect to the formation of new ideas (Figure 1.1, stage 1), recent evidence from a sample of European firms shows that the removal of product-specific quotas (on Chinese imports into Europe) following China's accession to the WTO triggered a significant increase in R&D, patenting and productivity (Bloom et al., 2011). Domestic

innovation is also driven by knowledge spillovers from abroad, which depend on the extent of openness to trade and absorptive capacity. For example, an increase in exposure to trading partners' R&D stocks – which measures how intensively a country trades with countries that do R&D – from the average level in Spain (around the OECD average in 2005) to the higher level in Canada (corresponding to the 75th percentile across countries) is estimated to boost patents per capita by around 20% in the long run (Westmore, 2013).

Trade liberalisation is also likely to increase the scope for technology transfer and the potential for adoption of frontier technologies. As such knowledge spillovers are partly embodied in imported intermediate goods, reductions in tariffs on intermediate inputs are associated with a (statistically and economically) significant increase in productivity growth in downstream manufacturing sectors (Bas et al., 2013). Moreover, to the extent that the benefits of foreign knowledge diffuse through the direct transmission of ideas rather than through trade in goods and services that embody them, barriers to foreign direct investment hinder knowledge adoption and growth.

For the subsequent stages of the innovation process in Figure 1.1, reductions in barriers to trade and investment increase the ability of patenting firms to attract the capital needed to implement and commercialise new ideas (Figure 1.14, Panel B). Moreover, reforms to trade and investment policy improve the ability of national economies to leverage the benefits of innovation at the firm level through increases in the market share of successful firms. Across the services sector in OECD countries, higher restrictions on FDI are associated with lower allocative efficiency (Andrews and Cingano, 2012). These findings imply that lowering FDI restrictions from the relatively high levels of Poland to the levels of Germany could lead to a rise in aggregate productivity of around 2%.

Job protection legislation

By raising labour adjustment costs, stringent employment protection legislation slows the reallocation process (Haltiwanger et al., 2006) and aggregate productivity growth (Bassanini et al., 2009; Autor et al., 2007).[20] At the same time, EPL has important effects on the nature of innovation. For example, by raising exit costs, stringent EPL makes experimentation with uncertain growth opportunities – which is essential for promoting investment in KBC – less attractive. From this perspective, strict EPL curbs incentives to develop new ideas through its negative effects at the later stages of the innovation process (Figure 1.1).

New OECD evidence shows that more stringent EPL lowers productivity growth by handicapping firms that operate in environments subject to frequent technological change and place high value on flexibility in order to experiment with uncertain technologies. As Figure 1.14 shows, stringent EPL significantly reduces the ability of innovative firms to attract the tangible resources they need to implement and commercialise new ideas (Figure 1.1, stage 2). Moreover, the burden falls disproportionately on young firms. This reinforces the idea that stringent EPL reduces the scope for experimentation with radical innovation.

These findings are in line with firm-level evidence that more stringent EPL is associated with lower MFP growth in ICT-intensive sectors in which experimentation is common, particularly in firms close to the technology frontier (Andrews, 2013; see Annex 1.A1). In fact, countries with stringent EPL tend to have smaller high-risk innovative sectors associated with intensive use of ICT (Bartelsman et al., 2010). MNEs tend to concentrate more technologically advanced innovation in countries with low EPL that accommodate disruptive shifts in resources more readily (Griffith and Macartney, 2010). More stringent EPL also disproportionately reduces R&D expenditure, one

indicator of the investment in the formation of new ideas (stage 1), in sectors with higher rates of patenting intensity and particularly in more turbulent sectors where reallocation needs are likely to be more intense (see Appendix 2 of Andrews and Criscuolo, 2013).

EPL also affects the ability of national economies to gain from successful innovations through increases in the market share of innovating firms (Figure 1.1, stage 3). For example, in sectors with naturally higher reallocation needs, as measured by job layoffs, firm turnover and ICT intensity (e.g. electrical and optical equipment), less stringent EPL disproportionately raises allocative efficiency (Andrews and Cingano, 2012) relative to other sectors. Similarly, in more R&D-intensive industries, less stringent EPL raises productivity growth because it is associated with a more dynamic firm growth distribution, that is, a lower share of static firms and higher share of growing and shrinking firms (Bravo-Biosca et al., 2013; Figure 1.16).

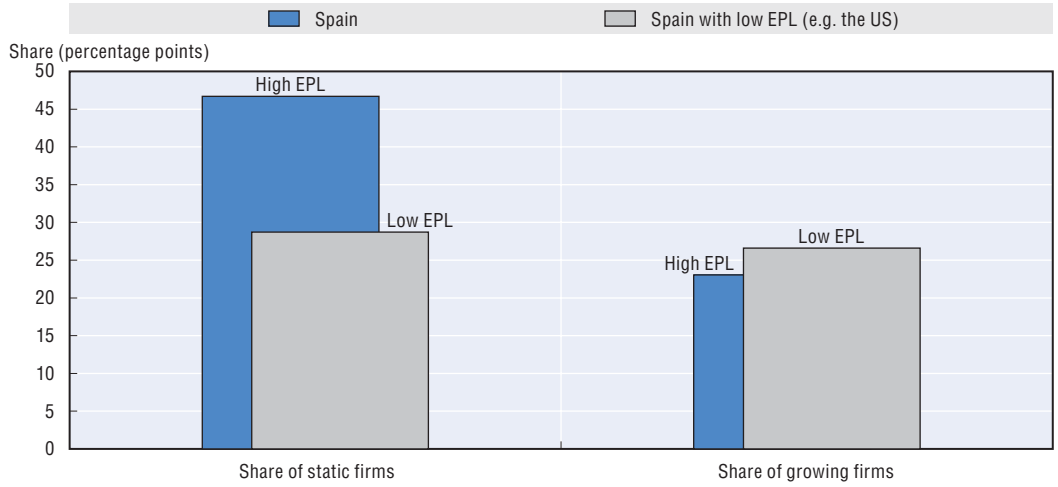
In Europe, stringent EPL also stunts the development of venture capital (VC) financing in highly volatile sectors (Bozkaya and Kerr, 2013). This is because strict EPL hinders the overall development of the high-growth sectors in which VC specialises and weakens the core VC business model, which relies on the aggressive reallocation of resources across the investment portfolio from failing to high-performing ventures. However, there is no such trade-off between VC and social protection in countries that rely more on labour market expenditures (e.g. unemployment insurance benefits) than on EPL to protect workers against labour market risk. This is because the costs of the higher general taxation required to finance labour market expenditures are not concentrated on a single margin of adjustment (like EPL), but are shared throughout the economy. Thus, well-designed social safety nets and the portability of health and pension benefits can help workers displaced by reallocation without imposing significant costs in terms of resource flexibility and innovation.

While stringent EPL is undesirable from the perspective of promoting experimentation and thus investment in KBC, employment protection may also raise worker's commitment and firm's incentives to invest in firm-specific human capital and potentially raise within–firm productivity (Autor, 2003; Wasmer, 2006). While empirical evidence for this hypothesis is scarce (see below), it nonetheless suggests that labour market reforms should be designed and implemented in a broad-based fashion. Indeed, the asymmetric liberalisation of employment protection for temporary contracts while leaving in place stringent regulations on permanent contracts – which took place in many European countries – may have adverse effects on the accumulation of firm specific human capital, to the extent that firms substitute temporary for regular workers and temporary workers are less likely to participate in job-related training (see Martin and Scarpetta, 2012).

Empirical evidence for the hypothesis that stringent EPL might be beneficial to innovation and within–firm productivity via these channels is scarce. Acharya et al., (2010) find a positive relationship between EPL and patenting based on a sample of five countries and argue that strict EPL fosters innovation by making firms less likely to dismiss workers in the event of short-run project failures. New OECD research, however, does not confirm this relationship for a broader sample of countries (Westmore, 2013). Nevertheless, there is some evidence to support the idea that stringent EPL is less detrimental in industries characterised by cumulative innovation processes, where innovation-driven labour adjustments are more likely to be accommodated by upgrading the skills of existing employees than by worker turnover. For example, Andrews and Cingano (2012) find that while strict EPL has an adverse effect on resource allocation in turbulent innovative sectors, this is not the case in sectors characterised by cumulative patterns of innovation (such as the chemicals sectors).

Figure 1.16. More flexible EPL is associated with a more dynamic distribution of firm growth in R&D-intensive industries

The differential impact of EPL on the share of firms in each employment growth grouping



Note: The darker columns show the estimated shares of static and growing firms in an R&D-intensive industry (electrical and optical equipment; NACE Rev.1.1. 30-33) in a country with stringent EPL (e.g. Spain). The lighter columns show the estimated shares of static and growing firms in the electrical and optical equipment sector if Spain adopted more flexible EPL (e.g. corresponding to the policy setting in the United States). Higher EPL also has modest negative effects on the share of shrinking and high-growth firms but these effects are not shown. Therefore, the shares presented in the figure do not sum to 100.

Source: Bravo-Biosca et al. (2013), "What Drives the Dynamics of Business Growth?", *OECD Science, Technology and Industry Policy Papers*, No. 1, OECD Publishing. doi: http://dx.doi.org/10.1787/5k486qtttq46-en.

Bankruptcy legislation and judicial efficiency

Like stringent EPL, bankruptcy laws that impose excessively high exit costs in the event of business failure may make entrepreneurs less willing to experiment with risky technologies. At the same time, bankruptcy codes that provide no safeguards for creditors may reduce the supply of credit. Therefore, some balance is required.

Bankruptcy regimes that severely penalise failed entrepreneurs, whether by forcing liquidation more often or limiting entrepreneurs' ability to start new businesses in the future, are likely to reduce the willingness to take risks and thus the supply of new ideas (Peng et al., 2010; de Serres et al., 2006).[21] Similarly, studies that control for the possibility that economic outcomes influence bankruptcy regimes (i.e. reverse causality) find that more debtor-friendly bankruptcy codes are associated with greater intensity of patent creation, patent citations and faster growth in countries relatively more specialised in innovative industries (Acharya and Subramanian, 2009). More debtor-friendly bankruptcy codes are also associated with more rapid technological diffusion, which enables laggard countries to catch up to the technological frontier (Westmore, 2013).

The right balance between leniency and protection of creditors in bankruptcy legislation will also depend on specific features of entrepreneurs' activities. Bankruptcy legislation that does not excessively penalise failure – as measured by a lower cost to close a business – can promote the flow of capital to more innovative firms (Figure 1.14, Panel B; Andrews et al., 2013), by reducing entrepreneurs' expectations that they will be heavily penalised in case of failure. By contrast, if the cost of winding down a business is very high, risky entrepreneurial ventures may not be brought to the market to avoid

incurring high exit costs in case of failure. Indeed, bankruptcy codes that heavily penalise failure are negatively associated with MFP growth and the share of high-growth firms in capital-intensive industries (Bravo-Biosca et al., 2013). Finally, across OECD countries, less stringent bankruptcy legislation is associated to some extent with higher allocative efficiency (Figure 1.15, Panel B). This effect is particularly strong in sectors with naturally higher firm turnover rates where regulations affecting exit costs are most likely to bind (Andrews and Cingano, 2012).

Swift reallocation of resources from failed ventures will also be affected by the time required to complete legal procedures to wind up a business and by obstacles to the use of out-of-courts arrangements. In extreme cases, legal procedures may take years to complete, and would undermine effective reallocation and the accumulation of entrepreneurial capital.

Finally, well-designed legal systems can support efficient resource allocation (Haltiwanger, 2011) and raise returns to innovation (Nunn, 2007).[22] For example, in countries with more efficient judicial systems – proxied by a lower cost of enforcing contracts[23] – labour flows more readily to patenting firms (Figure 1.14, Panel A).[24]

Innovation-specific policies are important but generate trade-offs

Private investment may be at or above the socially desirable level for some types of KBC (e.g. branding), but government intervention is warranted to compensate for market failures in innovative efforts such as R&D. This section discusses a range of innovation policies and focuses on their effects on the formation of new ideas (Figure 1.1, stage 1), and the possible unintended consequences for the reallocation mechanisms that are central to the later stages. Key risks for innovation policies are that they might: i) support activities that would take place in the absence of support; ii) distort or reduce innovation effort; and iii) be prone to rent seeking. Such schemes should therefore aim to minimise wasteful expenditures (OECD, 2006). As robust evidence on the effectiveness and optimal design of innovation policies is scarce, more effective cost-benefit analyses of policies are required.

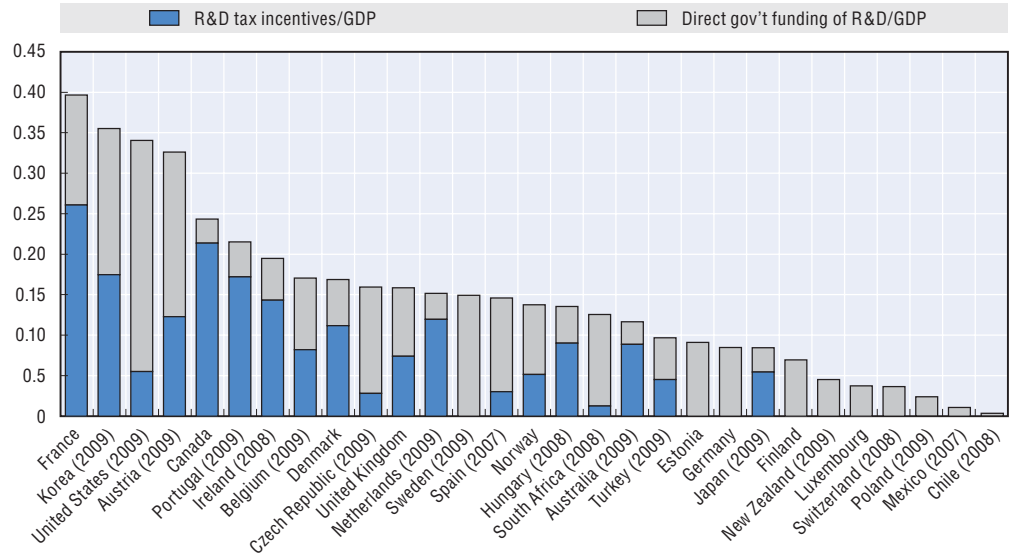
Fiscal incentives for R&D

R&D tax incentives, a non-discriminatory tool that aims to reduce firms' marginal cost of R&D activities, are provided in 27 of the 34 OECD member countries and in Brazil, China, India and the Russian Federation.[25] Support for business R&D through the tax system is typically combined with a broader set of direct support policies (e.g. grants, loans, loan guarantees) to address market failures related to investment in innovation. While there are significant cross-country differences in the policy mix (Figure 1.17), there has recently been a shift away from direct support (Figure 1.18) and towards more generous R&D tax incentives (OECD, 2009b).

These trends should be assessed in light of new evidence suggesting that while R&D tax incentives remain a useful policy instrument, direct support measures may be more effective in encouraging R&D than previously thought. It also appears that the features of both kinds of policies determine their cost to tax payers and their unintended consequences. It would seem, therefore, that issues related to the design of these schemes should take precedence over increases in their generosity.

Figure 1.17. Direct government funding of business R&D (BERD) and tax incentives for R&D

Budget impact as a percentage of GDP; 2010 or latest available year

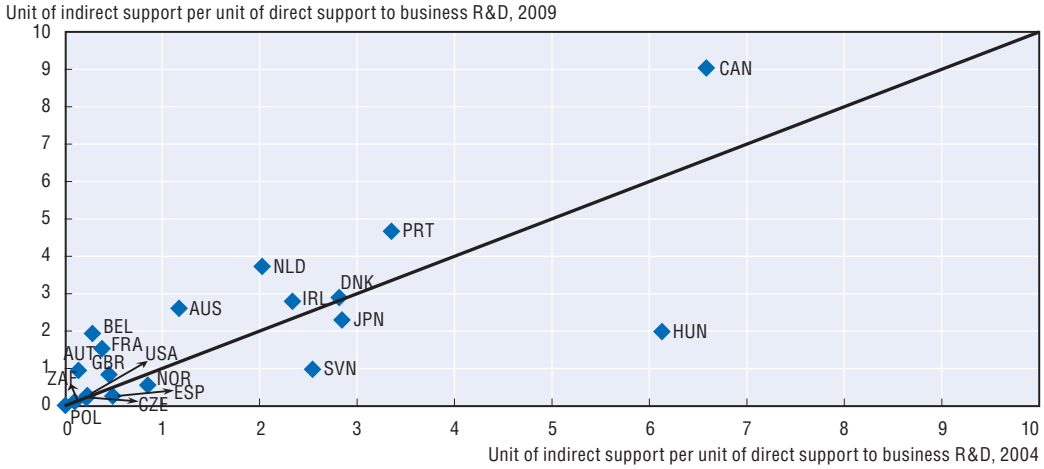


Notes: Countries ranked from highest to lowest R&D tax incentives/GDP. R&D tax incentives do not include sub-national incentives. Direct government funding includes grants and public procurement of R&D and excludes repayable loans. Figures are not shown for Greece, Israel, Italy, the Slovak Republic, China and the Russian Federation, which provide R&D tax incentives, but cost estimates are not available. For the United States, direct government funding of R&D includes defence spending on R&D by the government in the form of procurement contracts or the subcontracting by government agencies of non-classified projects to private firms. That is, it includes only R&D spending not directly performed by national or publicly funded institutions (e.g. military laboratories etc). If a project is conducted by the private firm in direct collaboration with the government, publicly funded institutions or universities, only the part that is done by the private firm and paid to her would be included.

Source: OECD, Main Science and Technology Indicators (MSTI) Database, June 2012; OECD R&D tax incentive questionnaires of January 2010 and July 2011; OECD (2011a), *OECD Science, Technology and Industry Scoreboard*, OECD publishing, Paris, doi: http://dx.doi.org/10.1787/sti_scoreboard-2011-en; and national sources.

Figure 1.18. R&D tax incentives versus direct support to business R&D, 2004 and 2009

Foregone tax revenues on R&D for USD 1 of direct support



Source: OECD (2011a), *OECD Science, Technology and Industry Scoreboard 2011*, OECD Publishing, doi: http://dx.doi.org/10.1787/sti_scoreboard-2011-en.

There are, moreover, cross-country differences in the design and administration of both R&D tax incentives and direct support measures. R&D tax incentives differ significantly in terms of their targets (Table 1.3), and the composition of direct programmes (loans, loan guarantees, grants, etc.) varies across countries. These differences should be kept in mind for the following discussion.[26]

Effectiveness of R&D tax incentives and direct support measures

Estimates of the private "R&D price elasticity" indicate that a 10% reduction in the user cost of R&D increases the volume of private-sector R&D spending by about 1% in the short run and 10% in the long run (Bloom et al., 2002).[27] The greater responsiveness in the long run reflects adjustment costs (Hall and van Reenen, 2000) and is consistent with limited effectiveness of an R&D tax incentive if the supply of scientists and engineers is not sufficiently elastic (Goolsbee, 1999). New OECD evidence broadly supports these conclusions. For example, a 6% increase in the generosity of R&D tax incentives – e.g. from the level in the United States to the level in Japan in 2008 – is estimated to increase the level of R&D by about 6% in the long run (Westmore, 2013).

Table 1.3. Differences in R&D tax incentives schemes across selected countries, 2013

Design of the R&D tax incentive scheme	*Volume-based R&D tax credit*	Australia*, Austria, Belgium (capital), Canada, Chile, Denmark, France, Norway
	Incremental R&D tax credit	United States (mostly)**
	Hybrid of a volume-based and an incremental credit	Ireland, Italy, Japan, Korea, Portugal, Spain
	R&D tax allowance	Belgium (Capital Region), Brazil, China, Chile, Columbia, Czech Republic, Finland, Hungary, India, Netherlands, Russian Federation, Singapore, Slovenia, South Africa, Turkey, United Kingdom
Payroll withholding tax credit for R&D wages		Belgium, Hungary, Netherlands, Spain, Turkey
R&D tax incentive is not refundable		Brazil, China, Chile, Columbia, Czech Republic, India, Italy, Japan, Korea, Poland, Portugal, Russia, Singapore, Slovenia, South Africa, United States (mostly)**
R&D tax incentive does not contains carry-over provisions		Austria, Brazil, Columbia, Italy, Norway.
More generous R&D tax incentives for SMEs		Australia, Canada, France, Hungary, Japan, Korea, Netherlands, Norway, Portugal, United Kingdom
Targeting	*Special for energy*	United States (volume-based)
	Special for collaboration	Hungary, Italy, Japan, Norway
	Special for new claimants	France
	Special for young firms and start-ups	Belgium, France, Netherlands, Portugal
Ceilings on amounts that can be claimed		Austria, Denmark, France, Ireland, Italy, Japan, Netherlands, Norway, Portugal, Singapore, Spain, United Kingdom, United States
R&D income-based R&D tax incentives		Austria (individuals), Belgium, China, France, Hungary, Luxembourg, Netherlands, Spain, Switzerland, Turkey, United Kingdom
Special treatment of technology acquisitions (capital cost)		Poland
No R&D tax incentives		Estonia, Germany, Israel, Mexico (repealed), New Zealand (repealed), Sweden

Note: R&D tax allowances are tax concessions up to a certain percentage of the R&D expenditure and can be used to offset taxable income; R&D tax credits reduce the actual amount of tax that must be paid. No R&D tax incentives means no R&D tax credit or allowance but does not preclude accelerated depreciation allowances. * In 17 February 2013, the Australian Government announced that companies with aggregated turnover of USD 20 billion (about USD 21 billion) or more will no longer be eligible for the R&D tax incentive. This change will apply to income years commencing on or after 1 July 2013, but is yet to be legislated. **Qualified energy consortia in the United States are eligible for a volume-based R&D tax credit.

Source: OECD Directorate of Science, Technology and Industry. Based on information available as of March 2013.

The effectiveness of R&D tax incentives also depends on the stability of the policy regime over time (Guellec and van Pottelsberghe, 2003). In countries that have experienced a high number of R&D tax policy reversals, the estimated impact of R&D tax incentives on private R&D expenditure appears to be greatly diminished (Westmore, 2013).

New OECD research also shows that direct government subsidies can encourage additional business R&D (Westmore, 2013). However, this result does not hold when the analysis is conducted on data pre-dating the 2000s; this is consistent with earlier research that did not find a significant relationship between direct R&D subsidies and additional private R&D spending over the period 1982-2001 (Jaumotte and Pain, 2005b). The estimated increase in the effectiveness of R&D direct support may reflect a shift in the structure of public support, which has become more focused on subsidies for commercial R&D activities and has seen matching grants become a more common feature of government funding programmes (Blanco Armas et al., 2006; Hall and Maffioli, 2008). [28]

Evidence on the relative effectiveness of these policy instruments in stimulating intramural R&D is scarce. A study for Norway (Hægeland and Moen, 2007) suggests that an additional dollar of tax credits had a somewhat larger effect on R&D than an additional dollar of direct support. While estimating these "bang for the buck" multipliers in a cross-country setting is more complicated and requires a number of restrictive assumptions, the available evidence suggests that direct support has a larger impact than volume-based tax incentives on R&D (Westmore, 2013).[29] As discussed below, however, the impact of R&D tax incentives and direct support mechanisms may vary across different types of firms.

While R&D tax incentives and direct support boost R&D expenditure, it is important that they ultimately raise productivity growth to the extent that such programmes carry associated compliance and administration costs. They can be expected to have positive effects on productivity growth, since both lead to additional business R&D and business R&D has important effects on productivity growth (Westmore, 2013). However, direct empirical evidence on the impact of R&D tax incentives and direct support on productivity growth is not clear-cut (Brouwer et al., 2005; Lokshin and Mohnen, 2007; Westmore, 2013).

The failure to find that these fiscal incentives have a clear direct positive effect on productivity growth may be due to measurement and identification issues, but may also arise if:

- These fiscal incentives lead to an increase in the price of R&D (e.g. via higher wages of scientists) rather than the volume of R&D. Recent estimates suggest that a wage effect could reduce the effectiveness of R&D tax incentives (in terms of the volume of R&D) by 10% (Lokshin and Mohnen, 2008) to 30% (Haegeland and Møen, 2007). In this case, the effectiveness of such schemes could be enhanced by education policies that raise the supply of skilled workers.
- Projects financed by R&D tax incentives have lower than average marginal productivity (Hægeland and Moen, 2007) and may not have the highest social rate of return (i.e. the most knowledge spillovers). For example, evidence suggests that R&D tax incentives have a positive effect on incremental innovations that are new to the firm (e.g. Czarnitzki et al., 2005; De Jong and Verhoeven, 2007) but not on innovations new to the market (Cappelen et al., 2012).
- R&D tax incentives may lead to duplication of R&D or relabeling of non-R&D activities as R&D investment (Lemaire, 1996; Hall and Van Reenen, 2000). However, tentative evidence suggests that such policies are unlikely to lead to significant increase in relabeling of investment (Westmore, 2013).
- Information problems can limit governments' ability to channel direct support measures to projects with the greatest potential.

- The firms that benefit the most from these fiscal incentives are those for which R&D is less likely to generate large spillovers and significant increases in aggregate productivity growth. While smaller – but not necessarily younger – firms tend to be more responsive to R&D tax incentives than larger firms (Lokshin and Mohnen, 2007; Hægeland and Moen, 2007)[30] the aggregate impact of R&D tax incentives might be dwarfed if such firms focus on niche markets (Bloom et al., 2013b).

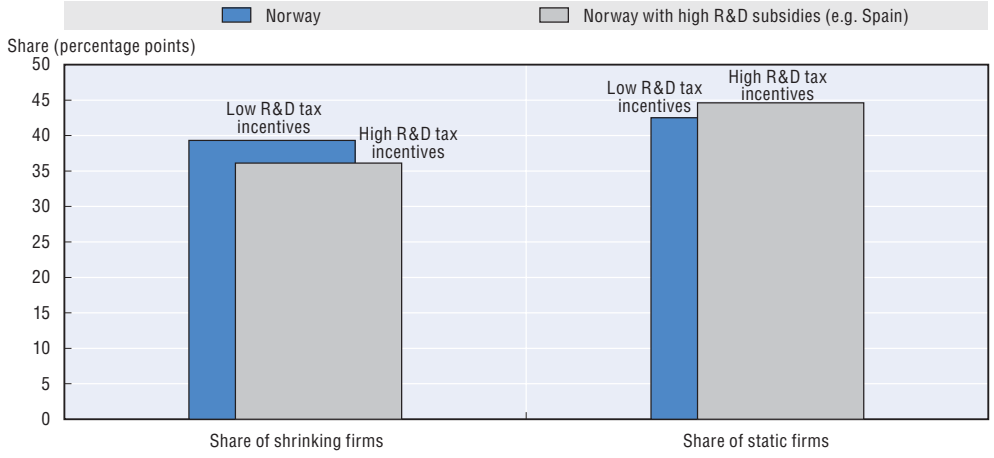
The importance of policy design

These issues are likely to be affected by the design of innovation policies. Design also plays an important role in minimising the cost to tax payers and the unintended consequences of these policies.[31]

New OECD evidence suggests that R&D tax incentives protect incumbents at the expense of potential entrants, thus slowing the reallocation process (Bravo-Biosca et al., 2013). Figure 1.19 shows that more generous R&D tax credits are associated with a less dynamic distribution of firm growth in R&D-intensive sectors, i.e. a higher share of stagnant firms and a lower share of shrinking firms. They thus benefit disproportionately the slowest-growing incumbent firms. This suggests that R&D tax incentives may involve an important trade-off from the perspective of the KBC-innovation-reallocation nexus. At the same time, differences in the extent of direct support – as measured by the share of business R&D financed by government – do not appear to shape the distribution of firm employment growth, suggesting that such policies have a more neutral impact on incumbents than on entrants.[32]

Figure 1.19. More generous R&D fiscal incentives are associated with a more static distribution of firm growth in R&D-intensive industries

The differential impact of R&D tax incentives on the share of firms in each employment growth grouping



Note: The figure gives a numerical example of how more generous R&D tax incentives affect the distribution of firm employment growth, based on the (statistically significant) coefficient estimates in Bravo-Biosca et al. (2013). The darker columns show the estimated shares of shrinking and static firms in an R&D-intensive industry (electrical and optical equipment; NACE Rev.1.1. 30-33) in a country with relatively low R&D tax incentives (Norway). The lighter columns show the estimated shares of shrinking and static firms in the electrical and optical equipment sector if Norway adopted more generous R&D tax incentives (corresponding to the level of R&D tax subsidies in Spain).

Source: Bravo-Biosca et al. (2013), "What Drives the Dynamics of Business Growth?", *OECD Science, Technology and Industry Policy Papers*, No. 1, OECD Publishing. doi: http://dx.doi.org/10.1787/5k486qtttq46-en.

When countries' R&D tax incentive schemes lack immediate cash refunds and/or carry-over provisions (Table 1.4), they may provide less assistance to young firms, which are typically in a loss position in the early years of an R&D project. In fact, the lack of an immediate refund may significantly reduce the effective rate of the tax subsidy to R&D, even in countries that apparently provide relatively generous support (Elschner et al., 2011). The use of payroll withholding tax credits for R&D wages, whereby firms receive an immediate refund for expenditure on the wages for R&D personnel, is another way to provide support for (young) firms in a loss position.

Even if R&D tax incentive schemes are refundable and contain carry-over provisions, young firms may not fully benefit if they lack the upfront funds required to start an innovative project. Direct public funding might be more beneficial than R&D tax incentives for young, financially constrained firms (Busom et al., 2012) if direct support helps to certify the quality of young firms and projects. This could reduce problems associated with information asymmetry (e.g. Lerner, 1999; Blanes and Busom, 2004), which tend to be much more pronounced for radical than for incremental innovations (Czarnitzki and Hottenroot, 2011). This would lower the cost of capital for the firms that receive grants when they apply for external sources of financing.

Table 1.4. Characteristics of R&D tax incentive schemes with respect to refunds and carry-over provisions

Selected countries, 2013

	Refundable	Carry-over provisions
Austria	This benefit is refundable to the extent the credit exceeds the amount of the tax liabilities.	No
Australia	Small firms can claim a refund; any excess non-refundable R&D tax credts can be forward indefinitely but not carried back	Carry-forward available for all firms
Belgium	A payroll withholding tax credit or allowance works in practice like a fully refundable system since the remission (tax benefit) is immediately implemented through the wage tax system, while unused credit (from the tax credit scheme) can be refunded after 5 years.	Investment deduction may be carry forward indefinitely or converted into a tax credit refundable after 5 years
Brazil	No	No
Canada	Cash refund for small Canadian-owned firms, but with a cap (baseline limit is CAD 3 million and is reduced according to a function of taxable income and taxable capital.)	Carry-back (3 years) and carryforward (20 years) available for all firms
China	No	Tax losses attributable to R&D super deduction claims can be carried forward up to 5 years
Chile	No	Carryfoward (10 years)
Colombia	No	No
Czech Republic	No	Carry-forward for 3 years available for all firms
Denmark	25% of any deficit related to R&D expenses (2012 reform)	n/a
France	2009: immediate refund of all unused credit for all firms (instead of 3 years waiting period) as a temporary measure.Otherwise only refundable for SMEs; new companies; YICs and financially distressed companies	Carry-over (3 year) available
Finland	n/a	n/a
Hungary	A payroll withholding tax credit or allowance works in practice like a fully refundable system since the remission (tax benefit) is immediately implemented through the wage tax system	R&D benefits can be claimed retrospectively within the statute of limitations
India	No	Unused benefits may be carried forward for the next eight years, but cannot be carried back to earlier years.

Table 1.4. Characteristics of R&D tax incentive schemes with respect to refunds and carry-over provisions (*continued*)

	Refundable	Carry-over provisions
Ireland	Refunds available for all firms to be paid over a period of 3 years (Refunds are limited to the greater of the total corporation tax paid by the company for the 10 years prior to the period for which the company is making the claim or the payroll tax liabilities for the specific period in which the expenditures were incurred).	Carry-back (1 year) and indefinite carry-forward also available.
Italy	No	No
Japan	No	Carry forward for 1 year available only if R&D expenditures are higher than the prior year. 2009 to 2010: carry-forward available for 3 years.2010-2011: carry-forward available for 2 years.
Korea	No	Carry-forward up to 5 years.
Netherlands	A payroll withholding tax credit or allowance works in practice like a fully refundable system since the remission (tax benefit) is immediately implemented through the wage tax system	Unused credit (from the innovation income box) can be carried-forward up to 5 years.
Norway	Refund available for all firms within the year the expenses are incurred.	No
Poland	No	Carry-forward for 3 years for new technology (intangible assets) acquisitions available for all firms.
Portugal	No	Carry-forward up to 6 years.
Russia	No	Carry-forward 10 years
Singapore	No	Unutilised R&D expenditures may be carried forward indefinitely, subject to substantial shareholders' test. They may also be carried back subject to certain restrictions.
Slovenia	No	Unused business losses may be carried forward for 3 years
South Africa	No	n/a
Spain	A payroll withholding tax credit or allowance works in practice like a fully refundable system since the remission (tax benefit) is immediately implemented through the wage tax system	Carry-forward up to 15 years.
Turkey	A payroll withholding tax credit or allowance works in practice like a fully refundable system since the remission (tax benefit) is immediately implemented through the wage tax system	Indefinite carry-forward, but with cap
United Kingdom	Refund available for SMEs (refund of GBR 25 by GBR 100 of eligible R&D after April 1 2011). Large companies will become eligible for refundable tax credits beginning in 2013.	Carry-forward (infinite) available for all firms.
United States	No (but available for certain energy research)	Carry backward 1 year (5 years for SMEs). Carry-forward for 20 years available for all firms

Source: OECD Directorate of Science, Technology and Industry. Based on information available as of February 2013. "n/a" denotes that no recent information on policy design was available.

Allocation of direct support should not be automatic but based on a competitive, objective and transparent selection, e.g. by involving independent international experts in the selection process. While this obviously means administrative and compliance costs, subsidies allocated on a selective basis tend to have larger direct effects on firm productivity than automatic subsidies and enable recipient firms to signal their quality to potential investors (Colombo et al., 2011). More broadly, a well designed and transparent system of direct support measures may complement R&D tax incentives as it may help direct public funding to high-quality projects with high social returns (e.g. relevant to green growth and population ageing) and through targeting, may limit forgone tax revenues.

Design issues are also important to minimise the fiscal cost of public support for innovation:

- Incremental tax incentives (which only apply to R&D expenditures above some baseline amount) are more effective in inducing additional business R&D spending than volume-based tax credits (Parsons and Phillips, 2007; Lokshin and Mohnen, 2009). They are less costly from a fiscal perspective since they are less likely to subsidise R&D that would have been conducted in any case. While incremental tax incentives are likely to be preferable to volume-based schemes, their uptake by young and small firms may be limited by the associated compliance costs (e.g. they might need an accountant).
- Governments should recognise that the actual cost will depend on the success/uptake of the policy. This may be difficult to predict when the policy is designed, especially if it triggers a response from multinational enterprises, because, other things being equal, more generous R&D tax incentives abroad are associated with lower levels of domestic R&D. This is because R&D tax incentives tend to tilt MNEs' decisions on the location of their R&D activities amongst very similar locations (Criscuolo et al., 2009). At the same time, new OECD research shows that MNEs can use cross-border tax strategies to shift profits generated by KBC across countries (Chapter 2; Karkinsky and Riedel, 2012), and that this might lead to unintentionally high levels of total tax support for R&D.[33] In addition, R&D tax incentives may unintentionally create scope for rent-seeking behaviour that may adversely affect resource allocation and lead to tax competition. Indeed, the increasing generosity of R&D tax incentives in comparable countries may pressure countries that do not offer them to introduce similar measures.

While the evidence presented above suggests that a policy mix of incremental R&D tax incentives and selective direct grants might be optimal, it is important to keep in mind that the related administrative and compliance costs might be higher than for volume and automatic subsidies. However, it is unlikely that they would be as high as the foregone tax revenue associated with policy measures that support activity that would have taken place in absence of the scheme.

Finally, to evaluate the effectiveness of these policies, monitoring and evaluation are essential: the evaluation of these policies should be part of the policy design. This can be done at a relatively low cost and will help to ensure good value for money in the longer run. The evaluation could entail, for example, *ex ante* collection of data and *ex post* access to data and disclosure of relevant information for academic researchers and independent evaluation agencies as well as *ex ante* experimental policy design (randomisation of participants, use of pilot phases, etc.).

Non-business sector R&D and collaborative research

Some R&D activities have potentially high social value, but much uncertainty may surround their possible commercial applications and the appropriability of potential benefits. Such basic research can lead to future innovations and generate significant economic benefit. In such circumstances, governments may perform (as well as fund) research through universities or public laboratories.

While public research has been at the root of some revolutionary technologies (Sheehan and Wyckoff, 2003), the lags can be long and variable.[34] Some evidence shows that basic research has a positive effect on private R&D investment (Falk, 2004; Jaumotte and Pain, 2005b) while other evidence shows significant crowding out (Guellec and Van Pottelsberghe, 2003). New OECD research finds that increases in government spending on basic research (as a percentage of GDP) are associated with higher firm-level MFP growth in R&D-intensive sectors (Andrews, 2013; see Annex 1.A1). This is in line with survey-based evidence (Cohen et al., 2002).

The initial stage of idea formation (e.g. Figure 1.1, Stage 1) may also involve collaboration between private firms and public research entities, especially for young firms that are less likely to have access to their own research facilities. Indeed, collaboration on R&D by private firms and public research entities has become increasingly common in OECD countries (OECD, 2002) with the growing complexity of innovation and the need for complementary knowledge. New OECD evidence shows that more collaboration, as proxied by the share of higher education R&D financed by industry, is also associated with stronger productivity growth in firms in R&D-intensive sectors (Andrews, 2013; see Annex 1.A1).

Some countries seek to foster these linkages through fiscal incentives for firms that collaborate with a public research institution. Public support is often justified on the basis that: i) co-operative projects are more akin to basic research than other projects; and ii) universities produce knowledge that is more valuable to firms than firms realise. However, it is unclear whether fiscal incentives for collaboration can be justified on the basis of a traditional market failure argument and evidence on the effectiveness of such policies is scarce (Criscuolo et al., 2009).[35]

The role of intellectual property rights

The legal means to protect the intellectual property (IP) embedded in different types of KBC include patents, copyrights, trademarks and design rights. In each case, the primary aim is to preserve incentives to innovate by granting holders the (temporary) ability to exclude others from using an invention. By pushing firms to innovate, competition also plays an important role in fostering innovation. The central policy challenge is to strike a balance between exclusive rights and competition so that the one does not undermine the other. While this is a long-standing issue, a key question today is whether the growing importance of information technology and other KBC-intensive industries has altered the nature of the trade-off. Certain factors suggest that this may be the case, at least for patents.[36]

Balancing incentives to innovate with broad diffusion of knowledge

Patents grant temporary monopolies to inventors in exchange for public disclosure of the technical information relating to the innovation. Such public disclosure is important for fostering further technological advancement, as follow-on innovators may learn from and build upon the patented invention. The patent system can also play a role in easing financial constraints for young firms, as patents may serve as collateral or signals/certification to investors (Häussler et al., 2012; Danguy et al., 2009). Since markets for KBC are underdeveloped, the sale or licensing of patents also serves to facilitate technology trade.

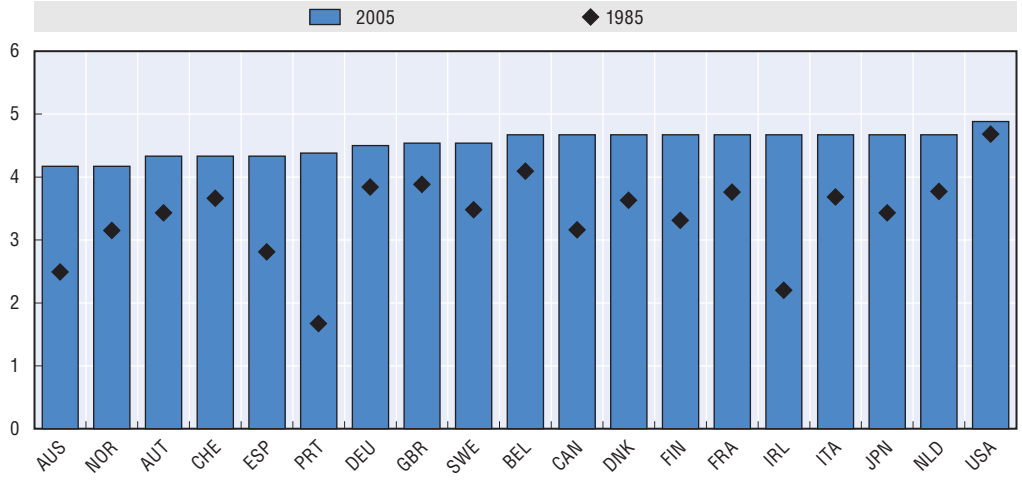
Patents also entail costs. Exclusivity can give the rights holder market power, the impact of which varies with the importance of the protected innovation as an input to other activities and the availability of alternatives. Patents can also raise transactions costs for follow-on innovators, via search costs to ensure that they are not infringing patent rights and legal costs in case of litigation.

While the strengthening of patent protection in recent years (Figure 1.20) has been accompanied by a substantial increase in the number of patents, it is unclear whether this reflects more innovation or more widespread use of patents (Lerner, 2002). Evidence from the United States suggests important differences across sectors, with patents more likely to be associated with increased innovation in the pharmaceutical, biotechnology and chemical sectors (Arora et al., 2001; Graham et al., 2009). This is consistent with the fact that innovation boundaries may be clearer in these sectors and the fact that the invention process is neither particularly cumulative nor highly fragmented (Hall and Harhoff, 2012). This contrasts with information technology industries, where it is common to see products composed of many components, each covered by numerous patents (FTC, 2011)

Complementarities with competition policy

Given the strengthening of patent protection, it is essential not to stifle the competitive forces that motivate innovation or the diffusion of ideas. The complementarity of patent protection and product market regulation settings is highlighted by the positive relationship between the strength of patent regimes and the number of patent applications per capita, but only in countries with pro-competition product market regulations (Westmore, 2013; OECD, 2006). Similarly, increases in patenting rates have a stronger association with MFP growth when product market regulations are lower as it is easier to implement and commercialise new ideas in more competitive markets. More firms can also capitalise on the related knowledge spillovers when barriers to entry are low (Westmore, 2013).[37] While pro-competitive product market regulations are crucial, patent systems can also address market power concerns through safeguards such as compulsory licensing. However, there is little evidence on the impact of such provisions (Box 1.3).

Figure 1.20. Index of patent protection



Source: Park (2008), "International Patent Protection: 1960-2005", *Research Policy*, Vol. 37, pp. 761-766.

Box 1.3. Compulsory licensing in OECD countries

Patent regimes in many OECD countries contain safeguards such as compulsory licensing, which compels a patent owner to license its innovation to another party in certain circumstances. The grounds for compulsory licensing of patents in most OECD countries generally include at least one of the following (WIPO 2010): i) the non-working of a patent; ii) dependent patents (i.e. a patent that cannot be worked without exploiting an earlier patented invention); iii) patent abuse (i.e. refusing to deal with applicants for a licence); iv) public interest (e.g. national emergencies and pharmaceuticals); and v) breaches of competition law. Compulsory licences have seldom been granted in most OECD countries, and most frequently in the United States, often to remedy anticompetitive conduct and patent infringement (Australian Productivity Commission, 2012).[1]

A key issue is whether compulsory licensing blunts the incentives to innovate. However, the empirical evidence is limited and dated. In the United States in the 1970s companies that were subject to compulsory licensing did not undertake less R&D than firms of similar size in the same industry (Scherer, 2000). In contrast, survey results from the United Kingdom suggested adverse effects on R&D in the pharmaceuticals industry (Taylor and Silberston, 1973). Moser and Voena (2012) find that compulsory licensing encourages domestic invention in the licensing country but do not find a clear long-run effect on invention in the country in which the invention originated. These findings should be interpreted with caution because the effects of compulsory licensing on innovation are likely to be context-specific and at least partly dependent on the how licensing fees are determined.

1. Compulsory licensing has also been used in the United States to gain access to patented inventions for national security purposes. In the European Union, compulsory licensing has been more frequent for copyrights, particularly for software.

The patent system and the KBC economy

While patents are important for encouraging firms to innovate, they may have unintended consequences in some sectors. In rapidly growing domains such as ICT, the patent system may favour incumbents at the expense of young firms and lessen incentives to invest in KBC. Evidence from the United States suggests, for example, that the cost of litigation exceeded the profit from patents in the late 1990s in industries other than pharmaceuticals and chemicals (Bessen and Meurer, 2008). Moreover, the emergence of "patent aggregators" (PAs) that accumulate software patents in order to extract rents from innovators may affect innovation activities (Bessen et al., 2011). While PAs can improve the reallocation of KBC,[38] litigations prompted by PAs show substantial deadweight losses (Bessen et al., 2012).

Finally, with the emergence of "patent thickets"[39] firms may have to pay licensing fees to several parties or hold up production before they can commercialise new technology (UK IPO, 2011). Such patent thickets may affect market entry and disproportionally disadvantage young firms with little bargaining power (Cockburn et al., 2009). They also reduce the ability of young firms to obtain financing (Cockburn and MacGarvie, 2007).

Financing and corporate reporting in the knowledge-based economy

For knowledge-based firms, profitability partly depends on the ability to leverage investments in KBC through rapid increases in the scale of production. This requires access to complementary tangible resources, typically through external finance. Through their effect on reallocation mechanisms, deeper financial markets play an important role in helping firms to implement and commercialise new ideas, thus raising the returns to innovation. For example, resource flows to innovative firms tend to be stronger in countries with a higher ratio of stock market capitalisation to GDP (Figure 1.14, Panel A; Andrews et al., 2013). Similarly, deeper financial markets are associated with a more dynamic distribution of firm growth (i.e. more growing and shrinking firms and fewer static firms) in industries that are highly dependent on external finance (Bravo Biosca et al., 2012).[40]

While the size and development of financial markets matter for innovative firms (Aghion et al., 2005), insufficient collateral may limit access to external financing for firms that rely heavily on KBC. Traditional debt and equity markets primarily rely on tangible assets with well-defined market prices that can serve as collateral. KBC assets are less easy to define and often non-separable and non-transferable, two impediments to the mobility of any single asset across parties and the realisation of full salvage value in the event of bankruptcy.[41] Difficulties in collateralising KBC also arise from the uncertainty and perceptions of risk that characterise KBC, which tend to amplify information asymmetries in lending markets. The importance of collateral is well documented in modern macroeconomic theory; a long line of literature, beginning with Kiyotaki and Moore (1997), draws on the magnifying effects of the availability of collateral to explain business cycle fluctuations.

Corporate reporting of KBC

Such capital market imperfections are often addressed through greater corporate disclosure, such as the release of financial accounting statements (Healy and Palepu, 2001). Good corporate disclosure regimes can promote more efficient resource allocation (EC, 2003) and growth in sectors that are more dependent on external finance (Rajan and Zingales, 1998). The benefits of corporate disclosure are more difficult to achieve for firms that rely heavily on KBC. As excludability is only partial, these firms cannot address asymmetric information via full disclosure because of the risk that imitators will appropriate the rents arising from their KBC. More fundamental, perhaps, is the inability of current corporate accounting frameworks to deal properly with KBC. To be recorded in company accounts, intangibles must adhere to five criteria (Box 1.4) but there is a clear disconnect between these criteria and the economic characteristics of KBC (Hunter et al., 2005). For example, its non-separability, which is partly due to the tendency for KBC to be embodied in people, is clearly at odds with identifiability (as defined in Box 1.4).[42]

Box 1.4. Treatment of intangible assets in International Accounting Standards (IAS)

As outlined in Hunter et al. (2005), intangibles are only recorded in the accounting system as assets if the items, first, meet the asset definition criteria and, second, meet the asset recognition criteria.[1]

Asset definition criteria for intangibles have three attributes:

1. Identifiability: i) the asset is separable, being capable of being separated or divided from the entity and sold, transferred, licensed, rented or exchanged, either individually or together with a related contract, asset or liability; or ii) the asset arises from contractual or other legal rights, regardless of whether those rights are transferable or separable from the entity or from other rights and obligations.[2]
2. Control: "an entity controls an asset if the entity has the power to obtain the future economic benefits flowing from the underlying resource and to restrict the access of others to those benefits."[3]
3. Future economic benefits: benefits flowing from an intangible asset that may include revenue from the sale of products or services, cost savings, or other benefits resulting from the use of the asset by the entity.[4]

Asset recognition criteria for intangibles have two attributes:

1. It must be probable (presumably more than 50% probable) that the economic benefits embodied in the asset will eventuate.
2. The asset must possess a cost that can be measured reliably.[5]

1. IAS 38 Intangible Assets, paragraph 18. 2. IAS 38 Intangible Assets, paragraph 12. 3. IAS 38 Intangible Assets, paragraph 13. 4. IAS 38 Intangible Assets, paragraph 17. 5. IAS 38 Intangible Assets, paragraph 17.

Adherence to such strict accounting criteria leads to an inadequate – but also arbitrary and ad hoc – treatment of KBC in corporate accounting (Hunter et al., 2005). While internally generated intangibles are expensed, otherwise indistinguishable intangibles that are acquired externally (as a complete set) through the market are treated as assets since they are separable and have a verifiable cost.43 These deficiencies in formal accounting for KBC are particularly worrying in the light of evidence showing that in sectors that are more dependent on external finance, growth in R&D expenditure as a share of value added is stronger in countries with good corporate disclosure regimes (Carlin and Mayer, 2000).

Relatively few analysts currently advocate better recognition of KBC in financial statements, but there is a case for encouraging firms to disclose information on their investments in intangibles through so-called narrative reporting (OECD, 2008). Even for narrative reporting, progress has been hampered by the fact that very few jurisdictions have guidelines on such reporting. In principle, policy makers could leverage existing reporting frameworks to encourage firms to report on their intangible assets by developing voluntary national guidelines, but a global dialogue on KBC disclosure is also necessary.

Financing KBC and macro-financial stability

Given the inherent difficulty of collateralising KBC assets, financial markets have been reluctant to provide debt financing to KBC-intensive firms (Jarboe, 2008). KBC has therefore traditionally been financed out of retained earnings (Hall and Lerner, 2009). However, KBC-backed lending rose significantly in the United States up to the financial crisis (Loumioti, 2011). Between 1997 and 2005, the share of secured syndicated loans collateralised by KBC in total secured loans rose from 11% to 24%. This trend was largely underpinned by unregulated lenders – i.e. investment banks – that did not face the same regulatory constraints as commercial banks for valuing KBC as collateral.

The use of KBC as collateral partially alleviated borrowing constraints for large firms, but the practice emerged in a period of excessive expansion of credit. It thus raises the question of whether the collateralisation of KBC was an innovation (with lenders allocating capital prudently) or a symptom of the general deterioration in lending standards. Clearly, this is a difficult hypothesis to test and research is scarce. However, the findings of one econometric study that exploits detailed information on the characteristics of borrowers that received credit over this period are consistent with the hypothesis that the collateralisation of KBC is a credit market innovation (Loumioti, 2011). Rather than ignoring economic considerations in a search for yield and market share, lenders' decisions to accept KBC as collateral appeared "economically rational" in the sense that they: i) prioritised liquid and redeployable KBC (e.g. patents and licensing) as loan collateral, since this is where information asymmetries and moral hazard are less severe; ii) demanded higher compensation for monitoring costs in the form of higher loan spreads; and iii) made loans of similar quality to other secured loans, as measured by *ex post* loan performance (Loumioti, 2011).[44]

Reforms such as Basel III – to the extent that they make banking safer and more stable – are clearly desirable. However, given the risk that more stringent capital requirements could reduce the supply – or increase the cost – of capital for risky business enterprises in the short term (Aghion et al., 2013), it will be interesting to see how this affects the financing prospects of firms that rely mainly on KBC.

Some consequences of the financial crisis for KBC

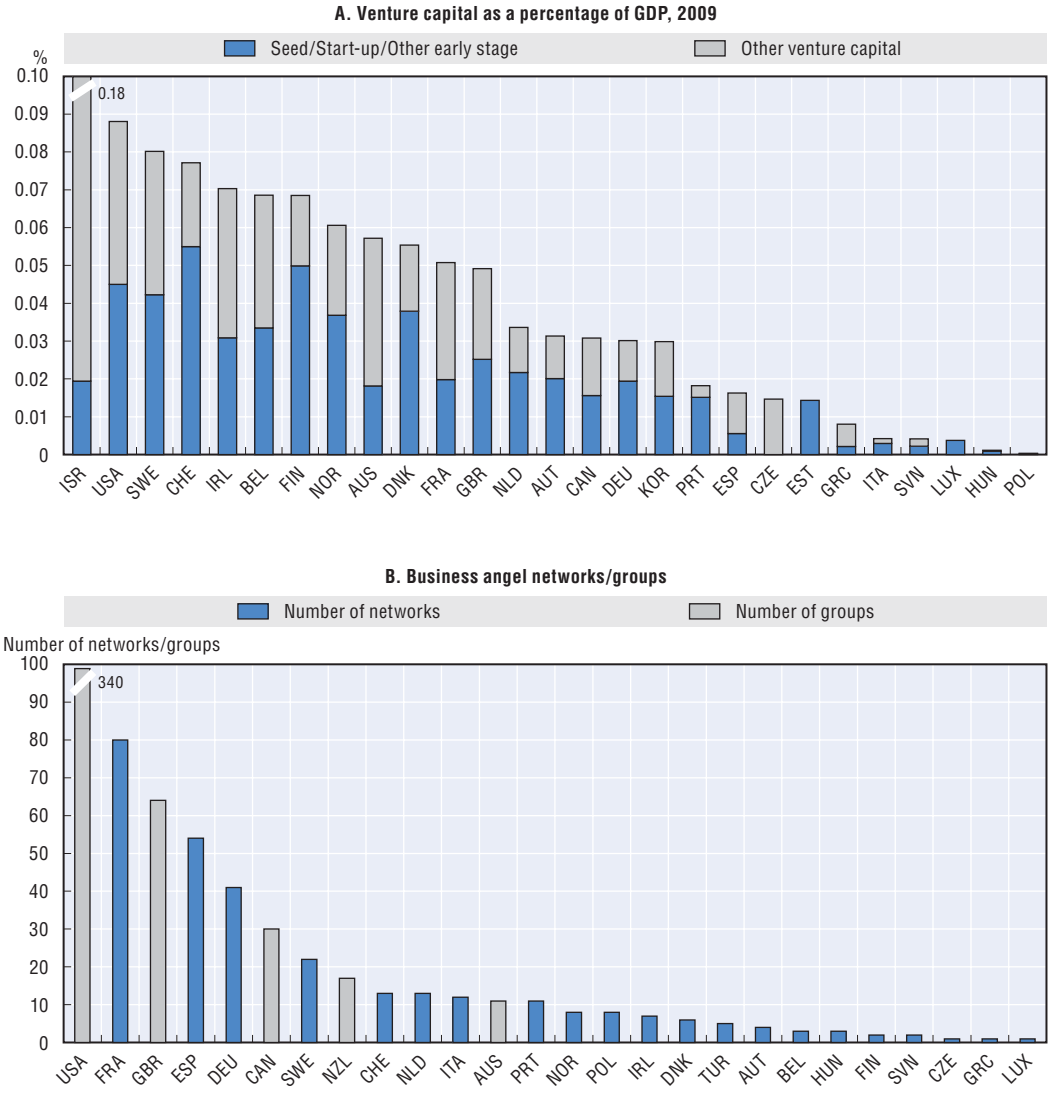
There is little systematic evidence on how firms that rely on KBC have fared in capital markets since the financial crisis. Although recessions typically provide firms with an opportunity to restructure at low cost (Hall, 1991), it is important to recognise the damage that the financial crisis may have done to the financing prospects of KBC-intensive firms. Existing evidence points to the strong adverse effects of financial crises on net (new) firm entry (Caballero and Hammour, 2005), which are likely to reduce the scope for experimentation with new ideas and thus investment in KBC (Ziebarth, 2012; Buera and Moll, 2012). An important risk at present is that the near-zero interest rate policy and distortions in the financial sector sustain highly inefficient firms, thereby preventing the release of resources for the expansion of innovative firms. Aggregate productivity performance in Japan during the 1990s was held back by the tendency for resources to be trapped in "zombie firms", which continued to receive credit despite their poor economic fundamentals (Caballero et al., 2008).

Policies to nurture seed and early-stage financing

Financing constraints tend to be more acute for young firms with limited internal funds and lack of a track record to signal their potential to investors. When asymmetric information problems are large, a "missing markets" problem may arise, and many innovations of young start-up firms may never be commercialised. This financing gap is partly bridged by venture capitalists or business angels, who address information asymmetries by intensive scrutiny of firms before they provide capital and by then monitoring them (Hall and Lerner, 2009; OECD, 2011b). Countries with more developed seed and early-stage venture capital markets tend to invest more heavily in KBC and appear to be more effective at channelling capital and labour to young innovative firms (Figure 1.14).[45] More broadly, econometric studies based on the variation in venture capital (VC) financing that is exogenous to the arrival of entrepreneurial opportunities, tend to find that VC has a sizeable positive impact on innovation and economic growth (Kortum and Lerner, 2000; Samila and Sorenson, 2011b).

Nevertheless, the question of why there is more seed and early-stage VC (SES-VC) financing in some countries remains (Figure 1.21). It is likely that differences in human capital, entrepreneurial attitudes and framework and innovation policies play a role. For example, less stringent employment protection legislation and bankruptcy regimes, with strong exit mechanisms and that do not excessively penalise business failure, can foster the development of SES-VC (Armour and Cumming, 2006), while high rates of taxation on corporate income and capital gains have negative effects on SES-VC (Da Rin et al., 2006). Regulatory barriers may also affect the availability of SES-VC, particularly as regards the ease with which venture capitalists and business angels can organise as limited liability entities (OECD, 2013).[46] Finally, new OECD evidence suggests that regulations that aim to create a market for clean technologies are associated with a higher level of VC investment, while fiscal incentives for investment in these technologies are not effective (Criscuolo and Menon, 2013).[47]

Figure 1.21. Investments in alternative funding mechanisms, 2009



Source: OECD (2011b), *Financing High-Growth Firms: The Role of Angel Investors*, OECD Publishing.
doi: http://dx.doi.org/10.1787/9789264118782-en.

Governments attempt to nurture the market for seed capital through a range of supply-side policy initiatives (Table 1.5). Most OECD countries have some type of government equity finance programme, such as direct public VC funds, "funds of funds" (an investment strategy consisting of holding a portfolio of other investment funds rather than investing directly in companies) and co-investment funds, whereby public funds are matched with those of private investors that are approved under the scheme. These programmes, especially funds of funds and co-investment funds, have grown in importance over the past five years. While fiscal incentives are less common, 17 OECD countries still employ either "front-end" tax incentives or tax deductions for investment in seed and early-stage VC and "back-end" tax relief on capital gains, including rollover or carry-forward of capital gains or losses. Of course, it is important to keep in mind the broader taxation environment – and particularly the existence of capital gains tax – when assessing these fiscal incentives.

Table 1.5. Tax and equity policy instruments to support the market for early-stage financing

Policy setting at mid-2012; change in the policy setting in the last five years

	Fiscal incentives			Government Equity Financing Instruments		
	Young innovative company schemes	"Front-end" tax incentives	"Back-end" tax incentives	Public equity funds	Fund of funds	Co-investment Funds
Australia			unchanged			increased
Austria		decreased	decreased		new	
Belgium	increased	increased	decreased	new & increased	new	new
Canada	unchanged	unchanged	increased	increased	increased	
Chile						unchanged
Czech Republic						new
Denmark			increased	increased	increased	
Estonia				decreased		
Finland				unchanged	unchanged	increased
France	decreased	decreased	unchanged	increased	increased	increased
Germany					increased	unchanged
Greece					unchanged	increased
Hungary				unchanged		increased
Ireland	new	increased		new	new	increased
Israel	new	new	new			new
Italy	new	new	new	new	new	new
Japan		increased				
Korea	increased	increased			increased	
Mexico				increased	new	unchanged
Netherlands						increased
New Zealand					unchanged	unchanged
Norway				increased	increased	increased
Poland					unchanged	
Portugal		decreased			increased	increased
Slovak Republic	yes*	yes*		unchanged	increased	
Slovenia			new		new	new
Spain						
Sweden				increased	unchanged	increased
Switzerland		ceased				
Turkey	unchanged	new	unchanged		new	new
United Kingdom		increased	increased		increased	unchanged
United States						

* The Slovak Republic has both young innovative company schemes and front-end tax incentives but no information is available on changes in the generosity of such schemes over time.

Source: See Wilson and Silva (2013), "Policies for Seed and Early Stage Finance: Summary of the 2012 OECD Financing Questionnaire", OECD DSTI Working Paper *forthcoming*.

Evidence on the contribution of supply-side policy interventions in the market for SES-VC is scarce and research on whether public VC funds crowd out private activity is inconclusive (Da Rin et al., 2012). Given the potential for regulatory capture (Lerner, 2008), however, government funding is likely to be most effective when it is disciplined by private venture capital and does not exert control over business decisions (Brander et al., 2011). This suggests that public co-investment funds and funds of funds might be preferable to public equity funds. However, there is little evidence on this issue and the effect is likely to be contingent on the design of the schemes. More broadly, preliminary, albeit crude, findings (Da Rin et al., 2013; see Annex 1.A2) show that the more support for SES-VC there is in a country – as proxied by the number of tax and equity policy instruments – the lower the age at which firms receive SES financing.[48] Although causation is difficult to establish and the ultimate performance of firms that receive public funding is unclear, this may suggest that such programmes warrant further attention and further analysis of their effectiveness.

Some countries set portfolio restrictions that bar or limit institutional investors (e.g. pension funds, insurance companies) from investing in SES-VC, though comparable cross-country information in this area is incomplete. These restrictions may be important, in light of existing research showing that VC activity in the United States increased significantly following the removal of restrictions on pension funds in 1979 (Kortum and Lerner, 2000). Similarly, the existence of viable exit markets for venture investments, particularly the existence of secondary stock markets (e.g. NASDAQ), increases the expected return to investors and entrepreneurs and stimulates the development of markets for seed capital (Da Rin et al., 2006).[49] This suggests that rules affecting initial public offerings are also important.

Policy reform options for increasing KBC and innovation

Appropriate framework policies raise the returns to investing in KBC

Regulations that promote flexibility in product, labour and credit markets and bankruptcy laws that do not excessively penalise failure can encourage firms to experiment with uncertain growth opportunities and raise the expected net benefits of KBC investment by making it easier for successful firms to implement and commercialise new ideas. While policy reforms that promote competition in domestic and global product markets have pervasive impacts on the KBC-innovation-reallocation nexus, the impact of bankruptcy legislation and EPL is more nuanced and may mean trade-offs with other policy goals.

Less stringent EPL and bankruptcy laws that do not excessively penalise business failure are desirable to the extent that they reduce exit costs and thus encourage firms to experiment with new forms of KBC. Policy reforms along these lines, however, may shift the distribution of risk from entrepreneurs to workers and creditors. For example, reforms to job protection legislation could be accompanied by broader mechanisms to insure workers against labour market risk, such as well-designed social safety nets and portable health and pension benefits. More generally, while efficient reallocation mechanisms raise returns to KBC, the shifting of resources also entails costs for workers and firms. This raises questions regarding the role and best design of structural adjustment packages. Bankruptcy regimes that punish failure less severely are desirable if they encourage experimentation with risky technologies, but they might also discourage investment in KBC because of a possible reduction in credit supply. Striking the right balance between these forces makes the design of bankruptcy provisions complicated. More generally, the issue of bankruptcy legislation and exit costs raises important questions about the optimal level of risk-taking in an economy, which are beyond the scope of this chapter.

Rethinking innovation policies by focusing on policy design

The analysis of innovation policies, which include direct support measures and R&D tax incentives in many countries, demonstrates that design is crucial, not only to achieve maximum effectiveness but also to minimise their fiscal cost and possible unintended consequences. One concrete policy recommendation is that R&D tax incentives should be refundable (or allow for payroll withholding tax credits for R&D wages) and contain carry-over provisions in order to make them more compatible with the needs of young firms. From a fiscal perspective, incremental R&D tax incentives might be more cost-effective than volume-based schemes in raising R&D. It is also likely that well-designed, selective and transparent direct support measures complement R&D tax incentives and may help channel public funding to high-quality projects with high social returns. The administrative costs of such schemes should always be taken into account. Consideration should also be given to the public funding of basic research and to institutional frameworks that foster collaboration on innovative activities, but more policy evaluations in these areas are needed. This reinforces the idea that innovation policies should be designed to allow for the *ex post* evaluation of their effectiveness.

IPR protection should be coupled with pro-competition product market policies to ensure that the market power of incumbents does not stifle the creativity of new entrants. In some KBC sectors with an innovation process that is typically fragmented (e.g. software),[50] the marginal costs of patent protection may outweigh the benefits. While patent aggregators may be able to improve the reallocation of KBC assets, they may also stifle radical innovations owing to the transaction and entry costs they impose on young firms. Given the importance of the patent system to sectors such as pharmaceuticals and chemicals, this creates an important policy dilemma that has yet to be resolved in academic and policy circles.

Trade-offs between KBC and other policy priorities

This chapter has described a policy reform agenda to boost KBC, but it is not clear that gearing public policy to maximise the growth potential of KBC will always have unambiguously positive effects, and trade-offs with other policy goals may arise. For example, there may be tensions between promoting an increasingly knowledge-based economy and keeping a lid on rising inequality. This may increase the focus on education and adult learning policies that facilitate adjusting workforce skills to complement the changes in demand for labour that often accompany technological progress. To the extent that those needs are fulfilled, rising investment in KBC might translate into higher aggregate productivity growth without greatly exacerbating income inequality (Goldin and Katz, 2008).

Annex 1.A1.

MFP Growth and Policies: Firm-level evidence

The effect of framework policies and innovation-related policies on MFP growth at the firm level is explored using a neo-Schumpeterian growth framework and a sample of 18 OECD countries over the period 1999-2009.[51] The impact of policies on firms' MFP is allowed to vary with a firm's distance from the technological frontier to facilitate an analysis of the policies associated with the expansion of the most productive firms – one possible indicator of dynamic allocative efficiency. This exercise is also of interest given the significant contribution that a relatively small number of high-growth firms make to aggregate growth.[52]

Data

The analysis exploits cross-country firm-level data from ORBIS, a commercial database provided to the OECD by Bureau Van Dijk, which contains administrative data on tens of millions of firms worldwide. The financial and balance sheet information in ORBIS is initially collected by local Chambers of Commerce and is relayed to Bureau Van Dijk through some 40 different information providers (Pinto Ribeiro et al., 2010).

While representing a potentially useful tool to analyse cross-country patterns of productivity, ORBIS has a number of drawbacks. The main one relates to representativeness, with firms in certain industries and the many smaller and younger firms typically under-represented. Accordingly, the ORBIS sample of firms was aligned with the distribution of the firm population as reflected in the OECD Structural Demographic Business Statistics (SDBS), which is based on confidential national business registers. Following the procedure first applied in Schwellnus and Arnold (2008) and refined in Gal (2013), re-sampling weights – based on the number of employees in each SDBS industry-size class cell – are applied, which essentially "scales up" the number of ORBIS observations in each cell so that they match those observed in the SDBS.[53] However, since it is not possible to distinguish accurately entry into the market from entry into the sample and exit from the market from exit from the sample using ORBIS, it is important to keep in mind that the analysis pertains to a sample of continuing firms.[54] The sample is restricted to firms in the non-farm business sector – i.e. industries 15-74 according to NACE Rev 1.1, excluding mining and financial intermediation.

Econometric framework

The empirical specification is based on the estimation of the Aghion and Howitt (1998) neo-Schumpeterian growth framework, which has been implemented in a number of studies (e.g. Griffith et al., 2006; Arnold et al., 2011b). Multi-factor factor productivity (A) is assumed to follow an error correction model (ECM) of the form:

$$\Delta \ln A_{icst} = \delta_1 \Delta \ln A_{Fcst} + \delta_2 gap_{icst-1} + \delta_3 RI_{ct-1} + \sum_j \delta_4^j \left(P_{ct-1}^j * E_s^j\right) + \gamma_s + \gamma_{ct} + \varepsilon_{icst}$$

Productivity growth of firm *i* is expected to increase with productivity growth of the frontier firm *F* and the size of the gap – as proxied by $\ln\left(A_{Fcst-1} / \ln A_{icst-1}\right)$ – which measures how far each firm is away from the frontier F. Following Arnold et al. (2011b), the frontier firm is defined as the average MFP of the 5% most productive firms in sector *s* and year *t* in the sample of countries analysed (the frontier firms are excluded from the analysis). The specification controls for both industry and country*time fixed effects and standard errors are clustered by country and sector to allow for correlation of the error term in an unrestricted way across firms and time within sectors in the same country (Moulton, 1991; Bertrand et al., 2004). To compare MFP levels across countries and industries, MFP is estimated using the superlative index number approach (Caves et al., 1982a; 1982b; Griffith et al., 2006) but it should be kept in mind that this approach is based on a number of potentially restrictive assumptions, including constant returns to scale and perfect competition on factor markets. See Gal (2013) for more details.

To explore the impact of policies on MFP growth, regulation impact (RI) – which varies at the sectoral level – is included to control for the knock-on effect of product market regulations in upstream services sectors (Bourlès et al., 2010; Conway and Nicoletti, 2006). For policies that only vary at the national level, however, a differences-in-differences strategy is adopted since the country*time fixed effects will absorb the effects of policies that only vary at the country level over time. To gain within-country variability (over time) in the policy variables of interest, an interaction term between the country-level policy (*P*) and a relevant sectoral exposure variable (*E*) is included. This approach, popularised by Rajan and Zingales (1998), is based on the assumption that there exist industries that have "naturally" high exposure to a given policy (i.e. the treatment group), and such industries – to the extent that the policy is relevant to the outcome of interest – should be disproportionally more affected than other industries (i.e. the control group). In other words, identification will be obtained by comparing the differential MFP growth between highly exposed and marginally exposed industries in countries with different levels of a given policy. It is important to note, however, that this approach does not provide an estimate of the average effect of the policy of interest.

Industry-level indexes of exposure are taken from the large literature exploiting the same framework to infer the relevance of country-level policies on a number of economic outcomes. The exposure indexes are generally computed from US data because the United States is generally perceived to be a low regulation (i.e. "frictionless") country. Accordingly, the United States is excluded from the analysis. See Table 1.A1.1 for details on the country-level policy variables of interest and the corresponding industry-level exposure variables used in the difference-in-differences estimator.

To further explore the heterogeneous impact of policies, the term (*P***E*) is interacted with a firm's gap from the technological frontier to form a triple interaction term.

$$\Delta \ln A_{icst} = \delta_1 \Delta \ln A_{Fcst} + \delta_2 gap_{icst} + \delta_3 RI_{ct-1} + \sum_j \delta_4^j \left(P_{ct-1}^j * E_s^j\right) + \sum_j \delta_5^j \left(P_{ct-1}^j * E_s^j\right) * gap_{icst} + \gamma_s + \gamma_{ct} + \varepsilon_{icst}$$

The parameter combination of interest is $\delta_4 + \delta_5 * gap$. For example, when *P* corresponds to employment protection legislation (EPL), this parameter combination provides estimates of the effect of EPL on the evolution of firm-level productivity across countries, depending on the distance to the technological frontier. If $\delta_4 < 0$ and $\delta_5 < 0$, less

stringent EPL boosts productivity growth and the effect increases with the distance to the frontier; if $\delta_4<0$ and $\delta_5>0$, the boost to firm productivity from less stringent EPL decreases with distance to the frontier – that is, less stringent EPL enhances productivity growth relatively more (in exposed industries compared to non-exposed industries) for firms that are closer to the technological frontier. This implies that less stringent EPL would be associated with the expansion of the most productive firms, thereby raising dynamic allocative efficiency.

Table 1.A1.1. Structure of the differences-in-differences estimator and data sources

Variable	Country-level variable	Industry-level exposure variable
EPLR	EPLR is the OECD Employment Protection Legislation (EPL) sub-index of restrictions on individual dismissal of workers with regular contracts.	Layoff rates (defined as the percentage ratio of annual layoffs to total employment) at the industry level in the United States. Sourced from Bassanini et al. (2009). Sectoral ICT intensity: the share of ICT capital compensation in total capital compensation. Sourced from EU-KLEMS
Top marginal income tax rate	Sourced from the OECD.	Firm turnover rate (defined as the entry rate + exit rate) at the industry level in the United States. Sourced from Bartelsman et al. (2008). Sectoral ICT intensity: the share of ICT capital compensation in total capital compensation.
Corporate tax rate	Combined (government) corporate income tax rate, sourced from the OECD.	Relative profitability for the United States. Sourced from Schwellnus and Arnold (2008). Sectoral ICT intensity: the share of ICT capital compensation in total capital compensation.
Innovation-related policies	Higher education R&D as a percentage of GDP. Basic research as a percentage of GDP. Percentage of higher education R&D financed by industry. Each variable is sourced from the OECD Main STI Indicators.	Sectoral R&D intensity (R&D/value added) for the United States

Empirical results

While many empirical specifications were estimated, this section reports, for the sake of brevity, some of the key results given in the main text.

Baseline results

The baseline estimates are contained in Table 1.A1.2. The coefficient of the frontier firm's growth is positive while the coefficient on the gap term is also positive, reflecting the fact that as a firm gets closer to the frontier, the speed of catching-up slows down. The key policy results include:

- Lower product market regulation, as measured by regulation impact, is associated with higher firm MFP growth (columns 1-9). This is consistent with the findings of Arnold et al. (2011b) but covers a larger sample of OECD countries.
- In sectors with higher job layoff rates (where reallocation needs are likely to be more intense), lower EPL is associated with higher MFP growth but this effect is not statistically significant (columns 2 and 5).

- In sectors with higher relative profitability (where corporate taxes are most likely to bind), lower corporate tax rates are associated with higher firm MFP growth column 3 and 5) compared to other sectors. This confirms the findings of Schwellnus and Arnold (2008) but covers a larger sample of OECD countries.
- In sectors with higher rates of firm turnover (top marginal income taxes are more likely to bind in entrepreneurial sectors), lower top marginal income tax rates are associated with higher firm MFP growth compared to other sectors (columns 4 and 5).
- In more R&D-intensive sectors, increases in government spending on basic research (as a percentage of GDP) are associated with higher firm-level MFP growth (column 8) compared to other sectors. The same is true for higher rates of R&D performed by universities (column 7) and greater collaboration between industry and universities, as proxied by the share of higher education R&D financed by industry (column 9).

Table 1.A1.2. Firm level productivity growth and framework policies: Baseline results

Dependent variable: MFP growth, selected OECD countries, 1999-2009

	Selected Framework Policies					Selected Innovation Policies		
	(1)	(2)	(3)	(4)	(5)	(7)	(8)	(9)
VARIABLES	PMR	EPL	Corp-Tax	Top MTR	All-in	Higher Ed	Basic	Collab
Gap with frontier (t-1)	0.300***	0.300***	0.300***	0.301***	0.301***	0.281***	0.242***	0.242***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.015)	(0.011)	(0.011)
Growth at the frontier (t)	0.200***	0.200***	0.200***	0.199***	0.199***	0.178***	0.183***	0.183***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.018)	(0.024)	(0.024)
Regulation Impact(t-1)	-0.209**	-0.204**	-0.204**	-0.201**	-0.190**	-0.225***	-0.208***	-0.202***
	(0.094)	(0.092)	(0.089)	(0.094)	(0.086)	(0.074)	(0.060)	(0.062)
EPLR(t-1) X layoff		-0.007			-0.007			
		(0.008)			(0.008)			
Corporate tax rate(t-1) X profitability			-0.003		-0.004*			
			(0.002)		(0.002)			
Top marginal tax rates (t-1) X turnover				-0.000***	-0.001***			
				(0.000)	(0.000)			
Higher education R&D to GDP (t-1) X R&D						1.232***		
						(0.471)		
Basic reseach expenditure to GDP (t-1) X R&D							1.800***	
							(0.471)	
Per cent of HERD financed by industry (t-1) X R&D								0.022*
								(0.012)
Country*year fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
Industry fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
Observations	16 238 040	16 238 040	16 238 040	16 238 040	16 238 040	15 360 766	15 360 766	15 360 766
R-squared	0.195	0.195	0.195	0.196	0.196	0.167	0.167	0.167

Notes: MFP estimates are based on the superlative index approach. The standard errors are clustered at country*industry cells. Resampling weights are applied to match the observed industry and size class structure for each country from the SDBS (Gal, 2013). The estimation covers all non-frontier firms for the years 1999-2009 for the non-farm business sector, excluding mining. Both TFP measures use uniform, cross-country average labour shares (Solow) or reference values (superlative index) in order to ensure international comparability of productivity levels. The regression includes 18 countries: AT, BE, CZ, DE, DK, ES, FI, FR, GB, GR, HU, IT, KR, NL, NO, PT, SE, SK. The United States is excluded from the regressions since it is the benchmark country for the sectoral exposure variables. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Experimentation and dynamic allocative efficiency: Evidence from ICT-intensive sectors

Experimentation and reallocation may be more important in sectors with high ICT intensity, while there are important complementarities between ICT and KBC assets such as organisational capital, as discussed in the main text. Accordingly, the extent to which the impact of policies varies with the ICT intensity of the sector is explored (Table 1.A1.3).

Table 1.A1.3. Firm level productivity growth and framework policies in ICT-intensive sectors

Dependent variable: MFP growth, selected OECD countries, 1999-2009

	Base model				Policies vary with distance to frontier			Memo
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	EPL	Corp-Tax	Top-MTR	All-in	EPL	Corp-Tax	Top-MTR	Org Cap
Gap with frontier (t-1)	0.276***	0.275***	0.276***	0.277***	0.246***	0.246***	0.250***	0.277***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.020)	(0.021)	(0.021)	(0.014)
Growth at the frontier (t)	0.176***	0.174***	0.175***	0.175***	0.177***	0.174***	0.176***	0.178***
	(0.016)	(0.016)	(0.016)	(0.016)	(0.015)	(0.015)	(0.015)	(0.017)
Regulation Impact(t-1)	-0.204***	-0.226***	-0.287***	-0.240***	-0.160	-0.199	-0.275*	-0.222**
	(0.065)	(0.079)	(0.078)	(0.071)	(0.121)	(0.140)	(0.142)	(0.087)
EPLR(t-1) X ICT	-0.111***			-0.087**	-0.277***			
	(0.042)			(0.038)	(0.054)			
Corporate tax rate (t-1) X ICT		-0.010*		-0.002		-0.019***		
		(0.006)		(0.006)		(0.006)		
Top marginal tax rate (t-1) X ICT			-0.011***	-0.009**			-0.015***	
			(0.003)	(0.003)			(0.004)	
Regulation Impact (t-1) X Gap with the frontier (t-1)					-0.042	-0.033	-0.015	
					(0.053)	(0.055)	(0.056)	
EPLR(t-1) X ICT X Gap with the frontier (t-1)					0.086***			
					(0.021)			
Corporate tax rate(t-1) X ICT X Gap with the frontier (t-1)						0.005***		
						(0.002)		
Top marginal tax rates (t-1) X ICT X Gap with the frontier (t-1)							0.003***	
							(0.001)	
Org capital stock/employment (t-1) X ICT								0.096**
								(0.048)
Country*year fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
Industry fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
Observations	17 536 040	17 536 040	17 536 040	17 536 040	17 536 040	17 536 040	17 536 040	15 963 936
R-squared	0.181	0.180	0.180	0.180	0.183	0.182	0.182	0.180

Notes: MFP estimates are based on the superlative index approach. The standard errors are clustered at country*industry cells. Resampling weights are applied to match the observed industry and size class structure for each country from the SDBS (Gal, 2013). The estimation covers all non-frontier firms for the years 1999-2009 for the non-farm business sector, excluding mining. The TFP measures use uniform cross-country reference values (superlative index) in order to ensure international comparability of productivity levels. The regression includes 18 countries: AT, BE, CZ, DE, DK, ES, FI, FR, GB, GR, HU, IT, KR, NL, NO, PT, SE, SK. The United States is excluded from the regressions since it is the benchmark country for the ICT intensity variables. The number of observations is larger than in Table 1.A1.2 owing to the greater industry coverage of ICT intensity relative to the sectoral exposure variables utilised in Table 1.A1.2. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

A number of findings concern the impact of framework policies on firm MFP growth:

- Less stringent EPL is associated with higher firm MFP growth in sectors with higher ICT intensity, compared to other sectors (column 1). This is consistent with the idea that less stringent EPL reduces exit costs, which is likely to increase the incentive to experiment with new and uncertain technologies.[55]

  - To appreciate the relevance of the estimated effect, consider the difference in annual firm MFP growth between a high ICT-intensive sector (such as computers and related activities) and a low ICT-intensive sector (such as rubber and plastics manufacturing). The estimates in column 1 suggest that reducing EPL from the high levels of Portugal to the low level of the United Kingdom implies a gain in the above differential in excess of 0.15 percentage points a year.
  - The triple interaction term EPL*ICT*Gap in column 5 is positive, indicating that the boost to productivity from less strict EPL diminishes the further away a firm is from the frontier. Thus, stringent EPL penalises the most productive firms and undermines dynamic allocative efficiency. The magnitude of this effect is considerably larger than for the average firm example cited above. Additional analysis suggests that the latter result (i.e. as implied by the triple interaction term) is also robust to using job layoff rates (as in Table 1.A1.2) to measure the exposure of each sector to EPL.

- Reductions in corporate taxes are associated with higher firm MFP growth in ICT-intensive sectors (column 2) and this effect is most powerful for firms close to the frontier (column 6). Additional analysis suggests that the latter result is also robust to using relative profitability (as in Table 1.A1.2) to measure the exposure of each sector to corporate tax rates.
- Lower top marginal tax rates are associated with higher firm MFP growth in ICT-intensive sectors (Column 3) and this effect is most powerful for firms close to the frontier (column 7), possibly reflecting the effect of taxes on entrepreneurial activity and risk taking. Additional analysis suggests that the latter result is also robust to using firm turnover rates (as in Table 1.A1.2) to measure the exposure of each sector to top marginal tax rates.

Finally, column 8 of Table 1.A1.3 explores the possible complementarities between organisational capital – a key component of KBC – and ICT. The positive coefficient on the interaction term suggests that in sectors with higher rates of ICT intensity, increases in organisational capital intensity (sourced from Corrado et al., 2012) are associated with swifter firm MFP growth than in other sectors.

Unreported results and robustness tests

The core results are robust to using different measures of MFP, such as Solow residual estimates based on uniform cross-country average labour shares. Unreported results include additional explorations of the impact of policies such as various measures of financial and banking regulation (interacted with the dependency of each sector on external finance); fiscal incentives for R&D (interacted with sectoral R&D intensity); intellectual property rights regimes (interacted with sectoral R&D and patenting intensity); time-invariant measures of bankruptcy law (interacted with firm turnover and the dependency of each sector on external finance). These results were generally inconclusive.

Annex 1.A2.

The market for seed and early-stage financing and supply-side policy initiatives

Governments attempt to nurture the market for seed capital through a range of supply-side policy initiatives (Table 1.4; Wilson and Silva, 2013). This annex summarises empirical work that explores the impact of policy indicators constructed from these data on outcomes in the market for venture capital and seed and early stage financing.

Data

The data on venture capital deals are sourced from ThomsonOne, a commercial database published by Reuters. ThomsonOne is the main available source for venture deals, and collects data based on voluntary reporting by venture capital firms. Therefore, these data constitute a (not necessarily random) sample of the whole population of venture capital deals.

Data collection by ThomsonOne started in the United States in the 1970s. Coverage has increased over time, both within and across countries. While ThomsonOne does not release information about coverage, it has clearly increased since the late 1990s, when venture capital boomed in the "dot.com" bubble years. Since both coverage and venture capital activity increased over time in most countries, it is not possible to tell them apart. It is important to be aware of these data limitations when interpreting the results reported below.

Deal-level data for the 34 OECD countries for 1990-2011 are collected (coverage in the database for 2012 is still incomplete).[56] Of the 124 000 deals in the dataset, nearly 75% are from the period since 2000. The United States accounts for well over half of the recorded deals.

The data have been collected at the country/year level and include the following variables:

- number of venture capital deals and early-stage deals
- company age (all deals) and company age (early-stage deals)
- amount invested (all deals, in USD) and amount invested (early-stage deals, in USD).

The result is a panel dataset that spans 34 countries and 21 years. As some data are not available for some countries or years, that the panel is somewhat unbalanced.

Econometric framework

The goal of this exercise is to assess the effectiveness of public policy support to venture capital financing. For this, the focus is on a variable that counts the number of policy support programmes (NAP) – i.e. tax incentives and government equity finance instruments (see Table 1.4) – active in each country and year. Of course, this policy measure captures only one aspect of policy support and clearly the amount of public money channelled into such programmes is important. Indeed, it is possible that a single,

but well-funded, policy initiative could be more effective that several small programmes, but data constraints currently prevent an exploration of this issue. A more refined policy variable would also contain more detailed information on the characteristics of firms that are eligible for support, in order to better capture the incentives created by such interventions. Codifying such programme design features is clearly a difficult task but may become possible as more detailed data are acquired on public support policies for VC and early stage financing.

A fixed effects panel framework of the following form is estimated:

$$y_{ct} = \alpha + NAP_{ct-1} + x'_{ct-1} + \gamma_c + \delta_t + \varepsilon_{ct}$$

where y is the dependent variable, measured at country/year level; all dependent variables are expressed in logs to minimise the effects of outliers. α is a constant. The variable of main interest is *NAP*, the (lagged) policy measure, which varies across countries and years. A vector of (lagged) control variables (x) that vary both across countries and over time is also included. In the baseline specification, x includes GDP per capita and the corporate income tax rate.

Country-fixed effects (γ_c) are included to control for unobserved time-invariant country characteristics that may affect both policy attitudes and the supply of or demand for venture funds, as well factors such as resource endowments, slow-moving labour force skills and ingrained preferences. Indeed, it is possible that a country with a more entrepreneurial culture provides more public support to venture capital, but at the same time also exhibits a higher level of entrepreneurial companies, which in turn attract more venture funding. By exploiting variation within a country over time, such potentially confounding effects can be controlled for. The use of year fixed effects (δ_t) has the advantage of assuaging concerns about the increasing coverage of ThomsonOne over time, in the same way as country fixed effects account for (time-invariant) differential coverage across countries. ε is the error term.

While the panel approach constitutes a defendable strategy to deal with omitted variable issues, it is certainly not exempt from limitations. One particular concern is the endogeneity of policy measures to the state of the venture capital markets. Policy intensity is not random, as assumed by the econometric model, and it could increase in periods following low (or decreasing) venture capital activity. Therefore, the results cannot be interpreted as causal, but rather reflect a correlation, robust to the control of a wider set of variables.

Empirical results

Table 1.A2.1 reports the main results. The number of active programmes (NAP) is positively correlated with the number of VC and early-stage financing deals and negatively correlated with the size of such deals, but none of these effects is statistically significantly. However, NAP is negatively correlated with the average age at which firms receive early-stage financing, suggesting that increases in policy intensity are associated with greater flows of financing to younger firms. Estimates suggest that an additional active programme is associated with a 4.9% decrease in the age of the financed companies. This represents a decline of 2.4 months from the average age (i.e. 51 months) at which early-stage firms in the sample typically receive financing.

Table 1.A2.1. Venture capital and early-stage financing: The role of public support

OECD countries; 1990-2011

	(1)	(2)	(3)	(4)	(5)
ln RD stock (c,s,t-1)	-0.029***	-0.029***	-0.029***	-0.029***	-0.029***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
∆ln(RD stock,c,s,t-1)	0.328***	0.327***	0.326***	0.327***	0.327***
	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)
∆ln(VA,c,s,t-1)	-0.018*	-0.018*	-0.017*	-0.017*	-0.017*
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
EPL (c,t-1) * Job turnover us (s)	0.007				
	(0.008)				
EPL (c,t-1) * Firm turnover us (s)		0.009			
		(0.006)			
EPL (c,t-1) * Patents us (s)			-0.002**		
			(0.001)		
EPL (c,t-1) * Patents us (s) * Job turnover us (s)				-0.001**	
				(0.000)	
EPL (c,t-1) * Patents us (s) * Firm turnover us (s)					-0.001**
					(0.000)
Industry fixed effects	Yes	Yes	Yes	Yes	Yes
Country-time fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	7,709	7,709	7,709	7,709	7,709
R-squared	0.420	0.420	0.420	0.420	0.420

Note: Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

The results are robust to the inclusion of a range of time-varying policy indicators for which sufficient information is available for all OECD countries and for recent years. These include: the share of government-financed business enterprise R&D expenditure; higher education expenditure on R&D as a percentage of GDP; and average years of tertiary education.

Ideally, time-varying policy indicators that capture regulations affecting the business environment – such as product market regulations – would also be included but this would result in a non-trivial reduction in sample size as these indicators are not available for the full sample period. As an alternative, NAP was interacted with (time-invariant) dummy variables measuring whether a country was in the top or bottom half of the regulation distribution over the sample period. Three measures of regulation were included: the OECD Employment Protection Legislation Index and two variables from the OECD Product Market Regulation Index – the overall index and barriers to entrepreneurship sub-index. These results did not support the hypothesis that the impact of NAP varied with the regulatory environment.

Finally, the evolution of the capital gains tax rate was also controlled for, but this results in a significant reduction in sample size (189 observations, down from 306) since this variable is only available from 2000 (the capital gains tax data are from Achleitner et al., 2012). The capital gains tax rate had a negative relationship with the number of venture capital deals, but the coefficient is not statistically significant.[57] While the sign of the relationship between NAP and the amount and age of early-stage deals remains the same, it loses statistical significance in this smaller sample. This suggests that these results should be treated with caution and that more research is needed to understand the impact of such policies on the market for seed and early-stage financing.

Notes

1. The policy levers to boost the supply of skills in an economy are discussed at length in OECD (2012b).
2. The introduction of new or improved goods may also lead to an increase in measured MFP if MFP is based on sales rather than physical output, with an increase in price leading to an increase in revenue-based MFP. Most product innovations are also associated with process innovations (OECD, 2010), which are directly linked to an increase in (quantity-based measures of) MFP.
3. Only firms that successfully introduce multiple product innovations or continuously improve products over time maintain strong profits in a highly competitive environment (Roberts, 1999).
4. This is important as many successful entrepreneurs experienced business failure in the past (Choi, 2008).
5. The same is true of innovations that appear relatively incremental from a technological point of view but require fundamental organisational restructuring (Henderson and Clark, 1990).
6. More knowledge exchange will take place within the multinational firm (Criscuolo et al., 2010), from headquarters to affiliates and *vice versa*, via reverse technology transfer (Griffith et al., 2006), and from the multinationals to local economic agents and *vice versa* (Puga and Trefler, 2010).
7. Put differently, policies that directly affect the later stages of the innovation process may influence the earlier stages as well. For example, policies may offer direct incentives for within-firm productivity improvements but such incentives may be enhanced by policies that facilitate between-firm reallocations. Thus, the typical distinction between within- and between-firm (i.e. reallocation) contributions to aggregate productivity is blurred: entrepreneurs' efforts to increase within-firm productivity depend on expectations about the ability to benefit from between-firm shifts in resources.
8. Policies have dynamic effects on innovation and growth. Size-contingent policies (e.g. special tax treatment or low firing costs for smaller firms) can distort the incentives of firms to grow beyond the applicable size threshold (Braguinsky et al., 2011), thereby undermining allocative efficiency. Similarly, policies that initially remedy market failures may be increasingly costly over time if they continue to prop up formerly productive but now unproductive entrepreneurs and impede entry (Buera et al., 2013).
9. MFP growth relates a change in output to changes in several types of inputs. MFP is often measured residually, as the change in output that cannot be accounted for by the change in combined inputs.
10. For details on how KBC investment figures are estimated and underlying assumptions, see Corrado et al. (2012).
11. This assumes that the estimated factor share reflects the marginal product of KBC.

12. For example, in a sample of 26 OECD countries in 2008, the rank correlation between headline business R&D (BERD) intensity and BERD adjusted for differences in industrial structure is around 0.80 (see OECD 2011a for details).

13. The estimates were constructed using a variety of sources and techniques, and require assumptions about depreciation rates and deflators. However, the approach is standardised to facilitate cross-country comparisons. For more details, see Corrado et al. (2012).

14. In this study, Europe includes France, Germany, Italy, Poland, Portugal, Sweden and the United Kingdom.

15. The extent to which the most productive firms are also the largest at any point in time will reflect the extent to which resources are reallocated away from less productive to more productive uses over preceding time periods.

16. Cross-country differences in firm growth trajectories may also reflect differences in the extent to which young firms are absorbed by larger incumbent firms. Unfortunately, evidence on this issue is scarce.

17. The low sensitivity of resources to patenting in countries such as Denmark and Finland may reflect the fact that firms in small open economies may expand abroad rather than domestically, but it is difficult to capture this margin of adjustment with the available data. Additional analysis suggests that patenting has a larger effect on average profitability and wages than firm size in these countries, but this cannot explain all of the observed difference.

18. R&D and patents are proxies for investment in KBC and innovation outputs, respectively, and only capture (the technological) part of investment in KBC. However, both measures are comparable across countries: R&D because the definition is well codified and internationally harmonised in the *Frascati Manual* (OECD, 2002) and patents because they come from administrative data. Moreover, macro- and micro-level evidence of the link between R&D, patents and productivity (growth) has been growing steadily since the seminal work of Griliches (1979).

19. By lowering the cost and/or raising the quality of inputs required by innovative firms to underpin their expansion, pro-competitive reforms to regulations in the services sector might disproportionately raise the productivity growth of firms closest to the technological frontier (Arnold et al., 2011b).

20. See Martin and Scarpetta (2012) for a comprehensive review of recent cross-country evidence.

21. While the empirical evidence in this section is drawn from cross-country studies, a country-specific literature is emerging that models the behaviour of the firm in an optimisation framework and calibrates the resulting model to replicate the characteristics of the country's population of firms, e.g. Epaulard and Pommeret (2006) for France.

22. Robust public institutions that provide strong rule of law and minimise corruption and informality support efficient resource allocation (D'Erasmo and Moscoso-Boedo, 2012).

23. The cost of enforcing contracts is sourced from the World Bank and measures the court costs and attorney fees as a share of the debt value.

24. This is consistent with research showing that easier contract enforcement makes it less costly to hire the skilled workers needed to underpin firm growth (Bloom et al., 2013a).

25. The seven OECD countries that do not offer R&D tax incentives are Estonia, Germany, Israel, Mexico, New Zealand, Sweden and Switzerland.

26. Country-specific policy recommendations should take into account not only cross-country evidence but also evaluations of single programmes within countries.

27. User costs are captured by the B-index (Warda, 2001), which measures the present value of before-tax income that a firm needs to generate in order to cover the cost of an initial R&D investment and to pay the applicable income taxes. See Westmore (2013) for details.

28. Bloch and Graversen (2008) note that past government support for R&D often involved contracts whereby governments would fund and procure the output of firms' R&D activity. This may have meant that much of the R&D performed was not directly commercially viable and therefore limited the size of knowledge spillovers across firms and industries.

29. These estimates assume a volume-based R&D tax incentive regime for computational ease. However, caution is warranted in interpreting these results since single-country econometric exercises suggest that the bang-for-the-buck multiplier is much larger for incremental schemes than for volume-based schemes (Lokshin and Mohnen, 2008).

30. This is consistent with the idea that smaller firms are more likely to be credit-constrained.

31. R&D fiscal incentives can also be designed to incorporate a countercyclical dimension (Aghion et al., 2009; López-García et al., 2012). See Andrews and de Serres (2012) for a discussion.

32. This is consistent with recent evidence from Finland and Germany showing that direct support schemes do not preserve the dominance of market leaders but make small firms more likely to undertake R&D (Czarnitzki and Ebersberger, 2010).

33. Tax policy may also be encouraging the migration of KBC to offshore holding companies and the use of KBC in foreign rather than domestic production. In this case, tax revenues from R&D and domestic knowledge spillovers may be lower than they would be in the absence of R&D tax incentives.

34. Furthermore, some public R&D may not seek to foster commercial innovation but may concern areas such as environmental protection, public health and national security.

35. Recently, Belgium, Denmark, Hungary, Italy, Spain, Canada and Japan have offered such inducements.

36. While the focus here is on patents other forms of IP are obviously important. See Andrews and de Serres (2012) and Hargreaves (2011). For a discussion of the international dimension of IPR protection, see Andrews and de Serres (2012).

37. Furthermore, in sectors with higher patenting intensity, less stringent barriers to firm entry are associated with higher allocative efficiency (Andrews and Cingano, 2012).

38. They do so notably by acquiring patents from bankrupt companies, by organising patent auctions and by helping businesses to obtain the rights to use ideas through licensing arrangements (see Chien, 2009).

39. These are webs of overlapping IPRs for which the rights are held by competing firms (Shapiro, 2001). They may be most common in fields in which innovation is relatively cumulative or there is incentive for firms to hold patents for defensive or strategic purposes.

40. Here, the financial market is defined as the sum of the stock and bond market and of private credit by banks, all normalised with respect to GDP.

41. Moreover, the uncertainty surrounding the treatment of intangibles during bankruptcy is likely to accentuate financing difficulties, partly because the value of intangible assets is more prone to erosion during asset "fire sales" given the greater tendency of intangible assets to generate firm-specific value (e.g. growth opportunities, managerial and firm-specific human capital, and operating synergies, the value of which depends on keeping the firm's assets together; Hotchkiss et al., 2008; Gilson et al., 1990).

42. There is also a tension between the limited appropriability and inherent uncertainty of intangibles, on the one hand, and, on the other, the capacity to control the asset and the probability of future benefits required for accounting purposes: attributes (b) and (d) in Box 1.5.

43. Likewise, intangibles that are acquired through mergers and acquisitions are recorded as assets since they are valued in a "market" transaction (von Hippel, 1988), based on a negotiated acquisition cost which is often quite arbitrary

44. Lenders also used soft information (e.g. prior lending relationships) to alleviate moral hazard and contain monitoring costs. This analysis is based on a sample of large firms as opposed to start-up firms.

45. The impact of seed and early-stage capital on resource flows to patenting firms is only statistically significant for young firms (Andrews et al., 2013).

46. For example, business angel groups in Mexico cannot organise themselves as limited liability entities (OECD, 2013b). This has important consequences both for the legal standing of minority shareholders and for issues related to management of trusts and execution of guarantees, which must be carried out by the courts. In order to protect their minority shareholders and be able to apply trusts decisions directly, Mexican business angel networks register as limited liability companies abroad, mainly in Canada and in the United States.

47. This likely reflects the frequent changes in the availability and generosity of such measures, further underscoring the importance of a predictable policy environment for the financing of innovative ventures.

48. Due to data constraints, it was only possible to measure generosity in terms of the number of policy instruments (fiscal incentives and government equity finance programmes; see Da Rin et al., 2013). Note that government equity finance programmes also include some business angel policies.

49. Secondary stock markets specialised in high-technology firms have traditionally constituted a popular exit route, owing to their lower costs and less stringent admission requirements relative to first-tier markets.

50. In the software industry, products are often made of multiple components, each covered by numerous patents.

51. See Table 1.2 for a list of countries included in the analysis.

52. The distribution of firm productivity and size is typically not clustered around the mean (as would be the case with a normal distribution) but is characterised by many below-average performers and a smaller number of star performers, captured in the long right tail of the distribution (Haltiwanger, 2011).

53. For example, if SDBS employment is 30% higher than ORBIS employment in a given cell, then the 30% "extra" employment is obtained by drawing firms randomly from the pool of ORBIS firms, such that the "extra" firms will make up for the missing 30%. See Gal (2013) for more details.

54. This analysis is still informative, however, since cross-country differences in the post-entry performance of firms tend to be more marked than differences in entry and exit patterns (Bartelsman et al., 2003).

55. Similarly, the adoption of new ICT often requires internal reorganisation (e.g. Brynjolfsson, 2011). This is likely to be easier to accommodate in environments where EPL is less stringent.

56. Note that countries with small venture markets (e.g. Chile, Greece, Mexico, Slovenia, Turkey) may have few venture firms reporting deals and therefore appear even smaller than they actually are.

57. The capital gains tax rate was also interacted with the dummies for high and low regulation to test if the effect of taxes on the number of venture capital deals differs depending on regulations. This turned out not to be the case.

References

Acemoglu, D. and J. Linn (2004), "Market Size in Innovation: Theory and Evidence from the Pharmaceutical Industry", *Quarterly Journal of Economics*, Vol. 119(3), pp. 1049–1090.

Acharya, V.V. and K.V. Subramanian (2009), "Bankruptcy Codes and Innovation", *Review of Financial Studies*, Vol. 22 (12), pp. 4949-4988.

Acharya, V.V., R.P. Baghai and K.V. Subramanian (2010), "Labour Laws and Innovation", *NBER Working Paper*, No. 16484.

Achleitner, A-K, C. Bock and M. Watzinger (2012), "The Selection Effect of Taxes: The Case of Venture Capital Investment", www.eea-esem.com/files/papers/eea-esem/2012/1991/workfile1.pdf.

Aghion P. and P. Howitt (1992), "A Model of Growth through Creative Destruction", *Econometrica*, Vol. 60(2), pp. 323-351.

Aghion, P. et al. (2005), "Competition and Innovation: An Inverted-U Relationship", *Quarterly Journal of Economics*, Vol. 120(2), pp. 701-728.

Aghion, P. et al. (2004), "Entry and Productivity Growth: Evidence From Microlevel Panel Data." *Journal of the European Economic Association*, April-May, 2(2-3). pp. 265-276.

Aghion, P., P. Howitt and D. Mayer-Foulkes (2005), "The Effect of Financial Development on Convergence: Theory and Evidence," *Quarterly Journal of Economics*, Vol. 120(1), pp. 173-222.

Aghion, P. D. Hemous, and E. Kharroubi (2009), "Credit Constraints, Cyclical Fiscal Policy and Industry Growth", NBER Working Paper No. 15119.

Aghion, P. et al. (2013), "Investing for Prosperity: Skills, Infrastructure and Innovation", Report of the LSE Growth Commission.

Akcigit, U. and W.R. Kerr (2010), "Growth through Heterogeneous Innovations", *NBER Working Paper*, No. 16443.

Altomonte, C. (2010), "Reform and Growth: Microfounding Europe 2020", presentation, www.irer.it/convegni/archivioeventi/eventi-2010/seminario-produttivita-imprese/reformand-growth-micro-founding-europe-2020.

Andrews, D. and C. Criscuolo (2013), "Knowledge Based Capital, Innovation and Resource Allocation", *OECD Economics Department Working Papers* No.1046.

Andrews, D. and F. Cingano (2012), "Public Policy and Resource Allocation: Evidence from Firms in OECD Countries", *OECD Economics Department Working Papers*, No. 996, OECD Publishing, doi: http://dx.doi.org/10.1787/5k9158wpf727-en.

Andrews, D. and A. de Serres (2012), "Intangible Assets, Resource Allocation and Growth: A Framework for Analysis", *OECD Economics Department Working Papers*, No. 989, OECD, Paris.

Andrews, D., C. Criscuolo and C. Menon (2013), "Do Resources Flow to Innovative Firms? Cross-Country Evidence from Firm-Level Data" *OECD Economics Department Working Papers*, forthcoming, OECD, Paris.

Andrews, D. (2013), "Policy Determinants of TFP Growth: Evidence from firms in OECD countries", mimeo (results are summarised in Annex 1.A1).

Armour, J. and D. Cumming (2006), "The Legislative Road to Silicon Valley", *Oxford Economic Papers*.

Arnold, J. et al. (2011a), Tax Policy for Economic Recovery and Growth, *The Economic Journal*, Vol. 121, F59–F80.

Arnold, J., G. Nicoletti and S. Scarpetta (2011b), "Regulation, Resource Reallocation and Productivity Growth", *Nordic Economic Policy Review*, Issue 2.

Arora, A., A. Fosfuri and A. Gambardella. (2001), "Markets for Technology and Their Implications for Corporate Strategy," *Industrial and Corporate Change*, Vol. 10(2), pp. 419-51.

Australian Productivity Commission (2007), "Public Support for Science and Innovation", Australian Productivity Commission.

Australian Productivity Commission (2012), "Compulsory Licensing of Patents", Australian Productivity Commission. Available at: www.pc.gov.au/projects/inquiry/patents/report

Autor, D., L. Katz, and A. Krueger (1998), "Computing Inequality: Have Computers Changed the Labor Market?", *Quarterly Journal of Economics*, Vol. CXIII, pp. 1169–1214.

Autor, D.H. (2003), "Outsourcing at Will: the Contribution of Unjust Dismissal Doctrine to the Growth of Employment Outsourcing", *Journal of Labor Economics*, Vol. 21(1), pp. 1-42.

Autor, D.H., W.R. Kerr and A.D. Kugler (2007), "Do Employment Protections Reduce Productivity? Evidence from US States", *Economic Journal*, Vol. 117, F189–F217.

Bartelsman, E.J., S. Scarpetta and F. Schivardi (2003), "Comparative Analysis of Firm Demographics and Survival: Micro-Level Evidence for the OECD Countries", *OECD Economics Department Working Papers*, No. 348, OECD, Paris.

Bartelsman, E.J., (2004), "Firm Dynamics and Innovation in the Netherlands: A Comment on Baumol", *De Economist*, Vol. 152(3), 353-363.

Bartelsman, E.J. and H.L.F. De Groot (2004), "Integrating Evidence on the Determinants of Productivity", in G. Gelauff, L. Klomp, S. Raes, Th. Roelandt (eds.), *Fostering Productivity: Patterns, Determinants and Policy Implications*, Elsevier, Amsterdam, pp. 160-184.

Bartelsman, E.J., J. Haltiwanger and S. Scarpetta (2004), "Microeconomic Evidence of Creative Destruction in Industrial and Developing Countries", *IZA Discussion Paper*, No. 1374.

Bartelsman, E.J. and J. Hinloopen (2005), "Unleashing Animal Spirits: Investment in ICT and Economic Growth", in L. Soete and B. ter Weel (eds.), *The Economics of the Digital Society*, Edward Elgar, pp. 272-304.

Bartelsman, E.J., E. Perotti and S. Scarpetta (2008), "Barriers to Exit, Experimentation and Comparative Advantage", *RICAFE2 Working Paper*, No. 056, London School of Economics.

Bartelsman, E.J., P.A. Gautier and J. De Wind (2010), "Employment Protection, Technology Choice, and Worker Allocation", *IZA Discussion Paper*, No. 4895.

Bartelsman, E.J., J. Haltiwanger and S. Scarpetta (2012), "Cross-Country Differences in Productivity: The Role of Allocation and Selection", forthcoming in: *American Economic Review*.

Bas, M., Å. Johansson, F. Murtin and G. Nicoletti (2013), "Do Lower Tariffs on Foreign Intermediate Inputs Raise Productivity? Panel Data Evidence for OECD Countries". *OECD Economics Department Working Papers*, forthcoming, OECD, Paris.

Bassanini, A., L. Nunziata and D. Venn (2009), "Job Protection Legislation and Productivity Growth in OECD Countries", *Economic Policy*, Vol. 24, pp. 349-402.

Beltramello, A., A. Nolan and D. Pilat (2013), "Intelligent Demand: Policy Rationale, Design and Potential Benefits", *DSTI Working Paper,* forthcoming.

Benner, M.J. and M. Tushman (2002), "Process Management and Technological Innovation: A Longitudinal Study of the Photography and Paint Industries", *Administrative Science Quarterly*, Vol. 47(4), pp. 676-706.

Bertrand, M., E. Duflo and S. Mullainathan (2004), "How Much Should We Trust Differences in Differences Estimates", *Quarterly Journal of Economics,* Vol. 119(1), pp. 249-275.

Bessen, J. and M.J. Meurer (2008), *Patent Failure: How Judges, Bureaucrats and Lawyers Put Innovators at Risk*, Princeton University Press, Princeton, NJ.

Bessen, J,, J. Ford and M.J. Meurer (2012), "The Private and Social Costs of Patent Trolls, Do Nonpracticing Entities Benefit Society by Facilitating Markets for Technology?", *Regulation*.

Bhide, A. (2000), *The Origin and Evolution of New Businesses*, Oxford University Press, New York, NY.

Blanco Armas, E. et al. (2006), "Public Financial Support for Commercial Innovation: Europe and Central Asia Knowledge Economy Study Part 1", *World Bank Chief Economist's Regional Working Paper Series*, Vol. 1, No. 1.

Blanes, J.V. and I. Busom (2004), "Who Participates in R&D Subsidy Programs? The Case of Spanish Manufacturing Firms", *Research Policy*, Vol. 33(10), pp. 1459-1476.

Bloch, C., and E.K. Graversen (2008), "Additionality of Public R&D Funding in Business R&D", *Danish Centre for Studies in Research and Research Policy Working Paper* 2008/5.

Bloom, N. and J. Van Reenen (2002), "Patents, Real Options and Firm Performance", *Economic Journal,* Vol. 111, C97-C116.

Bloom, N., R. Griffith and J. Van Reenen (2002), "Do R&D Tax Credits Work?", *Journal of Public Economics,* Vol. 85, pp. 1-31.

Bloom, N. and J. Van Reenen (2007), "Measuring and Explaining Management Practices Across Firms and Countries", *Quarterly Journal of Economics*, Vol. 122(4), pp. 1351-1408.

Bloom, N. and J. Van Reenen (2010), "Why Do Management Practices Differ across Firms and Countries?", *Journal of Economic Perspectives*, Vol. 24(1), pp. 203–224.

Bloom, N., M. Draca and J. Van Reenen (2011), "Trade Induced Technical Change: The Impact of Chinese Imports on Innovation, Diffusion and Productivity", mimeo. www.stanford.edu/~nbloom/TITC.pdf

Bloom, N., C. Genakos, R. Sadun and J. Van Reenen (2012a), "Management Practices Across Firms and Countries", *NBER Working Paper*, No. 17850.

Bloom, N., R. Sadun and J. Van Reenen (2012b), "Americans Do IT Better: US Multinationals and the Productivity Miracle", *American Economic Review*, Vol. 102(1), pp. 167–201.

Bloom, N., B. Eifert, A. Mahajan, D. McKenzie and J. Roberts. (2013a), "Does Management Matter: Evidence from India", *Quarterly Journal of Economics* Vol. 128(1), pp. 1-51.

Bloom, N., M. Schankerman and J. Van Reenen (2013b), "Identifying Technology Spillovers and Product Market Rivalry", *Econometrica*. forthcoming.

Bouis, R., R. Duval and F. Murtin (2011), "The Policy and Institutional Drivers of Economic Growth Across OECD and Non-OECD Economies: New Evidence from Growth Regressions", *OECD Economics Department Working Papers*, No. 843, OECD, Paris.

Bourlès, R. et al. (2010), "Do Product Market Regulations in Upstream Sectors Curb Productivity Growth?: Panel Data Evidence for OECD Countries", *OECD Economics Department Working Papers*, No. 791, OECD, Paris.

Bozkaya, A. and W.R. Kerr (2013), "Labor Regulations and European Venture Capital", *Journal of Economics & Management Strategy* (forthcoming).

Braguinsky, S., L. Branstetter and A. Regaterio (2011), "The Incredible Shrinking Portuguese Firm", *NBER Working Paper*, No. 17265.

Brander, J., Q. Du and T. Hellmann (2011), "The Effects of Government-Sponsored Venture Capital: International Evidence", NBER Working Paper No. 16521.

Bravo-Biosca, A. (2010), Growth Dynamics: Exploring Business Growth and Contraction in Europe and the US", research report, NESTA and FORA, London.

Bravo-Biosca, A., C. Criscuolo and C. Menon (2013), "What Drives the Dynamics of Business Growth?", *OECD Science, Technology and Industry Policy Papers*, No. 1, OECD Publishing, doi: http://dx.doi.org/10.1787/5k486qtttq46-en.

Bresnahan, T.F., E. Brynjolfsson and L.M. Hitt (2002), "Information Technology, Workplace Organization, and the Demand for Skilled Labor: Firm-Level Evidence", *Quarterly Journal of Economics*, Vol. 117(1), pp. 339-376.

Brouwer. E., T. Grosfeld, P. den Hertog and T. Poot (2005), "Evaluation of a Major Dutch Tax Credit Scheme (WBSO) aimed at promoting R&D", mimeo. ftp://ftp.zew.de/pub/zew-docs/evaluationR&D/EBrouwer.pdf

Brynjolfsson, E., A. Renshaw and V. Marshall Alstyne (1997), "The Matrix of Change: A Tool for Business Process Reengineering", *Sloan Management Review*, pp. 37-54.

Brynjolfsson, E., A. McAfee, F. Zhu and M. Sorell (2008), "Scale Without Mass: Business Process Replication and Industry Dynamics", SSRN eLibrary. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=980568

Brynjolfsson, E. and A. McAfee (2011), *Race Against The Machine: How the Digital Revolution is Accelerating Innovation, Driving Productivity, and Irreversibly Transforming Employment and the Economy*, Digital Frontier Press.

Brynjolfsson, E. (2011), "ICT, Innovation and the E-Economy", *EIB Papers*, Vol. 16(2), pp. 60-76.

Buera, F.J. and B. Moll (2012), "Aggregate Implications of a Credit Crunch", mimeo. www.princeton.edu/~moll/AICC.pdf

Buera, F.J., B. Moll and Y. Shin (2013), "Well-Intended Policies", *Review of Economic Dynamics*, 16(1), pp. 216-230.

Busom, I., B. Corchuelo and E. Martínez-Ros (2012), "Tax Incentives and Direct Support for R&D: What Do Firms Use and Why?," *Business Economics Working Papers* id-11-03, Universidad Carlos III, Instituto sobre Desarrollo Empresarial "Carmen Vidal Ballester".

Caballero, R. J. and M.L. Hammour (2005), "The Cost of Recessions Revisited: A Reverse-Liquidationist View," *Review of Economic Studies*, Vol. 72(2), pp. 313-341.

Caballero, R.J., T. Hoshi and A.K. Kashyap (2008), "Zombie Lending and Depressed Restructuring in Japan", *American Economic Review*, Vol. 98(5), 1943-1977.

Cappelen, Å., A. Raknerud and M. Rybalka (2012), "The Effects of R&D Tax Credits on Patenting and Innovations", *Research Policy*, Vol. 41(2), pp. 334-345.

Carlin, W. and C. Mayer (2000), "Finance, Investment and Growth", *Working Paper*, University of Oxford.

Caves, D., L. Christensen and E. Diewert (1982a), "The Economic Theory of Index Numbers and the Measurement of Input, Output and Productivity", *Econometrica*, Vol. 50(6), pp. 1393-1414.

Caves, D., L. Christensen and E. Diewert (1982b), "Multilateral Comparisons of Output, Input and Productivity Using Superlative Index Numbers", *Economic Journal*, Vol. 92, pp. 73-86.

Caves, R.E. (1985), "International Trade and Industrial Organization: Problems, Solved and Unsolved", *European Economic Review*, Vol. 28 (August), pp. 377-395.

Chien, C. (2009), "Of Trolls, Davids, Goliaths, and Kings: Narratives and Evidence in the Litigation of High-Tech Patents", *North Carolina Law Review*, Vol. 87, pp. 1571-1615.

Choi, A.S. (2008), "Entrepreneurs Turn Business Failure into Success" *Bloomberg Business Week*, 16 October 2008.

Ciccone, A. and E. Papaioannou (2007), "Red Tape and Delayed Entry", *Journal of the European Economic Association*, Vol. 5(2-3), pp. 444-458.

Cockburn, I.M. and M. MacGarvie (2007), "Patents, Thickets, and the Financing of Early-Stage Firms: evidence from the software industry", *NBER Working Paper*, No. 13644.

Cockburn, I.M., M.J. MacGarvie and E. Muller (2009), "Patent Thickets, Licensing and Innovative Performance", *ZEW Discussion Paper*, No. 08-101.

Coe, D.T. and E. Helpman (1995), "International R&D Spillovers", *European Economic Review*, Vol. 39, pp. 859-887.

Cohen, W.M., R.R. Nelson and J.P. Walsh (2002), "Links and Impacts: The Influence of Public Research on Industrial R&D", *Management Science* Vol. 48(1), pp. 1-23.

Colombo, M.G., L. Grilli and S. Murtinu (2011), "R&D Subsidies and the Performance of High-Tech Start-Ups". *Economics Letters*, Vol. 112(1), pp. 97-99.

Conway, P., D de Rosa, G Nicoletti and F Steiner (2006), "Product Market Regulation and Productivity Convergence", *OECD Economic Studies*, Vol. 2006(2), pp. 39-76, OECD, Paris.

Conway, P. and G. Nicoletti (2006), "Product Market Regulation in the Non-Manufacturing Sectors of OECD Countries: Measurement and Highlights", *OECD Economics Department Working Papers*, No. 530, OECD, Paris.

Corrado C., C. Hulten and D. Sichel (2005), "Measuring Capital and Technology: An Expanded Framework", in *Measuring Capital in the New Economy*, C. Corrado, J. Haltiwanger and D. Sichel (eds.), Studies in Income and Wealth, Vol. 65, The University of Chicago Press, Chicago, IL.

Corrado, C., J. Haskel, C. Jona-Lasinio and M. Iommi (2012), "Intangible Capital and Growth in Advanced Economies: Measurement Methods and Comparative Results", mimeo, INTAN-Invest.

Crespi, G., C. Criscuolo and J. Haskel (2008), "Productivity, Exporting, and the Learning-by-Exporting Hypothesis: Direct Evidence from UK Firms," *Canadian Journal of Economics*, Vol. 41(2), pp. 619-638.

Criscuolo, C., D. Czarnitzki, C. Hambro and J. Warda (2009), "Design and Evaluation of Tax Incentives for Business Research and Development: Good Practice and Future Development", final report submitted by the Expert Group on Impacts of R&D Tax Incentives to the European Commission, Directorate General – Research, 15 November.

Criscuolo, C., J.E. Haskel and M.J. Slaughter (2010), "Global Engagement and the Innovation Activities of Firms," *International Journal of Industrial Organization*, Vol. 28(2), pp. 191-202.

Criscuolo, C. and C. Menon (2013), "Feeding Green Ideas: Risk Finance in the Cleantech Sector", forthcoming *STI Working Paper*, OECD, Paris.

Czarnitzki, D., P. Hanel and J.M. Rosa (2005), "Evaluating the Impact of R&D Tax Credits on Innovation: A Microeconometric Study on Canadian Firms", Centre interuniversitaire de recherche sur la science et la technologie, *Note de recherche* 2005-02, Montreal, Canada.

Czarnitzki, D. and B. Ebersberger (2010), "Do Direct R&D Subsidies Lead to the Monopolization of R&D in the Economy", ZEW Discussion Paper No. 10-078, Mannheim.

Czarnitzki, D. and H. Hottenrott (2011), "Financial Constraints: Routine Versus Cutting Edge R&D Investment", *Journal of Economics and Management Strategy*, Vol. 20(1), pp. 121-157.

Danguy, J., G. de Rassenfosse and B. Van Pottelsberghe de la Potterie (2009), "The R&D-Patent Relationship: An Industry Perspective", *European Investment Bank Papers*, Vol. 14, No.1, pp. 170-195.

Da Rin, M., G. Nicodano and A. Sembenelli (2006), "Public policy and the creation of active venture capital markets", *Journal of Public Economics* 90, pp. 1699– 1723.

Da Rin, M., M. Di Giacomo and A. Sembenelli (2011), "Entrepreneurship, Firm Entry, and the Taxation of Corporate Income: Evidence from Europe", *Journal of Public Economics* 95(9-10), pp. 1048-1066.

Da Rin, M., T.F. Hellmann and M. Puri (2012), " A Survey of Venture Capital Research", in G. Constantinides, M. Harris and R. Stulz (eds.), *Handbook of the Economics of Finance*, Vol. 2, North Holland, Amsterdam.

Da Rin, M. et al. (2013), "The Market for Seed and Early Stage Financing and Supply-Side Policy Initiatives", mimeo (results are summarised in Annex 1.A2).

D'Erasmo, H.J. and P.N. Boedo (2012), "Misallocation, Informality, and Human Capital", mimeo. http://econweb.umd.edu/~derasmo/research/tfp_hk/dms.pdf

De Jong, J.P.J. and W.H.J. Verhoeven (2007), *WBSO Evaluation 2001-2005: Impacts, Target Group Reach and Implementation*, EIM, Zoetermeer and UNU-MERIT, Maastricht.

de Serres, A., S. Kobayakawa, T. Sløk and L. Vartia (2006), "Regulation of Financial Systems and Economic Growth", *OECD Economics Department Working Papers*, No. 506, OECD, Paris.

Duguet, E. and M. MacGarvie (2005), "How Well do Patent Citations Measure Flows of Technology? Evidence from French Innovation Surveys", *Economics of Innovation and New Technology*, Vol. 14(5), pp. 375-393.

Easterly, W. and R. Levine (2001), "It's Not Factor Accumulation: Stylized Facts and Growth Models", *World Bank Economic Review*, Vol. 15(2), pp. 221-224.

Elschner, C., C. Ernst, G. Licht and C. Spengel (2011), "What the Design of an R&D Tax Incentive Tells About its Effectiveness: A Simulation of R&D Tax Incentives in the European Union", *Journal of Technological Transfer*, Vol. 36, pp. 233-256.

Eisenberg, R. and R. Ziedonis (2010), "Markets for Patents", Research Conference, Technology Academics Policy. www.techpolicy.com/Blog/February-2010/-Markets-for-Patents%E2%80%9D-Research-Conference---Summar.aspx

Epaulard, A. and A. Pommeret (2006), "Bankruptcy Law and Firms' Behaviour", *Swiss Finance Institute Research Paper, No.* 07-08.

European Commission (2003), *Study on the Measurement of Intangible Assets and Associated Reporting Practices.* Brussels.

Falk, M. (2004), "What Drives Business R&D Intensity Across OECD Countries?", *WIFO Working Papers* 236, WIFO, Vienna.

Fisman, R.J. and V. Sarria Allende (2010), "Regulation of Entry and the Distortion of Industrial Organization", *Journal of Applied Economics*, Vol. 13(1), pp. 91-111.

FTC (2011), *The Evolving IP Marketplace: Aligning Patent Notice and Remedies with Competition*, Federal Trade Commission, Washington, DC.

Gal, P. (2013), "Measuring Total Factor Productivity at the Firm Level using OECD-ORBIS", *OECD Economics Department Working Papers*, No. 1049, OECD Publishing, doi: http://dx.doi.org/10.1787/5k46dsb25ls6-en.

Gambardella, A. (2008), "Ideas for Rent: An Overview of Markets for Technology", presented at 25th Celebration Conference on Entrepreneurship and Innovation – Organizations, Institutions, Systems and Regions, Copenhagen.

Geroski, P.A., S. Machin and J. Van Reenen (1993), "The Profitability of Innovating Firms", *RAND Journal of Economics*, 24(2), pp. 198-211.

Gilson, S.C., K. John and L.H.P. Lang (1990), "Troubled Debt Restructurings: An Empirical Study of Private Reorganization of Firms in Default", *Journal of Financial Economics*, Vol. 27, pp. 315-353.

Goldin, C. and L.F. Katz (2008), *The Race Between Education and Technology,* Harvard University Press, Cambridge, MA.

Graham, S.J.H., R.P. Merges, P. Samuelson and T. Sichelman (2009), "High Technology Entrepreneurs and the Patent System: Results of the 2008 Berkeley Patent Survey", *Berkeley Technology Law Journal*, Vol. 24, pp. 1255-1328.

Griffith, R., S. Redding and J. Van Reenen (2004), "Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Industries", *The Review of Economics and Statistics*, Vol. 86(4), pp. 883-895.

Griffith, R., R. Harrison and J. Van Reenen, (2006), "How Special Is the Special Relationship? Using the Impact of U.S. R&D Spillovers on U.K. Firms as a Test of Technology Sourcing", *American Economic Review*, Vol. 96(5), pp. 1859-1875.

Griffith, R., S. Redding and H. Simpson (2006), "Technological Catch-Up and the Role of Multinationals", Revised Version of *CEPR Discussion Papers*, No. 3765.

Griffith, R. and G. Macartney (2010), "Employment Protection Legislation, Multinational Firms and Innovation", *CEPR Discussion Papers*, No. 7628.

Griliches, Z. (1979), "Issues in Assessing the Contribution of Research and Development to Productivity Growth", *Bell Journal of Economics*, The RAND Corporation, Vol. 10(1), pp. 92-116.

Goolsbee, A. (1999), "Does Government R&D Policy Mainly Benefit Scientists and Engineers?", *American Economic Review*, Vol. 88(2), pp. 298-302.

Guellec, D. and B. van Pottelsberghe de la Potterie (2003), "The Impact of Public R&D Expenditure on Business R&D", *Economics of Innovation and New Technology*, Vol. 12(3), pp. 225-243.

Hægeland, T. and J. Møen (2007), "The Relationship Between the Norwegian R&D Tax Credit Scheme and Other Innovation Policy Instruments", Reports 2007/45, Statistisk sentralbyrå/Statistics Norway, Oslo-Kongsvinger.

Hall, R.E. (1991), "Labor Demand, Labor Supply, and Employment Volatility", In *NBER Macroeconomics Annual*, Vol. 6, pp. 17–46

Hall, B.H. and J.M. Van Reenen (2000), "How Effective are Fiscal Incentives for R&D? A Review of the Evidence", *Research Policy*, Vol. 29: pp. 449-469.

Hall, B. and A. Maffioli (2008), "Evaluating the Impact of Technology Development Funds in Emerging Economies: Evidence from Latin America", *NBER Working Paper* No. 13835.

Hall, B.H. and J. Lerner (2009), "The Financing of R&D and Innovation", *NBER Working Paper*, No. 15325.

Hall, B., J. Mairesse and P. Mohnen (2010), "Measuring the Returns to R&D", in *Elsevier Handbook of the Economics of Innovation*, B.H. Hall and N. Rosenberg (eds.), Burlington Academic Press.

Hall, B.H. and D. Harhoff (2012), Recent Research on the Economics of Patents, *NBER Working Paper*, No. 17773.

Haltiwanger, J., S. Scarpetta and H. Schweiger (2006), "Assessing Job Flows Across Countries: The Role of Industry, Firm Size and Regulations", *IZA Discussion Paper*, No. 2450, Bonn.

Haltiwanger, J. (2011), "Firm Dynamics and Economic Performance", mimeo. http://siteresources.worldbank.org/EXTABCDE/Resources/7455676-1292528456380/7626791-1303141641402/7878676-1306270833789/ABCDE_Haltiwanger_draft_May_2011.pdf

Hargreaves, I. (2011), *Digital Opportunity: A Review of Intellectual Property and Growth,* United Kingdom Intellectual Property Office.

Häussler, C., D. Harhoff and E. Müller (2012), "To Be Financed or Not - The Role of Patents for Venture Capital-Financing", *ZEW - Centre for European Economic Research Discussion Paper*, No. 09-003.

Healy, P.M and K.G. Palepu (2001), "Information Asymmetry, Corporate Disclosure, and the Capital Markets: A Review of the Empirical Disclosure Literature", *Journal of Accounting and Economics,* Vol. 31, pp. 405–440.

Henderson, R.M. and K.B. Clark (1990), "Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms", *Administrative Science Quarterly*, Vol. 35(1), pp. 9-30.

Henderson, R. (1993). "Underinvestment and Incompetence as Responses to Radical Innovation: Evidence from the Photolithographic Alignment Equipment Industry", *RAND Journal of Economics*, Vol. 24(2) pp. 248–270.

Holmes, T.J., D.K. Levine and J.A. Schmitz Jr. (2008), "Monopoly and the Incentive to Innovate When Adoption Involves Switchover Disruptions", *NBER Working Paper*, No. 13864.

Hotchkiss, E.S., K. John, R.M. Mooradian and K.S. Thorburn. (2008), "Bankruptcy and the Resolution of Financial Distress", *Handbook of Empirical Corporate Finance,* Vol. 2, Elsevier B.V., pp. 2-22.

Hsieh, C-T. and P. Klenow (2009), "Misallocation and Manufacturing TFP in China and India", *Quarterly Journal of Economics,* Vol. 124(4), pp. 1403-1448.

Hsieh, C-T. and P. Klenow (2012), "The Life Cycle of Plants in India and Mexico", NBER Working Paper No. 18133.

Hunter, L.C., E. Webster and A. Wyatt (2005), "Measuring Intangible Investment", *Melbourne Institute Working Paper Series, No.* 15/05, University of Melbourne.

Jarboe, K.P. (2008), "Building a Capital Market for Intangible Assets", *Intellectual Asset Magazine*, June/July, pp. 30-35.

Jaumotte, F. and N. Pain (2005a), "Innovation in the Business Sector", *OECD Economics Department Working Papers*, No. 459, OECD, Paris.

Jaumotte, F. and N. Pain (2005b), "From Ideas to Development: The Determinants of R&D and Patenting", *OECD Economics Department Working Papers*, No. 457, OECD, Paris.

Johansson, Å. et al. (2013), "Long-Term Growth Scenarios", *OECD Economics Department Working Papers*, No. 1000, OECD Publishing. doi: http://dx.doi.org/10.1787/5k4ddxpr2fmr-en.

Jones, C.I. (2005), "Growth and Ideas", Chapter 16 in P. Aghion and S. Durlauf (eds.), *Handbook of Economic Growth*, Vol. B, Elsevier B.V. Dan Diego.

Karkinsky, T. and N. Riedel (2012), "Corporate Taxation and the Choice of Patent Location Within Multinational Firms", *Journal of International Economics*, Vol. 88, pp. 176-185.

Kiyotaki, N. and J. Moore (1997), "Credit Cycles", *Journal of Political Economy*, Vol. 105, pp. 18-35.

Klapper, L., L. Laeven and R. Rajan (2006), "Entry Regulation as a Barrier to Entrepreneurship", *Journal of Financial Economics*, Vol. 82, pp. 591-629.

Kortum, S. and J. Lerner (2000), "Assessing the Impact of Venture Capital on Innovation", *Rand Journal of Economics*, Vol. 31, pp. 674-692.

Lemaire, J-P. (1996), "Sales Engineers Working on International Projects: Changing Patterns and Changing Roles", *International Business Review*, Vol. 5, Issue 6, pp. 603-629.

Lerner, J. (1999), "The Government as a Venture Capitalist: The Long-Run Impact of the SBIR Program", *Journal of Business*, Vol. 72(3), pp. 285-318.

Lerner, J. (2002), "Patent Policy Shifts and Innovation over 150 Years", *American Economic Review*, Vol. 92, pp. 221-225.

Lerner, J. (2008), *Boulevard of Broken Dreams: Why Public Efforts to Boost Entrepreneurship and Venture Capital Have Failed*, Princeton University Press, Princeton, NJ.

Lokshin, B. and P. Mohnen (2007), "Measuring the Effectiveness of R&D Tax Credits in the Netherlands", *CIRANO Working Papers*.

Lokshin, B. and P, Mohnen (2008), "Wage Effects of R&D Tax Incentives: Evidence from the Netherlands", *UNU-MERIT Working Paper*, No. 34, University of Maastricht.

Lokshin, B. and P. Mohnen (2009), "How Effective Are Level-based R&D Tax Credits ? Evidence from the Netherlands", Updated *UNU-MERIT Working Paper*, No. 29, University of Maastricht.

López-García, P., J.M. Montero and E. Moral-Benito (2012), "Business Cycles and Investment in Intangibles: Evidence from Spanish Firms", *Banco de España Working Paper*, No. 1219.

Loumioti, M. (2011), "The Use of Intangible Assets as Loan Collateral", Harvard Business School Job Market Paper.
http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1748675

Martin, J.P. and S, Scarpetta (2012), "Setting it Right: Employment Protection, Labour Reallocation and Productivity", *De Economist*, Vol. 160, pp. 89-166.

Marx, M., D. Strumsky and L. Fleming (2009), "Mobility, Skills, and the Michigan Non-Compete Experiment", *Management Science*, Vol. 55(6), pp. 875-889.

Melitz, M. (2003), "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity", *Econometrica*, Vol. 71, pp. 1695-1725.

Melitz, M. and G. Ottaviano (2008), "Market Size, Trade, and Productivity", *Review of Economic Studies,* Vol. 75, pp. 295-316.

Melitz, M. and D. Trefler (2012), "Gains from Trade When Firms Matter", *Journal of Economic Perspectives*, Vol. 26(2), pp. 91-118.

Moser, P. and A. Voena (2012), "Compulsory Licensing: Evidence from the Trading with the Enemy Act", *American Economic Review*, Vol. 102(1), pp. 396-427.

Moulton, B.R. (1991), "An Illustration of a Pitfall in Estimating the Effects of Aggregate Variables on Micro Units", *Review of Economics and Statistics*, Vol. 72, pp. 334-338.

Myles, G. (2009), "Economic Growth and the Role of Taxation", *OECD Economics Department Working Papers*, No. 713.

Nunn, N. (2007), "Relationship-Specificity, Incomplete Contracts and the Pattern of Trade", *Quarterly Journal of Economics*, Vol. 122 (2), pp. 569-600.

OECD (2002), *Frascati Manual 2002: Proposed Standard Practice for Surveys on Research and Experimental Development*, The Measurement of Scientific and Technological Activities, OECD Publishing.
doi: http://dx.doi.org/10.1787/9789264199040-en.

OECD (2006), *Economic Policy Reforms 2006: Going for Growth*, OECD Publishing.
doi: http://dx.doi.org/10.1787/growth-2006-en.

OECD (2008), "Intellectual Assets and Value Creation: A Synthesis Report", OECD, Paris? www.oecd.org/science/inno/40637101.pdf.

OECD (2009a), *Economic Policy Reforms 2009: Going for Growth*, OECD Publishing.
doi: http://dx.doi.org/10.1787/growth-2009-en.

OECD (2009b), *OECD Science, Technology and Industry Scoreboard 2009*, OECD Publishing.
doi: http://dx.doi.org/10.1787/sti_scoreboard-2009-en.

OECD (2010), *The OECD Innovation Strategy: Getting a Head Start on Tomorrow*, OECD Publishing.
doi: http://dx.doi.org/10.1787/9789264083479-en.

OECD (2011a), *OECD Science, Technology and Industry Scoreboard 2011*, OECD Publishing, doi: http://dx.doi.org/10.1787/sti_scoreboard-2011-en.

OECD (2011b), *Financing High-Growth Firms: The Role of Angel Investors*, OECD Publishing.
doi: http://dx.doi.org/10.1787/9789264118782-en.

OECD (2012), "New Sources of Growth: Knowledge-based Capital – Interim Project Findings", OECD Paris. www.oecd.org/innovation/50452962.pdf

OECD (2013), *Knowledge-based Start-ups in Mexico*, OECD Publishing. doi: http://dx.doi.org/10.1787/9789264193796-en.

Olley, G.S. and A. Pakes (1996), "The Dynamics of Productivity in the Telecommunications Equipment Industry", *Econometrica*, Vol. 64(6), pp. 1263-1297.

Parente, S.L. and E.C. Prescott (2000), *Barriers to Riches*, MIT Press, Cambridge, MA.

Park, W.G. (2008), "International Patent Protection: 1960-2005", *Research Policy*, Vol. 37, pp. 761-766.

Parsons, M. and N. Phillips (2007), "An Evaluation of the Federal Tax Credit for Scientific Research and Experimental Development", *Canadian Dept. of Finance Working Paper* 2007-08.

Peng, M.W., Y. Yamakawa and S.H. Lee (2010), "Bankruptcy Laws and Entrepreneur Friendliness", *Entrepreneurship Theory and Practice*, Vol. 34, pp. 517-530.

Pinto Ribeiro, S., S. Menghinello and K. De Backer (2010), "The OECD ORBIS Database: Responding to the Need for Firm-Level Micro-Data in the OECD", *OECD Statistics Working Papers*, 2010/1, OECD, Paris.

Puga, D. and D. Trefler (2010), "Wake Up and Smell the Ginseng: The Rise of Incremental Innovation in Low-Wage Countries", *Journal of Development Economics*, Vol. 91(1), pp. 64-76.

Rajan, R. and L. Zingales (1998), "Financial Dependence and Growth", *American Economic Review,* Vol. 88(3), pp. 559-586.

Roberts, P.W. (1999), "Product Innovation, Product–Market Competition and Persistent Profitability in the U.S. Pharmaceutical Industry", *Strategic Management Journal*, Vol. 20(7), pp. 655-670.

Roth, A.E. (2008), "What Have We Learned From Market Design?", Hahn Lecture, *Economic Journal*, No. 118 (March), pp. 285-310.

Samila, S. and O. Sorenson (2011a), "Noncompete Covenants: Incentives to Innovate or Impediments to Growth", *Management Science*, Vol. 57(3), pp. 425-438.

Samila, S. and O. Sorenson (2011b), "Venture Capital, Entrepreneurship and Economic Growth", *Review of Economics and Statistics*, 93(1), pp. 338-349.

Scherer, F. (2000), *Competition Policy, Domestic and International*, Edward Elgar Publishing, Northampton, MA.

Schmitz, J.A., Jr. (2005), "What Determines Productivity? Lessons from the Dramatic Recovery of the U.S. and Canadian Iron Ore Industries following Their Early 1980s Crisis", *Journal of Political Economy*, Vol. 113(3), pp. 582-625.

Schmookler, J. (1966), *Invention and Economic Growth*, Harvard University Press, Cambridge, MA.

Schumpeter, J.A. (1942), *Capitalism, Socialism and Democracy*, Harper, New York.

Schwellnus, C. and J. Arnold (2008), "Do Corporate Taxes Reduce Productivity and Investment at the Firm Level?: Cross-Country Evidence from the Amadeus Dataset", *OECD Economics Department Working Papers*, No. 641, OECD, Paris.

Shane, S. (2001), "Technology Regimes and New Firm Formation", *Management Science*, 47(9), pp. 1173-1190.

Shapiro, C. (2001), "Navigating the Patent Thicket: Cross-licenses, Patent Pools, and Standard-Setting", in A. Jaffe, J. Lerner and S. Stern (eds.), *Innovation Policy and the Economy*, Vol. 1, MIT Press for the National Bureau of Economic Research.

Sheehan, J. and A. Wyckoff (2003), "Targeting R&D: Economic and Policy Implications of Increasing R&D Spending", *OECD Science, Technology and Industry Working Papers*, 2003/08, OECD, Paris.

Taylor, C. and Z. Silberston (1973), *The Economic Impact of the Patent System*, Cambridge University Press, Cambridge.

Tushman, M.L. and P. Anderson (1986), "Technological Discontinuities and Organizational Environments", *Administrative Science Quarterly*, Vol. 31, pp. 439-465.

UK IPO (2011), "Patent Thickets: An Overview". www.ipo.gov.uk/informatic-thickets.pdf

van Ark, B., M. O'Mahony and M.P. Timmer (2008), "The Productivity Gap between Europe and the United States: Trends and Causes", *Journal of Economic Perspectives*, Vol. 22(1), pp. 25–44.

van Ark, B., J.X. Hao, C. Corrado and C. Hulten (2009), "Measuring Intangible Capital and its Contribution to Economic Growth in Europe", *EIB Papers*, Vol. 14(1), pp.62-93.

Vartia, L. (2008), "How do Taxes Affect Investment and Productivity?: An Industry-Level Analysis of OECD Countries", *OECD Economics Department Working Papers*, No. 656, OECD, Paris.

Von Hippel, E. (1988), *The Sources of Innovation*, Oxford University Press, Oxford.

Warda, J. (2001), "Measuring the Value of R&D Tax Treatment in OECD Countries", *OECD STI Review*, No. 27, pp.185-211.

Wasmer, E. (2006), "Interpreting Europe-US Labor Market Differences: the Specificity of Human Capital Investments", *American Economic Review,* Vol. 96(3), pp. 811-831.

Westmore, B. (2013), "R&D, Patenting and Growth: The Role of Public Policy", *OECD Economics Department Working Papers*, No. 1047, OECD Publishing. doi: http://dx.doi.org/10.1787/5k46h2rfb4f3-en.

Wilson, K. and F. Silva (2013), "Policies for Seed and Early Stage Finance: Summary of the 2012 OECD Financing Questionnaire", OECD DSTI Working Paper *forthcoming*.

WIPO (2010), "Annex 2, Patent Related Flexibilities in the Multilateral Legal Framework and Their Legislative Implementation at the National and Regional Levels", www.wipo.int/meetings/en/doc_details.jsp?doc_id=131629.

Ziebarth, N.L. (2012), "Misallocation and Productivity during the Great Depression", mimeo. www.iga.ucdavis.edu/Research/All-UC/conferences/berkeley-2012/ziebarth-paper

Chapter 2.

Taxation and knowledge-based capital

Effective tax rate measures of the tax burden on investment in R&D typically focus on the tax treatment of R&D expenditure, including the availability of R&D tax credits or allowances. This chapter reports work on identifying common cross-border tax planning strategies used by MNEs to avoid tax on returns from R&D, and incorporating these strategies in a new effective tax rate (QETR) model analysing effects of domestic and international tax policies on the tax burden on R&D, firm behaviour and tax revenues.

The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

Tax policy affects after-tax returns and may influence business decisions on investment in research and development (R&D) to create knowledge-based capital (KBC) and on the use of KBC in production. Through R&D tax credits or allowances, many OECD countries subsidise business expenditure on R&D. Indeed, tax relief of this kind is often central to efforts to foster innovation and growth. As emphasised in this chapter, significant tax relief on returns on KBC is available to multinational enterprises (MNEs) using cross-border tax planning strategies. A key message is that international tax policies and cross-border tax planning should be taken into account when measuring the tax burden on R&D by MNEs, and in assessing the design and behavioural effects of R&D tax incentives.

In spite of tax rules designed to protect the tax base, MNEs can often largely avoid domestic tax on income earned from the use of KBC, for example by assigning economic ownership of KBC to offshore holding companies. MNEs typically operate as integrated global businesses and are able (within the limits of the law) to exploit differences in tax systems and rates across countries and significantly reduce their overall tax bill. Because such tax planning is widespread in industries such as information and communications technology (ICT) and pharmaceuticals, for which KBC is crucial and MNEs are major players, this aspect must be addressed.

Owing in part to pressures to provide internationally competitive tax treatment, countries are generally reluctant to impose "controlled foreign company" (CFC) rules that tax on a current basis (rather than a deferred or exempt basis) royalty income received by offshore holding companies of resident MNEs. Moreover, it is difficult for tax authorities to establish an appropriate arm's-length price for transfers of KBC within a multinational group, as the characteristics of KBC often mean that there are neither similar transactions nor observable prices between unrelated parties. There are obvious risks that the managers of MNEs, possibly better aware of the value of KBC to the profitability of their businesses, may under-report its value in order to minimise their corporate tax burden.

It is difficult to make robust estimates of the global scale of profit shifting to no-/low-tax countries through MNE tax planning strategies that involve KBC, but the magnitudes appear to be significant. For example, research suggests that the corporate tax revenue cost to the US, in 2004, due to income shifting by US-based MNEs may be as high as USD 60 billion (approximately 35 per cent of corporate tax revenues), with possibly half of it due to aggressive transfer pricing of KBC-related transactions (Clausing, 2009).

Estimates of the tax burden (effective tax rate) on R&D tend to focus on the "pure domestic" case where KBC from domestic R&D is used in domestic production. While such estimates factor in R&D tax incentives, they largely ignore the international dimension of tax policy and overlook the effects of MNEs' tax planning behaviour. A main objective of the work on taxation undertaken in the New Sources of Growth project has been to identify common cross-border tax planning strategies of MNEs that use KBC in production and to incorporate these in a model analysing the effects of domestic and international tax policies on the tax burden on R&D, firm behaviour and tax revenues.

The OECD Centre for Tax Policy and Administration (CTPA) has developed a new effective tax rate (QETR) model for assessing tax burdens and examining the influence of domestic and international tax policy on business decisions to undertake R&D, where to hold KBC (e.g. patents) resulting from R&D, and where to locate production using it. The model captures effects of R&D tax credits and allowances, domestic "patent box" regimes that lower tax rates on income from KBC (to discourage the migration of KBC offshore), and common cross-border tax planning strategies, including tax avoidance on royalty income. These are important considerations, given the evidence that such tax planning is now widespread among MNEs (in some sectors more than others).

The overall objective of the project, with main findings presented here, is to assist countries in their efforts to assess how tax policy can most cost-effectively encourage investment in knowledge based capital. While the work presented here offers a new perspective, it needs to be more fully integrated into analyses of the broader questions of whether targeted government support should be provided, and if so, how much support should be given, to what types of KBC, and how public support is best provided (what policy instruments). The answers to these questions require other evidence and analyses to be brought together with more empirically based analyses, including further applications of the new QETR model.

Policy context and project objectives

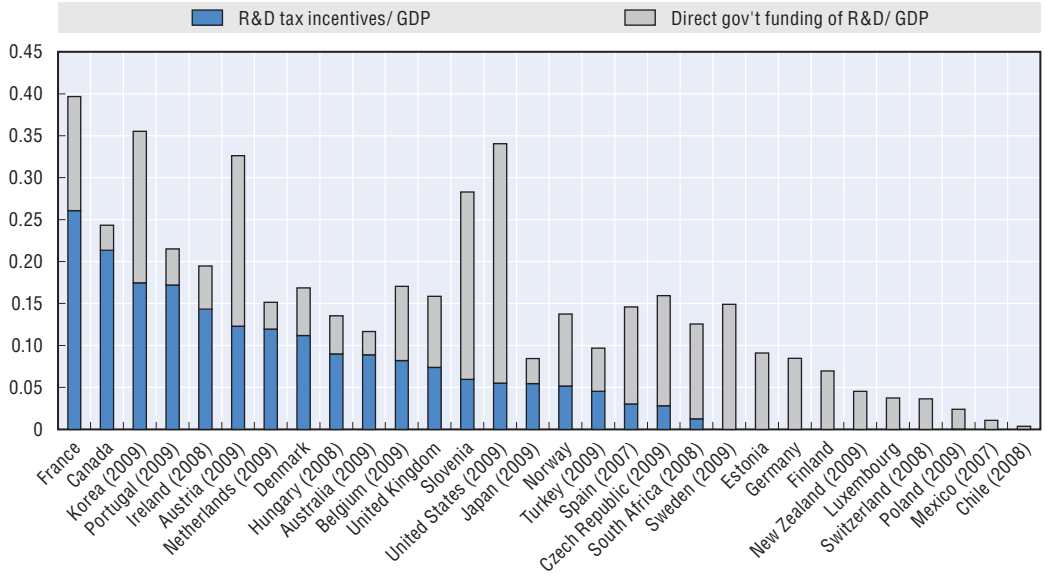
With numerous studies pointing to spillover benefits of R&D for the economy and the importance to growth of KBC, many countries offer up-front tax incentives that subsidise R&D expenditure.[1] As Figure 2.1 indicates, 24 OECD countries provided R&D tax credits or allowances in 2010 (double the number in 1995). Some countries also have "patent box" regimes that lower tax rates on income of resident taxpayers derived from KBC, including royalty income from patents. Today, governments face severe budget constraints and need to be sure that subsidies for R&D are worthwhile. This calls for systematic evaluation of tax relief measures in order to assess the continuing validity of their rationale and objectives and whether their targeting and design remain appropriate and intended outcomes are being achieved.

Assessment of the full scale of tax relief provided to R&D and predictions of behavioural responses require consideration not only of the tax treatment of R&D expenditure but also of the income earned on KBC created by R&D. Multi-national enterprises (MNEs), for example, use cross-border tax planning strategies – in particular, profit-shifting opportunities – to avoid corporate tax and obtain very high levels of overall tax relief on investment in R&D. The effects of such strategies are not captured by conventional effective tax rate measures. Incorporating these effects is an important complication, as there is considerable evidence that such tax planning is now widespread in industries such as pharmaceuticals and computer and electronic equipment manufacturing, where KBC is crucial and MNEs have a major market presence or even dominance.

International tax policies may result in the migration of economic ownership of KBC and intellectual property management activity to offshore holding companies, and encourage the use of KBC in foreign rather than domestic production. Resulting losses in domestic tax revenues and smaller domestic benefits from R&D weaken the case for special subsidies for R&D expenditure, including R&D tax credits and allowances. At the same time, relative to MNEs, stand-alone R&D performers (firms that are not part of a MNE group and thus without foreign affiliates to engage in cross-border tax-planning) may be placed at a competitive disadvantage relative to MNEs for undertaking R&D. In some cases this may inhibit the creation of KBC.

Figure 2.1. Direct government funding of business R&D (BERD) and tax incentives for R&D

Budget impact as a percentage of GDP; 2010 or latest available year



Notes: Countries ranked from highest to lowest R&D tax incentives/GDP. R&D tax incentives do not include sub-national incentives. Direct government funding includes grants and public procurement of R&D and excludes repayable loans. Figures are not shown for Greece, Israel, Italy, the Slovak Republic, China and the Russian Federation, which provide R&D tax incentives, but cost estimates are not available. For the United States, direct government funding of R&D includes defence spending on R&D by the government in the form of procurement contracts or the subcontracting by government agencies of non-classified projects to private firms. That is, it includes only R&D spending not directly performed by national or publicly funded institutions (e.g. military laboratories etc). If a project is conducted by the private firm in direct collaboration with the government, publicly funded institutions or universities, only the part that is done by the private firm and paid to her would be included. This figure is also included in Chapter 1 as Figure 1.17.

Source: OECD, Main Science and Technology Indicators (MSTI) Database, June 2012; OECD R&D tax incentive questionnaires of January 2010 and July 2011; OECD (2011), *OECD Science, Technology and Industry Scoreboard 2011*, OECD Publishing, doi: http://dx.doi.org/10.1787/sti_scoreboard-2011-en; and national sources.

It is particularly difficult for tax authorities to establish an appropriate arm's-length price for transfers of KBC within an MNE, as the characteristics of KBC often mean that there are no similar transactions or observable prices between unrelated parties. There are obvious risks that managers of a MNE, possibly better aware of the value of KBC to the profitability of their business, may under-report its value in order to minimise corporate income tax. Also, owing in part to pressures to provide internationally competitive tax treatment, countries are often reluctant to impose controlled foreign company (CFC) rules that tax on a current basis (rather than a deferred or exempt basis) royalty income received by offshore holding company affiliates of resident MNEs.

Some countries have introduced "patent/innovation box" rules which partly exempt from domestic corporate tax income derived from the use of KBC, including royalty income on licences. Such rules may discourage MNEs from locating economic ownership of KBC offshore. Of concern is that they may be used by MNEs for base erosion and profit-shifting (BEPS) purposes and result in significant foregone corporate tax revenues. The behavioural effects are unclear and depend on a number of factors. For example, MNEs may continue to have incentives to use offshore holding and finance companies to avoid tax on royalties (depending on patent/innovation box exemption rates) and interest income.

Designing cost-effective policies to promote innovation in a globalised economy in which KBC and MNEs play a major role is an enormous challenge. The intrinsic characteristics of KBC themselves create particular challenges for tax policy. For one, because of their intangible nature, intellectual assets may be developed in one country, held in another and used for production in a third. As noted, they are also hard to value when they are shifted between affiliates of an MNE, resident in different locations (owing to the absence of a market to gauge an arm's-length price). Transfer pricing challenges also concern other intangibles, such as brand names. All of this has made it easier for MNEs to shift profits between tax jurisdictions and harder for tax authorities to establish where profits have been earned and to tax them accordingly.

The liberalisation of trade and capital flows, technological and telecommunications developments and the increasing integration of emerging and developing economies in the global economy have heightened these concerns. These developments have had important effects on the structure and management of MNEs, which have shifted from country-specific operating models to global models. In today's MNEs the different companies of the MNE operate within a framework of group policies and strategies. These policies and strategies are likely to include managing the tax liabilities of the group as a whole, including by shifting profits between tax jurisdictions.

Against the backdrop of these developments and growing concerns over aggressive tax planning by MNEs (BEPS), international tax systems are being re-examined. A particular issue is the limited taxation of profits generated by KBC, given the relatively low cost and ease of moving intangible assets, including intellectual property, between the tax jurisdictions in which MNEs operate and the difficulties involved in pricing such assets.

These developments have led to a substantial gap in the analytical tools ("metrics") for assessing tax effects on R&D. To address this gap, standard theory on effective tax rates (ETRs) on investment projects (widely recognised in the public finance literature and used in ministries of finance in member countries) has been extended in the new QETR model to capture the impact not only of R&D tax credits and allowances but also of domestic "patent box" regimes for taxing returns to R&D. Common MNE cross-border tax planning strategies that involve KBC have also been identified and incorporated. The model is used to understand how domestic and international tax rules influence the tax burden on R&D, and to assess how taxation may influence decisions about how much R&D to undertake, where to locate economic ownership of KBC, and where to undertake production that exploits it.

A better understanding of MNEs' tax planning opportunities and implications for corporate decisions on where to locate economic ownership of KBC and where to use it in production, as well as implications for tax collections, has become a pressing issue. So far, the analysis has focused on illustrative examples under plausible parameter settings. Future work will incorporate OECD country-specific domestic and international tax policies and parameters and will examine effective tax rates on intangible and tangible capital, identify tax distortions, and explore the scope for efficiency and revenue-enhancing reforms.

Overall, the findings to date strongly suggest that the effects of international tax rules and tax avoidance strategies should be factored into tax burden assessment, despite the complexities involved. If substantial tax revenues, domestic productivity gains, and knowledge spillovers from R&D do not accrue to the country providing tax subsidies for R&D, some redesign of R&D tax incentives and tax allowances and, indeed, of the wider tax regime may need to be considered.

Market failure and productivity arguments for tax relief for R&D

In general, a neutral corporate income tax system is desirable, one that does not distort choice among investment projects. Under a neutral system, capital tends to be invested in line with pre-tax returns, with all projects meeting the same pre-tax "hurdle rate of return" at the margin. However, many OECD countries offer corporate tax incentives that lower the after-tax cost of R&D and thereby lower the hurdle rate of return, tending to stimulate R&D expenditure. Depending on their scale, R&D tax incentives may significantly offset the discouraging effects of corporate income tax (CIT) on investment. Indeed, if R&D incentive rates are set high enough, they may encourage R&D expenditure beyond levels that would be observed in the absence of tax.

As shown in Figure 2.1, many OECD countries offer up-front R&D tax incentives to spur R&D. A main reason is that KBC resulting from R&D enables productivity and process innovation, driving growth. While firms normally innovate as part of their profit-maximising strategy, governments keen to promote growth may wish to accelerate the innovation process. An additional rationale rests on the positive externality (spillover benefit) argument that, in the absence of subsidies for R&D, firms would tend to under-invest (relative to a socially optimal level) because they generally do not include in their R&D investment decisions the various benefits from their R&D that spill over into the economy.

Two properties of R&D and KBC have particularly positive implications for growth. First, benefits from investment in many forms of KBC flow not only to R&D investors in the form of returns on investment but also to others. For example, the staff who undertake R&D gain knowledge and experience which generates spillover benefits when they move to other firms, innovate and help achieve productivity gains. While the core spillover benefits from R&D may be those derived from R&D activity, secondary benefits may come from incorporating KBC into production. Such spillover benefits include the knowledge and experience gained by employees involved in embedding KBC into production. Such skills are also transportable.

Second, the cost incurred in developing KBC through R&D is not incurred again when KBC is used repeatedly in production. Software and product designs, for example, may be used simultaneously by many users without diminishing their productivity ("non-rivalry"). This can create economies of scale, with the effects on productivity reinforced by the positive network externalities created when the benefit from the network rises with the number of users. Such externalities are particularly prevalent in industries intensive in KBC, such as ICT.

Thus governments are generally keen to encourage R&D to realise domestic spillover benefits and drive growth. However, spillover benefits from R&D are increasingly global. Skilled R&D staff may be highly mobile and decide to relocate away from the jurisdiction where they performed tax-assisted R&D. Also, production activities of MNEs are becoming more global, with fewer and fewer restrictions on trade and investment and reduced transport, telecommunications and other trans-border business costs. With foreign production, there may be corresponding losses of domestic spillover benefits from R&D in the form of less knowledge and experience gained by workers from process innovation (involving the incorporation of new KBC in production). MNEs may in fact be encouraged to exploit KBC in low-tax foreign production and locate economic ownership of KBC in tax-favoured (offshore) holding company locations. Both effects could imply a tax-induced loss of potential spillover benefits and tax revenue. In some cases, such losses would tend to weaken the case for R&D tax credits for MNEs.

Evidence and elements of cross-border tax planning

A main objective of the study has been to identify common elements of cross-border tax planning strategies involving the use of KBC in production and to incorporate these in the QETR model.

Systematic and publicly available evidence on tax planning by MNEs is very limited, although tax authorities potentially have much more information available from taxpayer data. Much of the available evidence is for the United States, which makes such data publicly available, and suggests large amounts of offshore profits in sectors that use KBC intensively in production.

In particular, a 2011 report by the US Senate Subcommittee on Investigations gives a detailed account of the response to a tax provision introduced in the 2004 America Jobs Creation Act that provided a one-time reduction in US corporate tax on the repatriation of offshore profits.[2] This provision prompted the repatriation of USD 362 billion of dividends qualifying for tax relief. In the absence of this provision, significant amounts of US tax would have been payable on low-taxed foreign earnings, if repatriated, under the US worldwide tax system (with relatively low foreign taxes on foreign earnings achieved partly through complex tax planning strategies). The provision was aimed at encouraging US MNEs to repatriate such earnings, rather than invest them offshore, to promote domestic investment and employment.

Figure 2.2 shows cash dividends received by US-based MNEs, disaggregated by country of residence of the distributing controlled foreign company, while Figure 2.3 disaggregates the data by industry of the parent and by industry of the distributing CFC. The US study reports, as shown in Figure 2.3, that USD 289 billion (or roughly 80% of the USD 362 billion of dividends repatriated) were received by US manufacturing MNEs. Of this, USD 168 billion was paid directly by foreign manufacturing CFCs to their US parents, and USD 121 billion through other channels, including offshore holding companies.

Figure 2.2. Cash dividends of US MNEs on outbound FDI, repatriated under the one-time dividend received/corporate tax deduction provision, 2004-06

(millions USD)

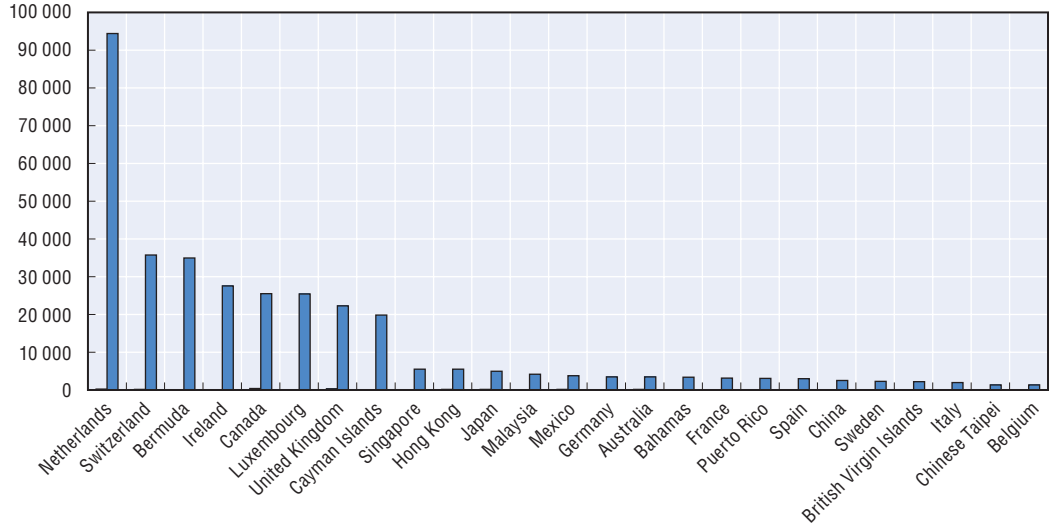


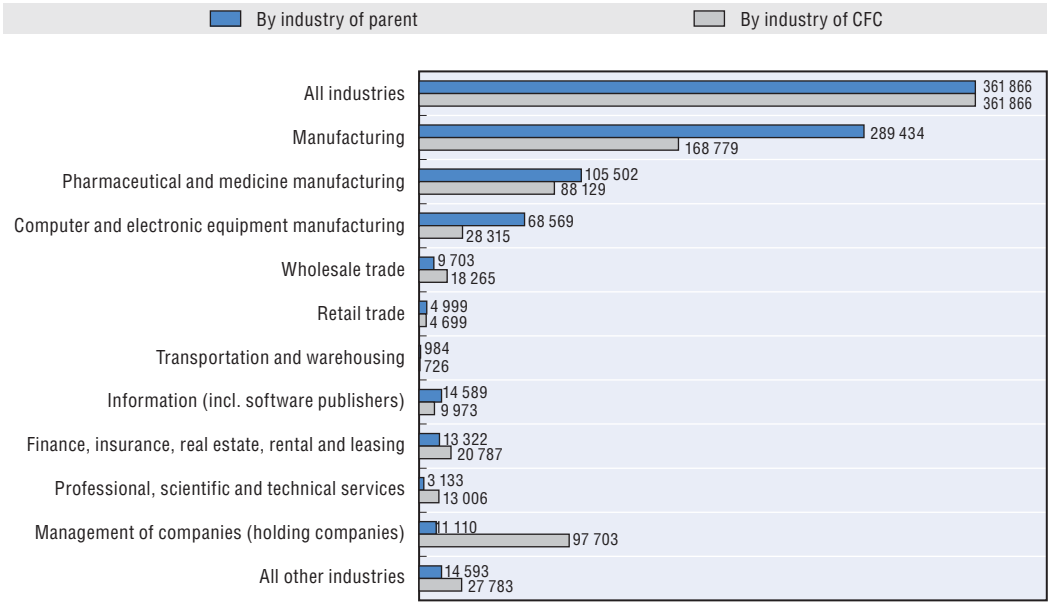
Chart shows data for the top 25 countries (where aggregate cash dividends exceeded USD 1.3 billion).

Source: US Internal Revenue Service (IRS), Statistics of Income Division.

Over USD 174 billion was received by MNEs in the pharmaceutical and technology manufacturing industries, where KBC is a key income-producing asset. In particular, USD 106 billion was received by MNEs in pharmaceutical and medicine manufacturing industries, and USD 69 billion by MNEs in computer and electronic equipment manufacturing industries. Of the 15 MNEs with the largest dividend repatriations, ten were in these manufacturing industries, and five (Pfizer, Merck, Hewlett-Packard, Johnson & Johnson, and IBM) accounted for 28% of total repatriations.

Figure 2.3. Cash dividends of US MNEs by industry of parent and by industry of CFC repatriated under the 2004-06 dividend received deduction

(millions USD)



Source: US Internal Revenue Service, Statistics of Income Division.

The US Senate Subcommittee investigation also reported that these repatriations came largely from jurisdictions with no corporate tax or otherwise attractive CIT regimes that enabled tax avoidance. Of the 19 companies accounting for the bulk of repatriations, seven repatriated between 90% and 100% of their offshore profits from jurisdictions with such regimes, another six repatriated between 63% and 89% of offshore profits, and another two between 30% and 39%.

To the extent that the available evidence (mostly from the United States) is representative, it points to the need for more systematic collection by other countries of data on cross-border related-party (inter-affiliate) royalty and interest flows. It also points to the need for more analytical and modelling work to assess rates of tax on investment in innovation more comprehensively, to inform strategies to counteract profit shifting and to promote innovation.

Based on reports of tax planning strategies and discussions with experts, the following common elements of cross-border tax planning involving the use of KBC in production were identified:

- Locating production in foreign host countries with an attractive (i.e. relatively low) statutory corporate income tax rate and possibilities to reduce or eliminate non-resident withholding tax at source on royalties, dividends and interest remitted abroad to another company in an MNE group (e.g. through the use of conduit entities).
- Reducing foreign (host country) corporate tax by increasing deductions against the host country corporate tax base (e.g. using tax-deductible royalty and interest payments), and through methods to reduce gross profit (e.g. risk stripping).
- Reducing domestic corporate income tax on the ultimate parent company – through the use of offshore holding and finance companies, conduits/intermediaries, preferential regimes, hybrid entities and hybrid instruments – on royalty income, interest income and profit.
- Using transfer pricing practices involving related-party transactions in knowledge capital (i.e. transfers of economic ownership, licences).
- Reducing domestic corporate tax using deductions for interest on funds borrowed to finance FDI that generates exempt or deferred foreign income.[3]

Metrics and main findings from the QETR model

The new QETR model measures tax wedges and corresponding effective tax rates (ETRs) as summary indicators of the tax burden on investment in R&D and the use of KBC in production. As described in Annex 2.A1, a "tax wedge" measures the difference between pre- and post-tax returns on investment at the margin. A positive (negative) tax wedge implies that taxation discourages (encourages) investment.

A main objective of the development of the QETR model is to provide summary tax burden indicators that account for the tax treatment of expenditures on R&D and income derived from the use of KBC in production.[4] In particular, the QETR metrics (tax wedges and ETRs) factor in R&D tax credits and allowances on R&D expenditure, as well as statutory tax relief from "patent box" regimes and reductions in domestic (home country) and foreign (host country) tax achieved by MNEs from various cross-border tax planning strategies.

The indicators are formula-based and thus provide a transparent means of examining how the details of international and domestic tax rules factor into tax burden assessment. One use of the indicators is to examine features of tax law that create differences in the tax burden for different taxpayer groups (e.g. the tax burden on R&D investment by MNEs versus that of stand-alone firms not part of an MNE group). Another is to assess the change in tax burden resulting from tax policy reform (e.g. reducing the R&D tax credit rate), or the tax policy required to achieve a given tax burden (e.g. the R&D tax credit rate that neutralizes the impediment to R&D resulting from corporate taxation of returns on investment).

A related application is the use of QETR metrics to assess how domestic and international tax policies may influence investment location and scale decisions. To varying degrees, R&D, intellectual property (IP) management and certain production activities employing KBC are geographically mobile, and MNEs' decisions about their location and the amount of capital to invest may be sensitive to tax policies affecting net returns on investment.

In general, IP management may be the most mobile and thus most sensitive to tax, to the extent that pre-tax profit determinants (e.g. management costs) are largely similar in alternative locations. Decisions on the location of R&D may also be sensitive to tax, particularly if R&D skills and facilities are supplied at similar pre-tax costs in alternative locations. As regards production, for certain outputs, key variables relevant to decisions on the location of production (e.g. transport and distribution costs) may vary significantly across locations so that tax considerations are not decisive in location choice. However, for other outputs (e.g. pharmaceuticals, electronic products), pre-tax returns may be similar and tax considerations may play a more decisive role.

The QETR metrics may be applied to assess possible tax distortions related to the location and scale of investment activity. By themselves, average effective tax rates indicate tax distortions that favour one location over another (with mobile investment attracted to relatively low-tax locations). For scale effects, tax wedges and corresponding marginal effective tax rates indicate the direction of bias. When combined with elasticity estimates of the sensitivity of investment to tax (derived from statistical analysis of investment data), they may be used to assess the percentage change in levels of investment when tax policy changes.

While R&D may be undertaken in the home country of the parent of a MNE, or in the country of a foreign affiliate or in more than one location, the QETR model assumes that R&D is carried out in the home country and assesses QETR metrics (tax wedges, ETRs) relevant to assessing tax effects on MNE decisions with respect to:

- the level of R&D
- the location of economic ownership of KBC
- the location of KBC used in production, i.e. home country vs. a foreign (low-tax) country
- the level of investment in physical capital used in production.[5]

As noted above, by itself the model indicates the direction of bias (e.g. whether tax encourages or discourages R&D relative to the no-tax case and under different uses of KBC), without measuring the level or percentage amounts by which investment is affected by tax.

An R&D tax wedge – measuring the (minimum) pre-tax net return on R&D that is just sufficient to pay corporate tax (see Box 2.A1.1 in Annex 2.A1) – is used to assess the tax burden on R&D, and tax effects (bias) on the level of R&D undertaken, relative to the no-tax case. The larger the tax wedge, the larger the tax burden on R&D and the larger the predicted negative effect of tax on the level of R&D. Taxation is predicted to be neutral and not distort R&D decisions when the average effective tax rate on economic profit derived from the use of knowledge in production ($AETR^*$) matches the effective rate at which R&D costs are offset by tax relief, in which case the R&D tax wedge is zero.[6]

The effective tax burden on production and possible tax distortions to the choice of where to locate KBC in production are assessed using an average effective tax rate on economic profit ($AETR^*$), calculated for different locations (home vs. foreign country). The $AETR^*$ is calculated as the present value of tax on royalties and profit (earnings in excess of royalties), divided by the present value of pre-tax economic profit. Tax policy is predicted to encourage investment in production in a location with relatively low $AETR^*$, and thus higher after-tax return, under the assumption of a fixed pre-tax rate of return. For

each location, a marginal effective tax rate (METR) is derived to assess tax distortions to the profit-maximising level (scale) of investment in physical capital in that location.

Based on illustrative results from the QETR model, the main findings are:

- In many countries, overall tax relief for R&D (particularly that of MNEs) may be greater than governments intended when they designed support of R&D expenditure. Analysis based on the QETR model suggests that when tax planning strategies to avoid tax on returns are taken into account, MNEs may obtain a much larger than intended tax subsidy for their investment in R&D, and the post-tax return on R&D spending may exceed the pre-tax return.
- Compared to MNEs, stand-alone R&D performers (firms that are not part of a MNE group, and thus without foreign affiliates to engage in cross-border tax planning) may be placed at a competitive disadvantage. This disadvantage in terms of scope for tax planning may be more pronounced for business start-ups that are not part of a MNE group and have not yet generated taxable income to make immediate use of R&D tax credits (if they are non-refundable). The absence of a level playing field may make it more difficult for such firms to compete with MNEs. This may inhibit knowledge creation, as such firms may have particular strengths as R&D performers (e.g. in creating radical innovations). The analysis strengthens the case for targeting R&D tax credits to SMEs, in particular those that are not part of a multinational group. This approach is supported by OECD analysis performed under the New Sources of Growth project which shows that the productivity impacts of fiscal incentives are unclear, possibly because they may favour incumbents at the expense of more dynamic young firms.

  If countries do not choose to target R&D tax credits, they may decide instead to consider scope for curtailing profit shifting by MNEs to level the playing field without significant negative impacts on innovation activity. OECD work on base erosion and profit shifting (BEPS) will provide a collaborative framework for developing appropriate reforms to international tax systems (OECD, 2013).
- No-/low-tax rates and favourable tax regimes encourage MNEs to locate economic ownership of KBC (and receipt of income in the form of royalties) in offshore holding companies. In addition, limited taxation of foreign royalty income tends to encourage the use of KBC in foreign production and particularly in host countries with relatively low corporate tax rates. It follows that:
  - Because MNEs are typically well placed to exploit cross-border tax planning strategies, countries that provide tax incentives for R&D expenditure may collect little tax on the commercialisation of the subsidised R&D. The host country will, however, benefit from the spillover of knowledge that results from the R&D performed.
  - If KBC is held offshore and used in foreign production, there may be an important loss of domestic spillovers from R&D (e.g. knowledge gained from embedding KBC in production technology). There may thus be leakages of the wider benefits of R&D as well as of tax revenues.
  - Domestic employment may be negatively affected by tax policies that encourage the use of KBC in foreign production. Over time, the economy is likely to adjust and other jobs may be created. While overall employment may thus change little the composition of employment may be altered and the wages paid by these jobs may be lower.

  - Global output may be lower than otherwise if capital is attracted away from locations where pre-tax rates of return are higher. That is, investments may be made in KBC not where they are most productive but where the tax arrangements afford the highest post-tax profitability.

  These effects tend to weaken the benefits from R&D commercialisation, insofar as they diminish benefits of R&D to the domestic economy, and underline the need to re-examine international tax policies that facilitate tax planning and profit shifting. These findings have important implications for the design of R&D tax incentives. In particular, policymakers should not assume that downstream activities such as production will take place in the same country, and any cost benefit analysis should consider this.

- The academic literature suggests that while R&D tax incentives generally increase the amounts of R&D undertaken, their cost-effectiveness is less certain (dependent in part on design features). There is a risk that international competition to raise levels of tax support for R&D, to attract R&D-intensive FDI, could lower tax revenue without commensurate increases in taxable income from R&D commercialisation. Scope for international co-operation could be usefully explored to limit unintended tax relief for R&D (and its use in production) from cross-border tax-planning, and possible inefficiencies arising from R&D support through tax credits and patent boxes. Additional research is needed to better understand spillover benefits stemming from R&D, their source (i.e. what parts of the R&D and production process generate them), their size and value and how they are affected by tax policy and how R&D responds to tax relief.

The main analytical findings are discussed below. Illustrative QETR model results are summarised in Table 2.1. All of the results assume equity finance (debt finance is ignored) in order to highlight the effects of avoidance of tax on royalty income.

Competitive disadvantage for stand-alone R&D performers

The QETR analysis finds that "stand-alone" R&D performing firms (not part of a MNE group, and thus without foreign affiliates to engage in cross-border tax planning) may be placed at a competitive disadvantage, relative to MNEs. This disadvantage in terms of scope for tax planning may be more pronounced for early-stage firms that are not part of a MNE group and have not yet generated taxable income to make immediate use of R&D tax credits (if they are non-refundable). The absence of a level playing field may make it more difficult for such firms to compete with MNEs. This may inhibit knowledge creation as such firms may have particular strengths as R&D performers (e.g. in creating radical innovations).

More specifically, the R&D tax wedge is much lower for MNEs than for stand-alone firms that only have domestic production and pay corporate income tax at domestic rates on income from KBC. In analysing the tax treatment of (taxable) domestic producers, both the "own-use" case and the domestic licence case are considered. In both, the taxation of returns to investment (royalties and profit) at the standard CIT rate results in relatively high average effective tax rates on income from production and a correspondingly high R&D tax wedge.

In the "own-use" case, a parent company undertakes R&D and uses newly created KBC in domestic production. If domestic income is subject to CIT at a 40% rate, with a tax deduction for R&D costs but no additional CIT relief, the R&D tax wedge is positive, at 16.2%. The wedge is positive, as the tax rate on total income (normal return plus

economic profit) assessed as a percentage of economic profit exceeds 40%. The positive wedge indicates that on balance taxation discourages R&D relative to a no-tax case.[7] A 5% R&D tax credit lowers the tax wedge to 6.1%.[8] These results are shown in Table 2.1, line 1.

Rather than undertake production itself, a parent may establish a domestic manufacturing subsidiary and license KBC to it in return for royalty payments. The R&D tax wedge results are unchanged from the own-use case. The reason is that with a domestic licence, royalty income is taxed at 40%, while distributed earnings in excess of royalties are also taxed (at source) at the 40% CIT rate. As in the own-use case, the tax rate on total income (normal return plus economic profit) assessed as a percentage of economic profit exceeds 40%. Introducing a 5% R&D tax credit lowers the R&D tax wedge from 16.2% to 6.1%.

These illustrative results strengthen the case for targeting R&D tax credits to SMEs, in particular those that are not part of a multinational group. This approach is supported by OECD analysis performed under the New Sources of Growth project which shows that the productivity impacts of fiscal incentives are unclear, possibly because they may favour incumbents at the expense of more dynamic young firms.

An alternative, and arguably better, approach to levelling the playing field may be to curtail the ability of MNEs to avoid tax on intra-group royalty (and interest) income. This is an issue that OECD countries are encouraged to analyse as part of a strategy for addressing base erosion and profit shifting (OECD, 2013).

Table 2.1. Summary R&D tax wedge and AETR* results

		R&D tax wedge No R&D tax credit (percentage points)	R&D tax wedge 5% R&D tax credit (percentage points)	AETR* (percentage)
1.	Own-use / Domestic licence and production	16.2	6.1	48.0
2.	Foreign licence and production (territorial system)	11.7	2.0	46.0
3.	Transfer of KBC to offshore holding company, foreign production, 80% domestic inclusion	-3.0	-11.5	38.2
4.	Transfer of KBC to offshore holding company, foreign production, 20% domestic inclusion	-32.4	-38.4	13.3
5.	R&D cost-sharing agreement with offshore holding company, foreign contract manufacturing, level I domestic tax base shifting	-14.5	-17.3	7.2
6.	R&D cost-sharing agreement with offshore holding company, foreign contract manufacturing, level II domestic tax base shifting	-20.7	-25.9	0.4
7.	Patent box, domestic production, 20% inclusion	-31.1	-37.3	14.7
8.	Patent box, foreign production, 20% inclusion	-32.8	-38.8	12.8

Note: The table reports results discussed in the text. R&D tax wedge=difference between pre-tax required "hurdle" rate of return on R&D at the margin, and the after-tax required rate of return of investors; AETR*=average effective tax rate on economic profit (return in excess of normal return) from KBC used in production. In case 5, level I domestic tax base shifting involves charging the parent company 200% of production costs for goods sold to it for domestic sales; in case 6, the charge is 280%. Tax rate assumptions: 40% statutory CIT rate in home country; 25% statutory CIT rate and 5% withholding tax rates on dividends and royalties in foreign host country B (no withholding tax on royalties in KBC transfer case and cost-sharing agreement case). Income derived from KBC at source equals 65% of pre-tax earnings. Equity finance is assumed in all cases.

Tax considerations tend to encourage offshore economic ownership and use of KBC

Illustrative results from the QETR model predict that no-/low-tax rates and favourable tax regimes encourage MNEs to locate economic ownership of KBC (and receipt of income in the form of royalties) in offshore holding companies. In addition, limited taxation of foreign royalty income tends to encourage the use of KBC in foreign production and particularly in host countries with relatively low corporate tax rates.

In particular, the results find a relatively low average effective tax rate ($AETR^*$) on economic profit from production and a correspondingly low R&D tax wedge, when economic ownership of KBC is assigned to an offshore holding company and KBC is used in foreign production. When factoring in cross-border tax planning, the tax burden on R&D is well below estimates derived from conventional ETR measures that assume taxation of returns on investment at the domestic CIT rate. This implies that corrective R&D tax incentive rates – if chosen on the basis of conventional ETR measures, and provided to gain spillover benefits from R&D and incorporating KBC in domestic production – may be too high.[9] Where this is the case, the findings strengthen calls for reassessment of the efficiency of R&D tax incentives.

Furthermore, relatively low $AETR^*$s on economic profit from investment in foreign production signal a tax distortion that favours the use of KBC in foreign rather than domestic production (for mobile production activities). In general, a low $AETR^*$ results from the avoidance of tax on foreign royalty income. $AETR^*$s on foreign production are lower still where the foreign corporate tax rate is low relative to the home country CIT rate (implying taxation at source of income in excess of royalties at a relatively low host country CIT rate).

Scope for tax avoidance is generally greater when economic ownership of KBC is assigned to an offshore IP holding company and KBC is licensed from there. As IP management/holding company activity tends to be highly mobile, location decisions for this activity can be expected to be highly sensitive to tax considerations. Evidence that MNEs locate ownership of KBC offshore tends to aggravate the production location distortions and attendant costs noted above, while also heightening concerns over foregone tax revenues (which have to be replaced through higher tax rates elsewhere).[10]

In general, tax relief from exploiting KBC in production in locations where host and home country tax on royalty income can be avoided encourages MNEs to consider such locations for mobile production, other factors being equal. Where domestic production and foreign production are substitutes, this distortion may reduce domestic employment and output. From an international perspective, production efficiency may be reduced to the extent that location-dependent production costs are higher in low-tax foreign countries chosen as production locations for tax reasons. Potential R&D spillover benefits tied to the incorporation of KBC in production may also be lost to the domestic economy. In addition, foregone home country tax revenues mean that other taxes have to be higher than otherwise.

Foreign licence and production (no offshore holding company)

The $AETR^*$ on economic profit derived from production is lower when an R&D performer (parent) licenses KBC directly (no intermediation) to a foreign operating subsidiary in a low-tax country, rather than to a domestic subsidiary, even if foreign and domestic royalty income are taxed at the home country CIT rate. This result (which is

sensitive to the percentage of production income paid out as royalties) arises with foreign income in excess of royalty payments, paid out as foreign dividends, subject to a relatively low host country CIT rate.[11]

Results from the QETR model consider, for illustrative purposes, production in a host country with a statutory CIT rate of 25% (compared to 40% in the home country). If 65% of gross earnings from production is paid out as royalties, the average effective tax rate on economic profit (AETR*) is 46%. This compares with 48% in the pure domestic case. The corresponding R&D tax wedge is 11.7% and falls to 2% with a 5% R&D tax credit.[12] These results are shown in Table 2.1, line 2.

Offshore holding company and foreign production

In the direct (non-intermediated) foreign licence case considered above, where economic ownership of KBC is held by a parent company (or domestic affiliate), foreign royalty income would normally be taxed at the basic domestic (home country) CIT rate.[13] Given the mobility of KBC, the parent company of an MNE may avoid home country tax on royalty income by transferring economic ownership of KBC to an offshore holding company located in a country that does not levy CIT on royalty income.

Consideration of transfer pricing and controlled foreign company rules

In general, tax relief due to the use of an offshore holding company would normally be limited by transfer pricing/anti-avoidance rules that trigger home country corporate tax. In particular, upon a transfer of economic ownership of KBC to a holding company, a parent company would normally be required under transfer pricing rules to include, in calculating its taxable income, an income amount established on an arm's-length basis that reflects the value of KBC surrendered to the holding company.

However, it is difficult for tax administrators to identify an appropriate arm's-length amount to include in the domestic tax base, particularly if KBC is unique and there are no identifiable markets or means to establish its value. Therefore, MNEs, possibly better aware of the value of KBC, may attempt to under-report values in order to minimise their home country tax burden.

Given the difficulty of establishing an appropriate taxable amount to accompany a transfer of economic ownership of KBC, a number of OECD countries have introduced so-called controlled foreign company (CFC) rules as an additional anti-avoidance measure. In general, such rules, if enforced, would have the effect (in the preceding example and others like it) of taxing resident corporations on a current basis on certain forms of passive income (as opposed to active business income) received through offshore affiliates. This would include, in the example, taxing a parent company on a current basis on royalty income received passively by its controlled foreign holding company. This home country taxation would tend to offset the advantages of the holding company as a tax avoidance vehicle.

Effective CFC provisions may take the pressure off transfer pricing rules by alleviating the need to value KBC when it is transferred offshore and its contribution to future profit may be still be highly uncertain for tax authorities (and possibly business).

Taxing a parent company, under CFC rules, on a yearly basis on royalty income received by its holding company may achieve a more appropriate allocation of the tax base to the home country that better reflects the costs and risks assumed by the parent in creating the KBC.

Circumvention of host country withholding tax and home country CFC rules

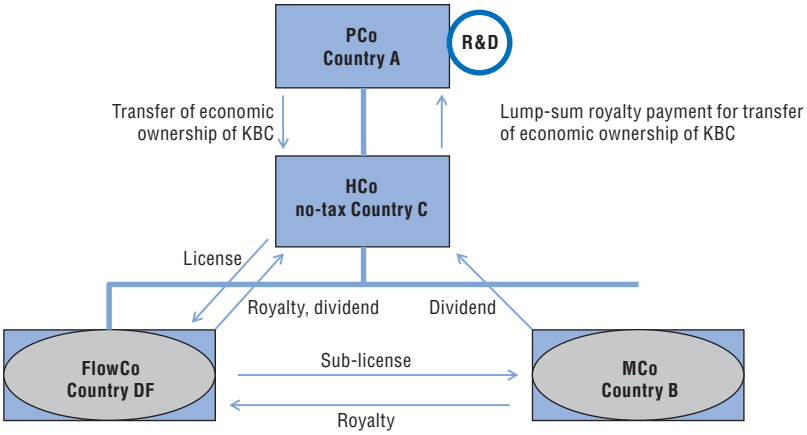
In countries with CFC rules that could, in principle, counter tax-planning opportunities presented by offshore IP holding companies, the CFC provisions may not be broad enough in scope to apply. In countries with broadly applicable CFC rules, there may be mechanisms for avoiding the application of those rules. Such mechanisms may be new or revised tax-planning strategies. In some cases, countries may tacitly accept schemes that avoid CFC provisions, given the absence in other countries of robust CFC rules and pressures from business for an internationally competitive tax system.

Figure 2.4 depicts a tax-planning structure designed to circumvent CFC rules in the United States and also avoid royalty withholding tax that would apply on royalties paid by a manufacturing affiliate (MCo) directly to an offshore holding company (HCo). Under the indirect licensing structure, a parent (PCo) transfers economic ownership of KBC to HCo in no-tax country C. HCo then licenses rights to KBC to FlowCo, a wholly owned controlled foreign company (CFC) resident in high-tax country D with an extensive tax treaty network. FlowCo then sub-licenses rights to the KBC to a manufacturing subsidiary MCo. The use of the conduit entity FlowCo ensures that no withholding tax is paid on royalties paid by MCo to FlowCo, or on royalties paid by FlowCo to HCo.[14]

Moreover, the possible application of CFC rules in home country A may be avoided where PCo elects, for home country tax purposes, to treat FlowCo and MCo as branches (disregarded entities) of HCo. With this election, royalty payments from MCo to FlowCo, dividend payments from MCo to HCo, and royalty and dividend payments from FlowCo to HCo are treated as payments within a single corporation, and thus are disregarded (not recognised) for home country tax purposes.

Tax relief under the preceding tax-planning structure may be illustrated with the QETR model, where the ETR and R&D tax wedge results depend on the amount of income taxed in the home country on the transfer of KBC to HCo.[15] In the limiting case in which home country tax rules do not impose any tax on PCo on income accruing to HCo (no home country tax base inclusion), the average effective tax rate on economic profit ($AETR^*$) is only 5% and the R&D tax wedge is highly negative (-38.7%, not shown in Table 2.1). Where PCo is taxed on this income, and the home country tax base inclusion is equal to 80% of royalty payments by MCo, the $AETR^*$ is 38.2%, and the corresponding R&D tax wedge is -3.0% or -11.5% if a 5% R&D tax credit is available. [16] This result is shown in Table 2.1, line 3. If the home country tax base inclusion is only 20% of royalty payments (e.g. owing to limited base protection rules), the $AETR^*$ is only 13.3%, and the corresponding R&D tax wedge is -32.4% (-38.4% if a 5% R&D tax credit applies). This result is shown in Table 2.1, line 4.

Figure 2.4. Foreign production: Transfer of KBC to offshore IP holding company, licence to conduit, sub-licence to manufacturing subsidiary



R&D cost-sharing agreement with offshore holding company and foreign contract manufacturing

Another tax planning structure analysed involves a cost-sharing agreement (CSA) between a parent company (R&D performer) and an offshore IP holding company, and contract manufacturing. Under the CSA, the parent is responsible for domestic sales, while the holding company is responsible for foreign sales.[17] The contribution of the holding company to the parent for its R&D costs is proportionate to the share of foreign sales in total worldwide sales of the MNE group. Withholding tax on royalties is avoided and host country corporate tax in the place of production is minimised, with a low-risk manufacturing subsidiary only paid a fee (with limited mark-up) for provision of manufacturing services. Taxable profits of the parent are reduced via transactions with a foreign base company that arranges production for the group and transfers profits to the IP holding company using deductible royalty payments.

It is not possible to compare directly R&D tax wedge results under the CSA structure and other tax-planning strategies, owing to the different methods by which host and home country tax are avoided. Under one scenario examined in the analysis, the AETR* on economic profit from foreign production is calculated at 7.2%, and the R&D tax wedge is -14.5% (-17.3% with a 5% R&D tax credit). With more aggressive shifting of the domestic tax base offshore, the AETR* on foreign production is only 0.4%, resulting in an even more negative R&D tax wedge of -20.7% (-25.9% with a 5% R&D tax credit) (Table 1, lines 5 and 6).[18]

The preceding findings raise the following considerations:

- Because MNEs are typically well placed to exploit cross-border tax planning strategies, countries that provide tax incentives for R&D expenditure may collect little tax on the commercialisation of the subsidised R&D. The host country will, however, benefit from the spillover of knowledge that results from the R&D performed.
- If KBC is held offshore and used in foreign production, there may be an important loss of domestic spillovers from R&D (e.g. knowledge gained from embedding KBC in production technology). There may thus be leakages of the wider benefits of R&D as well as of tax revenues.

- Domestic employment may be negatively affected by tax policies that encourage the use of KBC in foreign production. Over time, the economy is likely to adjust and other jobs may be created. While overall employment may thus change little the composition of employment may be altered and the wages paid by these jobs may be lower.
- Global output may be lower than otherwise if capital is attracted away from locations where pre-tax rates of return are higher. That is, investments may be made in KBC not where they are most productive but where the tax arrangements afford the highest post-tax profitability.

These effects tend to weaken the benefits from R&D commercialisation, insofar as they diminish benefits of R&D to the domestic economy, and underline the need to re-examine international tax policies that facilitate tax planning and profit shifting. These findings have important implications for the design of R&D tax incentives. In particular, policymakers should not assume that downstream activities such as production will take place in the same country, and any cost benefit analysis should consider this.

Overall levels and targeting of tax relief for R&D may not be aligned with policy intentions

The QETR analysis finds that overall tax relief for R&D (particularly that of MNEs) may be greater than governments intended when they designed support of R&D expenditure. Analysis based on the QETR model suggests that when tax planning strategies to avoid tax on returns are taken into account, MNEs may obtain a much larger than intended tax subsidy for their investment in R&D, and the post-tax return on R&D spending may exceed the pre-tax return.

As considered above, when cross-border tax planning relief involving the use of an offshore holding company does not apply, the R&D tax wedge is 16.2% in the domestic production case (6.1% with a 5% R&D tax credit), and 11.7% in the foreign production case (2% with a 5% credit). In contrast, if economic ownership of KBC is transferred to an offshore IP holding company, and 80% of income derived from KBC and received offshore is subject to domestic tax, the R&D tax wedge is -3% without any special tax relief for R&D expenditure (-11.5% with a 5% R&D tax credit). If an offshore transfer of economic ownership of KBC triggers a domestic income inclusion that is less than 80% of the income derived from KBC (a likely outcome in certain cases), the R&D tax wedge is more negative. Similarly, the analysis of cost-sharing agreements and contract manufacturing arrangements finds strongly negative R&D tax wedges (with and without R&D tax credits).

Moreover, the balance of tax relief for R&D by MNEs, compared with R&D by stand-alone firms, may be significantly different from what was originally intended. Again, this may result in cases where tax relief available to MNEs from cross-border tax planning strategies has been ignored.[19]

Results reported in Table 2.1 also show average effective tax rates calculated for the domestic licence and foreign licence cases, where economic ownership of KBC remains in the home country and patent/innovation box rules are in effect that tax 20% (exempt 80%) of royalty income. The AETR* for such cases, at 14.7% and 12.8% (Table 2.1, lines 7 and 8) are comparable to values calculated for the offshore IP holding company case (13.3%) in the case where the transfer of KBC to a holding company triggers a taxable income inclusion of only 20% of income from KBC (Table 2.1, line 4).[20]

These results demonstrate the need, when considering the design and pros and cons of a patent/innovation box regime, to address tax relief provided by cross-border tax-planning opportunities. This presupposes that a central objective in introducing and selecting taxable income inclusion rates for such a regime is to provide similar tax relief to that realised when holding KBC offshore, and thereby discourage offshore migration of economic ownership of KBC.[21]

The preceding considerations encourage reviewing R&D tax policies, even before recognising the possible need for reassessing spillover benefits. If further study finds that tax policies are encouraging offshore migration of ownership and use in foreign production of KBC, domestic spillover benefits may be considerably smaller than previously thought (when domestic production and employment are displaced, domestic productivity gains are diminished and domestic tax revenues are lost). If this is the case, the overall rates and targeting of tax incentives for R&D may be further in doubt.

Further research and analysis is required

The academic literature suggests that while R&D tax incentives generally increase the amounts of R&D undertaken, their cost-effectiveness is less certain (dependent in part on design features). There is a risk that international competition to raise levels of tax support for R&D, to attract R&D-intensive FDI, could lower tax revenue without commensurate increases in taxable income from R&D commercialisation. Scope for international co-operation could be usefully explored to limit unintended tax relief for R&D (and its use in production) from cross-border tax-planning, and possible inefficiencies arising from R&D support through tax credits and patent boxes.

Additional research is needed to better understand spillover benefits stemming from R&D, their source (i.e. what parts of the R&D and production process generate them), their size and value and how they are affected by tax policy. This would help assessments of the loss of domestic spillover benefits when economic ownership of KBC is transferred to an offshore holding company (possibly before its commercial value is widely recognised to minimise home country tax on KBC transfers) and KBC is used in foreign production.

Further empirical analysis would also help to gauge more accurately the responsiveness of R&D activity to R&D tax incentives. This would involve extending the application of the QETR model to incorporate country-specific information on domestic and international tax policies and profit margin data to calibrate the model, and using QETR metrics in regression analyses of R&D and production data. As biased measures of the effective tax rate on R&D have been used in the past, in particular measures that do not factor in tax relief from cross-border tax planning, new empirical work based on revised effective tax rate measures would help identify elasticity (sensitivity) estimates to guide policy making.

The illustrative QETR model results presented here have shown that international tax policies may create a competitive disadvantage for stand-alone R&D-performing firms not part of an MNE group. Assessments of whether on balance a country's tax system distorts the playing field of stand-alone firms and MNEs would need to take account of tax policies not captured in the QETR model, such as the treatment of small business losses and capital gains/losses on small business shares, as well as other targeted (non-tax) policies and programmes in support of innovation and entrepreneurship.

The implications of a co-ordinated policy response on the provision of cost-effective support for R&D might also be examined in order to address concerns over international competition. A full assessment of policy options could also include examining the implications of a co-ordinated tightening of defensive tax measures (e.g. CFC rules), to reduce concerns over loss of international competitiveness that may be holding back unilateral action.[22]

A central insight from the QETR model results reviewed so far is that, while the importance of KBC to economic growth has provided arguments for favourable taxation, globalisation makes designing and implementing a tax regime that provides cost-effective support increasingly difficult. In particular, profit-shifting by MNEs may mean that a substantial part of the return to R&D undertaken in a given home country may be lost to that country (through lost CIT revenues and spillovers) if an MNE shifts the ownership and exploitation of KBC to other jurisdictions.

While the work presented here offers a new perspective, it needs to be more fully integrated into analyses of the broader questions of whether targeted government support should be provided, and if so, how much support should be given, to what types of KBC, and how public support is best provided (what policy instruments). The answers to these questions require other evidence and analyses to be brought together with more empirically based analyses, including further applications of the new QETR model.

The analytical framework presented in this paper is the first of its kind and draws attention to the need for policy makers to use effective tax rate measures for investment in R&D that take account of tax relief from cross-border tax planning strategies when assessing tax burdens and implications of possible tax policy reforms. Further work and additional research are needed to:

- Better understand the types, sources and size (value) of the spillover benefits derived from R&D, and how closely they are linked to undertaking R&D and to embedding KBC in production.
- Extend application of the QETR model by incorporating country-specific information (including domestic and international tax policies, and profit-margin data used to calibrate the model).
- Improve elasticity estimates of the responsiveness of R&D to changes to tax policy (using revised effective tax rate measures for MNEs that factor in cross-border tax planning).
- Examine implications of a co-ordinated policy response on the provision of tax relief for R&D, to address concerns over international competition and enhance scope for cost-effective support for R&D.
- Examine implications of co-ordination in tightening defensive tax measures (e.g. controlled foreign company rules), to reduce concerns over loss of international competitiveness that may be holding back unilateral action.

Annex 2.A1

Overview of the QETR model

Standard indicators of the tax burden on R&D (e.g. B-index) do not separately treat KBC as an output of R&D, and focus on tax relief tied to R&D expenditure.[23] Such approaches only partly capture the tax relief available for R&D. Some governments provide special partial exemptions for returns to R&D (e.g. a patent/innovation box system). Moreover, virtually all allow MNEs to obtain significant tax relief when locating economic ownership of KBC offshore, or locating production using KBC in a no-/low-tax country. As tax regimes of host countries for production and international tax policies in the MNE's home country affect how much tax the MNE pays and where, such policies should be accounted for when assessing total amounts of tax relief provided (and the behavioural effects of R&D tax policies).

The QETR model developed to address these issues considers a two-stage process that involves R&D expenditure in a first stage to create KBC, and, in a second stage, the exploitation of KBC in the production of output requiring investment in physical capital.

Profit-maximising production involves a location decision (where to locate production) and a scale decision (how much physical capital to invest in a given location). In making a location decision, a parent of an MNE is assumed to compare after-tax rates of return on investment in production in the home country and in a (low-tax) foreign host country.[24] In each case, relevant corporate taxes on royalties and profit (earnings in excess of royalties) are modelled, which involves modelling host and home tax liabilities (withholding tax and corporate taxes) in the case of FDI.

Location choice is assumed to depend on a comparison of average effective tax rates ($AETR^*$), with tax policy tending to encourage investment in a location with relatively low $AETR^*$, and thus higher after-tax return, under the assumption of a fixed pre-tax rate of return. The $AETR^*$ is calculated as the present value of tax on royalties and profit (earnings in excess of royalties), divided by the present value of pre-tax economic profit at the optimal capital stock.[25] For each location, a marginal effective tax rate (METR) is derived to assess tax distortions to the profit-maximising level (scale) of physical capital in that location.

In the analysis of the effects of tax on the level of R&D, a parent company is assumed to invest in R&D as long as it is profitable to do so (i.e. up to the point where the marginal after-tax benefit of an additional unit of R&D expenditure just equals its marginal after-tax cost). The marginal after-tax cost depends on tax deductions for R&D costs, including tax credits. In the model all costs are assumed to be current costs (e.g. wages of scientists and engineers). The marginal benefit of additional R&D is the value of an increase in the probability of creating knowledge and enabling after-tax earnings in the production stage.[26] This equilibrium condition determines the pre-tax (minimum) "hurdle" rate of return to R&D (r^R_g) and the tax wedge (i.e. the difference between the pre-tax hurdle rate of return to R&D, and the fixed after-tax rate of return required by investors) which measures the degree of tax distortion – the larger the tax wedge, the larger the predicted negative effect of tax on the level of R&D (offset by tax relief).[27] See Box 2.A1.1.

Box 2.A1.1 The hurdle rate of return and R&D tax wedge

The "hurdle rate of return" (r^R_g) is the marginal (minimum) pre-tax net return on an additional dollar of R&D required by the parent to pay shareholders their required rate of return (ρ), and pay corporate tax on that return. The R&D tax wedge (RDTW) – derived from the hurdle rate of return, and calculated as (r^R_g-ρ) – which measures the marginal pre-tax net return on R&D that is just sufficient to pay corporate tax, provides a measure of tax distortion at the margin. As the tax burden and hurdle rate of return may be negative with large tax subsidies for R&D, interpreting a marginal effective tax rate for R&D is not obvious (if rRg<0 then METR=(rRg-ρ)/rRg is positive despite a negative tax burden). The R&D tax wedge is arguably a preferable, more easily interpreted tax burden indicator. When the R&D tax wedge is positive, tax is predicted to discourage R&D relative to the no-tax case (conversely, if RDTW<0, tax encourages R&D relative to the no-tax case).

As the hurdle rate of return (rRg) is a return at the margin, it cannot be measured directly and so is derived from profit-maximising conditions. Under the QETR model, profits are maximised where R&D is increased just up to the point where the marginal after-tax gross return from an additional dollar of R&D just equals its marginal cost:

$$\frac{\Delta q(RD)}{\Delta RD}\frac{PV\Pi(1-AETR^*)}{(1-d_A)}=(1+\rho) \quad (1)$$

The marginal after-tax gross return (left-hand-side of (1)) is the value of an increased probability of earning future after-tax economic profit from production using KBC, expected to result from an additional dollar of R&D. In equation (1) q(RD), measuring the probability that R&D is successful, is assumed to increase with the level of R&D but at a decreasing rate. PVπ measures the present value of future economic profit from production using KBC. The average effective tax rate on economic profit from production ($AETR^*$) is assessed as the present value of tax on future earnings from production, divided by PVπ. The term ($1-d_A$) factors in tax relief per unit of R&D expenditure (in particular, d_A factors in deductibility from the CIT base of current R&D expense (wages paid to staff performing R&D) and relief (if any) from R&D tax credits at rate ξ_A on current expenditure ($d_A=u_A+\xi_A$)).

Using (1), the **hurdle rate of return** (r^R_g) can be inferred as follows:

$$r_g^R=\frac{\Delta q(RD)}{\Delta RD}PV\Pi-1=\frac{(1+\rho)(1-d_A)}{(1-AETR^*)}-1 \quad (2)$$

Using (2), the **R&D tax wedge** is measured by:

$$RDTW=r_g^R-\rho=\frac{(1+\rho)(1-d_A)}{(1-AETR^*)}-(1+\rho)=\frac{(1+\rho)(AETR^*-d_A)}{(1-AETR^*)} \quad (3)$$

The R&D tax wedge is zero when the rate of tax relief for R&D expenditure equals the average effective tax rate on economic profit derived from KBC – that is, where $d_A=AETR^*$.

Taxation is predicted to be neutral and not affect the level of R&D when there is tax symmetry – that is, where the average effective tax rate on economic profit derived from the use of knowledge in production ($AETR^*$) matches the tax rate at which R&D costs are relieved (d_A), in which case the R&D tax wedge is zero.

Importantly, in the QETR model, the effects of taxation on the level of R&D depend on the treatment of R&D expenditure and the treatment of returns on the use of KBC in production. The present value of tax on income derived from the use of (intangible) KBC and tangible capital in production, captured by the $AETR^*$, depends on where production occurs and whether rights to the use of KBC in production are licensed directly or indirectly through an offshore IP holding company.

Including cross-border tax planning in tax burden measurement of ETR (i.e. AETR* on production, and R&D tax wedge) is potentially useful for policy analysis in several respects. First, in considering levels of support being provided to R&D, in addition to R&D tax incentives, policy makers need to consider (using the same ETR metric) how much tax relief MNEs may in effect be achieving for themselves ("self-help"). This might suggest greater targeting of R&D tax incentives to (small) stand-alone companies that are not in a position to exploit cross-border tax planning opportunities.

Second, the analysis illustrates how domestic and international tax policies may interact to influence MNEs' decisions about the location of economic ownership of KBC and the locations of its use in production. Such behavioural responses may significantly erode the tax base and the domestic spillover benefits of R&D, negatively affect domestic employment, and reduce global output if capital is attracted away from locations earning higher pre-tax rates of return.

Third, on the empirical side, if more representative ETR measures are generated when factoring in tax avoidance on returns to investment, they could be used in statistical work to estimate the sensitivity of FDI to taxation and the sensitivity of R&D to taxation. To date, empirical work has been based on theories of investment (used to specify investment equations used in statistical analysis) that overlook cross-border tax planning. Preliminary results from the QETR model suggest that this may be a serious oversight when attempting to explain MNEs' investment in KBC.

Notes

1. KBC comprises a range of assets: intellectual property (patents, copyrights, designs, trademarks); computerised information (software and databases); and economic competencies (firm-specific human capital, networks joining people and institutions, organisational know-how, and aspects of advertising and marketing). These assets create value (current and future income) but, unlike machines, equipment, vehicles and structures, they do not have a physical embodiment. This non-tangible form of capital is, increasingly, the largest form of business investment and a key contributor to growth in advanced economies. See Overview/ Chapter 1.

2. See Majority Staff Report, *Repatriating Offshore Funds: 2004 Tax Windfall for Select Multinationals*, prepared by the Permanent Subcommittee on Investigations, Committee on Homeland Security and Government Affairs, United States Senate, 11 October 2011. The 2004 AJCA repatriation provision allowed MNEs to deduct from their taxable income 85% of qualifying dividends received from controlled foreign corporations during 2004, 2005 or 2006. This provision reduced the statutory tax rate on dividends from 35% to 5.25%.

3. This element of tax planning is not incorporated in the version of the QETR model developed for the study.

4. In the QETR model, Q denotes knowledge-based capital (KBC) and ETR denotes effective tax rate. The analysis of tax effects on the level of R&D focuses on the R&D tax wedge as a preferred indicator. The R&D tax wedge is easy to interpret compared to a marginal effective tax rate for R&D – calculated as the R&D tax wedge, divided by the required pre-tax hurdle rate of return on R&D – given that the pre-tax hurdle rate of return may be negative in the presence of significant tax relief for R&D.

5. While not measuring the amount by which levels of R&D and production in a given location may be affected by tax, results of the model illustrate directions of bias to scale decisions – that is, whether home and host country tax policies can be expected on balance to encourage or discourage investment compared with alternative tax policy settings.

6. "Economic profit" refers to an above-normal return (i.e. a return in excess of the normal return to shareholders), with manufacturing income assumed to consist of a normal return plus an above-normal return. The average effective tax rate on economic profit (AETR*) is calculated as the present value of tax, divided by the present value of pre-tax economic profit. The R&D tax wedge is positive (negative) if the AETR* is greater (less) than the rate of tax relief for (deductible) R&D labour costs. A related tax burden indicator is the average effective tax rate (AETR) on manufacturing income, calculated as the present value of tax, divided by the present value of pre-tax income. As income exceeds economic profit, this tax burden indicator (AETR) is in each case lower than the AETR* assessed on economic profit.

7. See footnote 7. Also note that the R&D tax wedge is measured in *percentage points* (in particular, the percentage point difference between the pre-tax hurdle rate of return on R&D and the required after-corporate tax rate of return). The AETR* measures the

present value of tax as a *percentage* of present value of pre-tax economic income from production.

8. This result assumes taxation of manufacturing income at 40%. Under this treatment, the average effective tax rate on economic profit (AETR*), at 48%, exceeds the 40% rate of tax relief for (deductible) R&D labour costs, so the R&D tax wedge is positive. In contrast, under an allowance for corporate equity (ACE) system that provides a tax deduction for the normal return on equity, the AETR* is 40% and the R&D tax wedge is zero.

9. A "corrective" R&D tax incentive rate means a rate chosen to partly, fully or more than offset an assessed tax distortion to R&D.

10. In general, holding company activity involves relatively limited amounts of labour, physical capital and other productive assets. Therefore production efficiency concerns tied directly to this misallocation would not be significant. However, the knock-on effects – a deepening of the tendency to shift production to a low-tax location – may raise significant employment and production efficiency concerns.

11. Most OECD countries operate "territorial" tax systems which exempt foreign dividend income from home country tax. Some operate "worldwide" systems that tax foreign dividend income, but provide a tax credit to offset foreign tax on that income (to avoid double taxation), while also allowing taxpayers to defer home country tax by deferring the receipt of foreign dividends. Under both systems, the overall (host and home country) tax burden on income from production that exploits KBC is typically lower when locating production in a country with a relatively low CIT rate.

12. The AETR on foreign manufacturing income is 38.4%, while the AETR* is 46.0%. The calculations assume a 25% CIT rate in the foreign host country, withholding tax on dividends and royalties at 5%, and royalty payments equal to 65% of gross production earnings. With foreign royalty income subject to home country tax at 40%, host country withholding tax on royalty payments at 5% is assumed to be fully offset by foreign tax credits provided by the home country. Withholding tax on dividends, also at 5%, is final (no foreign tax credit, under the assumption of no home country taxation of dividend income, as under a territorial system).

13. This assumes that "patent box" rules that would exempt some percentage of royalty income do not apply. Also, some tax systems (e.g. the US system) allow excess foreign tax credits on high-tax dividend income to shelter foreign royalty income from home country tax.

14. Royalties paid by MCo to FlowCo are deductible against the CIT base of MCo in country B which does not levy withholding tax on royalty payments to country D. FlowCo pays relatively little CIT in country D on a small profit margin determined by royalty receipts from MCo, less royalty payments to HCo. Country D does not impose withholding tax on royalty payments to HCo, where they are received free of corporate tax. After-tax profits of FlowCo are distributed as a tax-free dividend to HCo (no withholding tax and no CIT in country C).

15. In the model, the home country tax base inclusion triggered by a transfer of KBC offshore is modelled as a percentage of the present value of royalties paid out by the manufacturing subsidiary. The lower the percentage taxed in the home country, the larger the tax subsidy. The results reported here assume that the statutory CIT rate in host country B (where KBC is used in production) is 25%; and all royalty and dividend payments are free of withholding tax, except dividends paid by the manufacturing subsidiary to the holding company, taxed at 5%.

16. The R&D tax wedge is -15.1% if the home country tax base inclusion is 60% of royalty income paid out by MCo.

17. Where PCo earns an R&D tax credit, a key policy design choice is whether the R&D cost contribution from the holding company reduces (or not) the base of the R&D tax credit. The R&D tax wedge of -11.5% assumes that the base of the R&D tax credit is not reduced by the R&D cost contribution. If the home country tax base inclusion is 60% (rather than 80%) of royalty payments by MCo, the AETR* falls to 29.9%, and the R&D tax wedge is -15.1% (-22.6% with a 5% R&D tax credit).

18. The results in lines 5 and 6 of Table 2.1 assume that a parent company is assigned domestic sales (50% of total sales), a holding company is assigned foreign sales (50% of total sales), and a manufacturing service affiliate is paid a 5% mark-up over production costs equal to replacement investment. In line 5 results, the transfer price charged by a foreign base company to the parent to cover 50% of the cost of goods produced equals 50% of manufacturing costs; in line 6 results, the transfer price charged is 100% of manufacturing costs (200% of manufacturing costs corresponding to domestic sales). In each case, profits of the foreign base company are paid to the holding company through royalty payments.

19. The AETR* results for the offshore holding company case do not incorporate tax planning relief (reductions in host country tax) that would result if the manufacturing affiliate is capitalised in part by related-party debt. Instead, the QETR results for the offshore holding company case assume 100% equity finance of the manufacturing affiliate. Introducing intra-group debt finance provided by a dual purpose offshore IP holding company (holding economic ownership of KBC, while also providing debt finance) would find lower average effective tax rates under the IP holding company structure.

20. The AETR* calculated for the offshore holding company case assumes that CFC rules are not in place. Instead, the transfer of knowledge capital to a holding company is subject to transfer pricing rules that require the parent company to include, in calculating its taxable income in country A, an income amount established on an arm's-length basis reflecting the value of knowledge capital surrendered to the holding company.

21. Patent/innovation box regimes may also be intended to stimulate R&D. However, effects on R&D would need to be considered alongside R&D tax wedge measures under alternative holding structures (that is, such a regime may have a limited stimulus effect on R&D if greater tax relief is possible by transferring KBC offshore).

22. In assessing the ramifications of a tightening of CFC rules that would tax on a current basis related-party royalty income received by an offshore holding company (and possibly interest income on related-party loans provided by an offshore finance subsidiary), it is difficult to gauge the tendency of MNEs to change the location of headquarters activities (i.e. corporate inversion), taking into account the attractions of a given home country as a place for headquarter activities.

23. Standard indicators include the B-index, and the more sophisticated "user cost of capital" model developed to analyse the effects of tax on investment in tangible capital, used to assess effects on investment in intangible capital. Such applications do not treat KBC as a distinct output of R&D, which makes the interpretation of results difficult. Treating KBC as an output of R&D better captures R&D and production processes, while also allowing the modelling of the tax implications of tax planning,

where R&D is undertaken in one country, economic ownership of KBC is assigned to second, and KBC is used in production in a third.

24. In practice, a parent may consider several foreign countries as host locations for production. The QETR results presented in this chapter consider a comparison between the home country and a low-tax foreign country. In this case FDI is either a) direct, with the parent company holding economic ownership of KBC, investing directly in a foreign manufacturing affiliate and licensing (directly) KBC to it, and receiving foreign dividends and royalty income, or b) intermediated, with economic ownership of KBC assigned to a dual purpose (IP and equity) offshore holding company, the parent investing in a foreign manufacturing affiliate indirectly through the holding company, and foreign dividend and royalty income received and retained indefinitely offshore).

25. The present value of tax on income derived from the use of intangible and tangible capital in production depends on where production occurs and whether rights to the use of KBC in production are licensed directly or indirectly through an offshore intellectual property holding company.

26. The probability that R&D is successful is assumed to increase with the level of R&D expenditure, but at a decreasing rate, implying diminishing marginal returns to R&D.

27. Tax distortions to the level of investment are normally assessed using a marginal effective tax rate calculated as the tax wedge divided by the pre-tax "hurdle" rate of return. However, with significant tax subsidies to R&D, the pre-tax hurdle rate of return may be negative. In such cases, a negative tax wedge divided by a negative pre-tax hurdle rate of return yields a positive METR, which is difficult to interpret (as a positive METR normally signals a tax distortion that discourages investment). To avoid confusion, the assessment of tax effects on the level of R&D focuses on the numerator of the METR, that is, on the R&D tax wedge.

References

Clausing, Kimberly A. (2009), *Multinational Firm Tax Avoidance and Tax Policy*, National Tax Journal, Vol. LXII, No. 4, p. 703-725.

OECD (2011), *OECD Science, Technology and Industry Scoreboard 2011*, OECD Publishing.
doi: http://dx.doi.org/10.1787/sti_scoreboard-2011-en.

OECD (2013), *Addressing Base Erosion and Profit Shifting*, OECD Publishing.
doi: http://dx.doi.org/10.1787/9789264192744-en.

Chapter 3.

Competition policy and knowledge-based capital

This chapter explores the relationship between knowledge-based capital (KBC), innovation and competition policy, beginning with an assessment of the theoretical underpinnings and the empirical evidence available to explain the link between market concentration and innovation, including the concept of the inverted U. Two broad recommendations for policymakers emerge: unnecessarily anticompetitive market regulation should be abolished, and effective enforcement of competition law is required to support innovation and economic growth.

The chapter then considers the role of intellectual property rights (IPR) in the development and use of KBC. IPR are used heavily in many KBC-focused markets and are often considered to be critical for technological development. Yet the abuse of IPR can discourage or prevent innovation and raise competition concerns. Potential problems include patent ambush in standard-setting, certain exclusionary licensing arrangements, and the strategic accumulation of standard-essential patents by individual firms. Finally, the chapter addresses the question of competition policy within the digital economy, which has much to do with the growing importance of KBC to economic activity.

KBC is increasingly recognised as an important driver of investment, innovation and growth in OECD economies. The term encompasses a broad range of ideas, intangible assets and innovations, including computerised information, scientific and non-scientific knowledge and processes, business methods, intellectual property, and economic competencies such as firm-specific human capital and efficiency-enhancing know-how. KBC complements and may even supersede physical capital in stimulating and facilitating economic growth. Competition also drives growth, investment and innovation, including investment and innovation related to KBC itself. Accordingly, sound competition policy and effective enforcement of competition law can and should support the development of KBC.

As KBC-focused businesses have grown in economic importance, they have started to encounter, and to raise, more competition law and policy issues. During the past several years, a string of high-profile competition law enforcement matters have involved KBC-focused businesses. Many of these have the digital economy and involved companies such as Google, Apple, Facebook, Microsoft and Intel. Not all were information technology (IT) firms, however, as settlements with major banks such as UBS and JPMorgan Chase over price fixing in bond markets illustrate.

Yet it remains the case that while most competition authorities and many courts in OECD countries have substantial experience with applying competition principles to markets that involve physical goods and capital, they generally have less experience with competition in KBC-intensive markets. Indeed, questions often arise concerning whether traditional competition law and policy principles are even applicable in such markets and, if they are, whether they need to be adjusted to account for the differences between KBC-intensive markets and other kinds of markets.

Competition law and policy, as a general rule, create a flexible framework that can be adapted to fit diverse markets. Traditional competition laws and principles can and should be applied to prevent and deter anti-competitive behaviour in any setting and can foster investment and innovation, including in KBC-focused markets. Nonetheless, certain features of these markets – such as their tendencies toward rapid change, constant innovation, market tipping (when the nature of a market makes it likely to be monopolised) and a prominent role for intellectual property – can complicate competition policy analysis.

This chapter identifies and discusses recurrent competition issues that may affect KBC-focused markets. It seeks to provide policy makers with a comprehensive overview of the role of competition and competition policy in supporting the development of KBC, including the use of enforcement to address anti-competitive behaviour that hinders innovation and retards economic growth.

Although the question of the degree of competition that leads to the most innovation is complex and probably varies from industry to industry, two key policy recommendations can be discerned from the available evidence: i) ensure effective enforcement of competition law to combat anticompetitive behavior; and ii) eliminate unnecessarily anticompetitive product market regulations.

Competition and innovation

Rapid innovation is a common and highly desirable feature of KBC-focused markets. Innovation leads to better, and often cheaper, products and services. Because competition influences the degree of innovation taking place in a market, competition policy has important implications for the evolution and success of KBC-focused industries.

The relationship between competition and innovation is a complex and often contradictory one. The intensity of product market competition affects innovation efforts, but the question of how, exactly, competition affects innovation appears to have no single response. Instead, the answer requires a host of conditions, exceptions and caveats. What seems certain, at least, is that competition is capable of both promoting and deterring innovation. On the one hand, strong competition can encourage companies to innovate so as to keep up with, get ahead of, or remain ahead of their competitors. On the other hand, some degree of market power (a firm has market power when it can profitably hold its price above the level that would prevail in a competitive market) may stimulate innovation by making it easier to recover costs and earn profits. Policy makers are faced with the complex task of creating an environment in which the rewards for innovation are sufficient to encourage it, but in which competitive pressures also encourage firms to create, use and circulate innovations. Finding the optimal degree of competition is further complicated by the fact that innovation processes, as well as the importance of factors such as IPR in spurring innovation, vary considerably across industry sectors and types of inventions.

The theory of competition and innovation

An academic debate about the relationship between competition and innovation has endured for many years. The Schumpeterian view, named for the work of Joseph Schumpeter, posits that big, dominant firms are more likely to innovate than smaller ones that lack market power, but also that innovations are "gales of creative destruction" that render market power ephemeral in high-innovation industries (Schumpeter, 1942). The opposing view, often associated with the work of Kenneth Arrow, is that competition promotes more innovation because entrenched market power makes managers less inclined to spend money on developing new technologies, while firms facing greater competition have more to gain by innovating (Arrow, 1962). In between, an intermediate theory asserts that moderate levels of competition produce the most innovation; that is, the curve describing the relationship between market concentration and innovation has an inverted U-shape.

As a result, in economic theory, the relationship between competition and innovation remains unsettled. If it is difficult for firms to appropriate the value of their innovations, theory predicts that competition will reduce incentives to innovate. This suggests that in some cases a merger (or some other type of conduct) that lessens competition will actually increase those incentives. However, theory also indicates that more competition should boost innovation in many situations.

Empirical evidence on competition and innovation

Unfortunately, the empirical data do not resolve those conflicting theoretical forces, as the empirical literature also reaches mixed results. In essence, some studies find that competition encourages innovation, while others conclude that it reduces it, depending on various circumstances and assumptions (OECD, 2007).

The unsettled state of the literature is not due to insufficient effort. An abundance of econometric studies focuses in one way or another on the relationship between competition and innovation. Because both competition and innovation are hard to measure directly, these studies almost always employ proxies, such as concentration ratios or profit margins (the Lerner Index) for competition and research and development (R&D) intensity or the number of patents granted for innovation. The proxies are imperfect, as it is now well understood that market structure and the level of competition in the market are not necessarily strongly correlated, and that R&D intensity and patents are not completely reliable indicators of innovation. Nevertheless, these models are continually being modified

in order to minimise distortional effects and make the proxies as useful as possible. If it is possible to tease one central, reasonably well-accepted finding from the empirical literature, it would probably be that there is an inverted-U relationship between market concentration and R&D intensity when the former is plotted on the horizontal axis and the latter on the vertical axis (Aghion et al., 2005). In other words, there is growing support for the proposition that concentration and R&D intensity generally have a positive relationship at low levels of concentration, with R&D activity reaching a peak at a moderate level of concentration, after which the relationship becomes negative and R&D intensity shrinks as concentration continues to rise. To the extent that market concentration is a good reflection of the degree of competition, the idea is that the most fertile environment for innovation is a market with a moderate amount of competition.

An early game theory approach predicted that greater rivalry, represented by lower concentration indices, stimulates R&D spending up to a certain point, but that too little market concentration discourages R&D because it becomes too difficult for firms to appropriate a sufficiently enticing share of the returns on their innovations (Scherer, 1967). In the 1980s, models based on decision theory agreed with Scherer's view that intermediate market structures often exhibit the most innovative activity (Kamien and Schwartz, 1982). Newer models continue to find that the relationship between product market competition and innovation is best described by the inverted-U shape (Aghion et al., 2005). It must be emphasised, however, that the inverted U is a generalised description. Findings vary from industry to industry, and some studies reach ambiguous or unsupportive results. As Scherer and others have pointed out, the inverted U theory does not always hold up well when other factors that affect innovation, such as the technological opportunity available in an industry, are taken into account (Scherer and Ross, 1990; Symeonides, 1996).

One area in which the data line up more in support of Schumpeter's vision concerns the kinds of innovation that large incumbents pursue compared to what challengers typically attempt. The former group tends to focus on developing inventions that build on or extend existing technology, whereas smaller firms and entrants are more likely to concentrate on disruptive innovation that will seriously alter the fundamental nature of markets. Because new technologies that change what is needed to succeed may reconfigure the state of competition, they are often welcomed as a strategic opportunity by marginal competitors and treated as a threat by leading firms. That is often true even if the leading firms created the new technology. In such cases, the incumbent simply shelves the technology, having patented it, kept its existence secret, or taken other measure to prevent competitors from using it. Consequently, breakthrough or disruptive inventions – the kind Schumpeter had in mind when he wrote about creative destruction – are often brought to market by small start-ups or companies that were operating in other markets (DeSanti and Cohen, 2001; Bower and Christensen, 1995). An implication for competition enforcers is that innovation is most likely to thrive in market environments that support a variety of firm sizes and feature low barriers to entry for technologically innovative entrants (Scherer and Ross, 1990).

Innovation-intensive markets frequently display some or all of the following characteristics: high R&D intensity and dependence on IPR coupled with a closely related heavy reliance on human instead of physical capital; a high degree of technical complexity; rapid technological change and short product cycles; increasing returns to scale; substantial network effects (meaning that a product or service becomes increasingly useful and valuable as more customers use it, e.g. telephones); and significant compatibility and standards issues (OECD, 2002). The stronger these features, the more competition may assume winner-takes-all characteristics. Indeed, high-innovation markets tend to have clear

market leaders. At the same time, market leadership may be highly dependent on continued superiority in innovation, and "dominant" firms may be unable in the long run to achieve substantial supra-competitive profits. These topics are discussed further below.

Anticompetitive market regulation

Anticompetitive or unnecessary market regulation can be a significant impediment to effective innovation, particularly in KBC-focused markets where the pace of innovation tends to be rapid. Empirical OECD work has found a negative correlation across national economies between the level of anticompetitive product market regulation and innovation (Jaumotte and Pain, 2005a). Of the many policy levers studied, reducing anticompetitive regulation was the second most powerful incentive to raise the level of business R&D spending (Table 3.1). More competitive market conditions had a substantially stronger effect on this measure of innovation than greater protection of IPR or state subsidies for private R&D.

Table 3.1. Long-run effects on proxies for innovation of a one standard deviation increase in various factors[1]

Measured in percentage change of the dependent variable

	Business R&D spending	Total domestic patents
Science policies and institutions		
B-index[2]	-1¾	-6
Subsidies for private R&D/GDP ratio	¼	-3
Share of business funding in non-business R&D	8¼	2½
Non-business R&D /GDP ratio	7¼	3¾
IPR index	1½	8
USA real wage of researchers	-3¼	-¾
Years of education	1	¾
Economic conditions		
Profit/GDP ratio	5¼	4¼
Private sector credit/GDP ratio	-1½	-3¼
Equity financing/GDP ratio	5¾	10
Foreign R&D stock/GDP ratio	12¾	6
Openness	-5¾	-4¼
Import penetration	-¼	0
Real interest rate	-5	-2¾
Real exchange rate	-3	-1¾
Framework policies (decrease)		
Product market regulation	9	4¼
FDI restrictions	..	13
Employment protection legislation	1	6½

1. The standard deviation is the average of within-country standard deviations, and the effects of a one standard deviation increase in factors are evaluated at the sample mean of the variables.

2. The B-index is defined as one minus the rate of tax subsidy for R&D.

Source: Jaumotte and Pain (2005a), "From Ideas to Development: The Determinants of R&D and Patenting", *OECD Economics Department Working Papers*, No. 457, OECD Publishing. doi: http://dx.doi.org/10.1787/702226422387.

Thus, while regulation continues to provide governments with an important tool for preserving and promoting public policy objectives, needlessly anticompetitive regulation harms the public interest by hindering beneficial innovation. Anticompetitive product market regulation should be eliminated where possible. The OECD's Competition Assessment Toolkit provides a comprehensive framework for identifying and assessing potentially restrictive regulatory arrangements (Box 3.1).

Box 3.1. The OECD's Competition Assessment Toolkit (2010)

The OECD developed the Competition Assessment Toolkit to help governments reduce counterproductive regulation. The Toolkit provides a general methodology for identifying unnecessarily anticompetitive regulatory restraints and developing alternative, less restrictive policies that still achieve government objectives. Designed for use by officials at all levels of government and requiring no specialised training in economics or competition policy, the Toolkit consists of a series of simple questions. In particular, the Toolkit aims to:

- Facilitate the evaluation of draft or new laws and regulations, for example, through regulatory impact assessment programmes.
- Enable the evaluation of existing laws and regulations, whether in the economy as a whole or in specific sectors.
- Assist government bodies engaged in development and review of policies, such as ministries that develop laws or the competition authority, in their evaluation of the competitive impacts of regulations.

The Competition Assessment Toolkit is available at www.oecd.org/daf/competition/.

Enforcement of competition law to facilitate innovation

A second conclusion that follows from the inverted U-shape relationship between market concentration and innovation is the need to maintain effective enforcement of competition law in KBC-focused markets. The inverted U-shape indicates that, in general, moderate amounts of competition create the market environment that is most conducive to competition. Most enforcement occurs in relatively concentrated markets; that is, in markets with significant potential for greater competition and therefore increased innovation. By addressing and eliminating anticompetitive restraints imposed by private firms in KBC-focused markets, competition authorities create space and opportunities for innovation and growth. Box 3.2 provides an example of competition law enforcement leading to greater innovation in the United States telecommunications market.

Box 3.2. Competition enforcement to foster innovation: The case of AT&T

Enforcement of competition law has a long track record of opening doors to a rise in innovation in KBC-heavy sectors. For example, in 1974, the US Department of Justice filed an antitrust lawsuit against telecommunications giant Atlantic Telephone & Telegraph, at the time the world's largest corporation. The complaint alleged that AT&T had been using its monopoly in local exchange telecommunications services to monopolise the telephone equipment manufacturing and long distance telecommunications service markets [*United States v. AT&T Co*., 552 F. Supp. 131 (D.D.C 1982).] Prosecutors claimed that AT&T had, among other things, failed to connect competing carriers with its network on reasonable terms and had reduced its prices only in markets where it faced competition. Several years later, the two sides reached a settlement agreement that imposed structural and behavioural remedies on AT&T.

The structural part of the remedy was a vertical divestiture. AT&T divested its local service providers, leading to the formation of seven regional operating companies (called "RBOCs"). AT&T kept its long distance, equipment manufacturing and research divisions, but was required to transfer enough assets to the RBOCs to allow them to operate. Those assets included, on a royalty-free basis, all existing patents as well as all patents issued for the next five years.

…/…

Box 3.2. Competition enforcement to foster innovation: The case of AT&T *(continued)*

The behavioural remedy took the form of regulatory provisions governing each RBOC. For example, to prevent the RBOCs from emulating AT&T's strategy, the decree required them to obtain the court's approval before expanding the scope of their business beyond local exchange services. The RBOCs were also obliged to provide every long distance carrier equal access to their local exchange networks.

The decision to break up AT&T was highly controversial. Opponents argued that the quality of service would decline, national security would be endangered, a precious R&D enterprise would be damaged, and shareholders would suffer. However, most observers now believe the net effects were quite positive, including on innovation. When the lawsuit was filed, wireless communication and the Internet were virtually unknown, while telephone answering and facsimile machines were just beginning to develop. People still used rotary dial phones and long-distance calls cost a fortune compared to today's rates. All of that changed rather quickly after the divestiture. Moreover, greater competition among long-distance providers led to the rapid deployment of fibre optic cable in the United States, which later supported the development of the Internet and the explosion of innovation that accompanied it.

Nonetheless, in markets characterised by high rates of innovation, any potential negative impacts of enforcement must be taken into account and may involve complex and uncertain calculations. In particular, in assessing restraints on innovation and competition by dominant firms, static efficiency gains must be balanced against dynamic effects. As it is difficult to identify in advance whether conduct restricts innovation and therefore competition, some commentators argue that *ex post* intervention, when agencies can identify competitive harm, is to be preferred over *ex ante* intervention. Others note, however, that care has to be taken to ensure that *ex post* interventions are effective, especially in situations in which there is a risk that all effective competition might be eliminated. Otherwise interventions may come too late, creating a risk of lasting harm to consumers.

Mergers in innovative markets

In innovation-intensive KBC-oriented markets, enforcement includes applying merger control rules. Determining whether a merger will be likely to promote or prevent innovation requires a complex, case-specific inquiry. A merger may lead to efficiencies in research and development (basically, the ability to do better and/or cheaper R&D), yet fewer rivals and greater market power could slow the post-merger rate of technological change. Although some mergers save costs by eliminating duplicative R&D, protecting competition in R&D is important because R&D is inherently uncertain. A special analytical framework is neither necessary nor desirable for merger review in innovation-intensive markets, as the traditional merger review process is sufficiently flexible. However, in high-innovation markets there may be a need for some customisation, in particular as regards defining markets and assigning market shares; assessing the significance of changes in market structure; giving proper weight to benefits consumers reap from innovation; assessing the ability of merging parties to exclude or restrict competitors; and designing appropriate remedies.

Market definition and assignment of market shares are particularly challenging tasks in rapidly changing sectors such as typical KBC-focused industries. In innovation-intensive markets, estimated changes in market shares may not say much about the likelihood that a merger will lead to higher prices or less innovation. Consequently, the traditional initial screening based on market shares should ideally be supplemented by other readily ascertainable data, such as the recent instability of market shares, the rate of growth of the market, and estimates of the rate of technological change. The higher the indicators, the greater the probability that the merger should be cleared without an in-depth analysis.

Owing to a high degree of product differentiation (basically, the opposite of commoditisation – differentiated products have features that distinguish them from other products on the market) and a potential for disruptive innovation, mergers in high-innovation markets are typically unlikely to lead to anticompetitive co-ordination. However, such mergers frequently raise concerns about unilateral anticompetitive effects, so that the ability or incentive to exclude or restrict rivals deserves close attention when reviewing mergers in high-innovation markets. In addressing the issue of anticompetitive mergers in high-innovation markets, there is good reason to question the traditional preference for structural over behavioural remedies. In fact, a highly customised use of behavioural remedies, sometimes accompanied by divestment, may be the best way to address potential competition problems. Moreover, the complexity of mergers in high-innovation sectors may require rethinking the merger review process (i.e. strict time limits), increasing sector-specific expertise in competition authorities, and taking pro-active steps to prepare for mergers in high-innovation markets.

Mergers sometimes create positive effects called efficiencies. Generally speaking, dynamic efficiencies are synergies that enable firms to improve their performance, whether in terms of cost, quality, service, or new product development, on a potentially continuing basis. This may involve learning by doing, eliminating redundant R&D expenditures, or achieving economies of scale in R&D. Static efficiencies, by contrast, enable improvements that occur only once – for example, by generating economies of scale in production. Today, efficiencies are commonly viewed as factors that favour allowing mergers. In markets where innovation is critical – as in many KBC-intensive industries – dynamic efficiencies are especially important.

It is difficult to measure the extent of the efficiencies that may result from a merger. In particular, dynamic efficiencies are difficult to gauge because such dynamic effects will occur – if at all – over quite a long time and may be more abstract in nature than static effects. Yet, it seems likely that dynamic efficiencies have considerably more potential to benefit consumers than static efficiencies. Therefore, it would be desirable – in an ideal world – for dynamic efficiency considerations to feature more frequently and more prominently in merger decisions. The problem in practice is that there is no robust methodology available for doing so. Rather than engage in speculation, courts have tended to avoid dynamic efficiency analysis in cases where it may be relevant. Due to their complexity, dynamic efficiencies will rarely be quantifiable, yet qualitative approaches may yield some helpful information.

Innovation and "green growth"

"Green growth" is generally defined as economic growth under environmental constraints and is similar to what is commonly referred to as sustainable growth. Technological innovation is generally acknowledged to play a central role in any strategy for encouraging green growth, such as the use of smart grids in the energy sector. The OECD's work to date on approaches to green growth indicates that market-based policies should be pursued wherever possible to encourage environmentally friendly innovation, such as the use of emissions trading schemes, subsidies for R&D provided that they do not distort competition and trade, production standards, or tax exemptions for green investment and production.

Competition and intellectual property

Intellectual property rights are an integral part of the development and use of KBC. Many see IPR as indispensable in modern, technologically advanced economies, and effective competition policy recognises and encourages the value of the innovation that

IPRs represent. Investment in innovation requires a predictable legal system and, as a result, antitrust policy should be formulated to ensure that incentives to innovate are not unnecessarily weakened or destroyed. It has therefore been argued that a strong and predictable IPR regime is important for many of the disruptive innovations that create dynamic competition and provide consumers with major technological advances.

Nonetheless, the exploitation of IPR challenges some traditional assumptions about the benefits of competitive markets. Competition policy generally aims to promote competition to secure the benefits that flow to consumers from marginal cost pricing. Intellectual property laws, instead, aim to bring about the benefits that accrue from new products and creations by protecting innovators from some forms of competition. This creates an apparent conflict between these policy regimes. Businesses generally have the freedom to determine the circumstances and terms under which they wish to license or refuse to license their IPR. When and whether competition law should be used to restrict that freedom is a controversial matter, but most agree that competition law should not be used to bludgeon IPR.

Patents do not necessarily create monopolies or dominance. Firms may apply for patents in the hopes of obtaining market power, but very few inventions constitute a true innovation that leads to a new product or process. Although dominance may occasionally relate to a single patent, a greater concern is agglomerations of patents that could close off a field of technology. The traditional view of patents is that they provide a positive incentive to innovate and may grant firms some market power. There is a concern, however, that patents may have a negative effect on innovation, particularly when a product is dependent on many patents and in industries that are based on standards and that have substantial network effects. Yet patents can also have a positive effect on competition and innovation. For instance, venture capitalists recognise that for investment purposes, patents are the only important asset possessed by many high-technology start-up companies.

Both intellectual property policy and competition policy aim to encourage innovation, but both can discourage innovation if pursued too strongly or too weakly. If patents are granted too readily, for example, potential inventors may be discouraged from innovating, because they must deal with so many parties with so many patents that it becomes too difficult and expensive to determine which licences are needed and to pay for them. Conversely, if competition enforcement is pursued so aggressively that rivals can make unencumbered use of a company's innovation, there is little incentive to innovate in the first place. The balance that has been achieved rewards inventors with some temporary protection from free riders (which in itself can facilitate dynamic competition); after that, competition is facilitated because anyone can copy and sell the invention or use it as a springboard for follow-on innovation. That balance does not ensure, however, that the two policies are always well aligned in practice.

The challenge for competition authorities, regardless of how far they venture into the intellectual property sphere, is to minimise the anticompetitive effects of IPRs while respecting their existence and the societal goals they are meant to promote. Moreover, in view of the recurrent use of IPR in KBC-focused industries, these concerns are especially pressing and acute in such markets.

The effects of patents on innovation

Patents reward inventors for their discoveries by giving patent holders the exclusive right to make, use and sell inventions for a limited time in the jurisdiction in which the patent is held. In general, patents should be granted only for inventions that are novel, non-obvious and useful. Moreover, a patent right – and the market power it may create – should be granted only if, and to the extent that, it is necessary to encourage the

innovation covered by the right. Patent "scope" or "breadth" helps to determine the value of a patent by setting the boundary between what is protected and what is not: the broader the scope, the more likely it is that competing products and processes will infringe the patent. "Patentability" refers to how easy or difficult it is to meet the standards for obtaining a patent on an invention. Patent breadth and patentability can have both positive and negative effects on innovation. Patent systems must strike the right balance between allowing patent owners an appropriate return from their innovations and fostering technological progress for society as a whole.

Patents encourage innovation in several ways. First, they give inventors incentives to innovate by providing a measure of protection against imitators. Second, and in exchange for that protection, patents require the inventor to tell the public that the technology exists and to explain how it works. That disclosure enhances the process of knowledge diffusion by helping others to understand the invention and improve upon it or incorporate it in a new invention of their own, thereby stimulating new ideas. Another benefit of disclosure is that it tends to decrease redundant R&D investments by firms that might otherwise try to develop the same technology. Finally, patents add to knowledge diffusion by facilitating exchanges via licensing agreements.

However, the exclusive rights conferred by patents may distort competition and prevent the efficient allocation of resources. The easier it is to obtain patents and the broader the patents granted, the more patents will tend to be issued and the more comprehensive they will be, up to a saturation point. This can lead to five types of costs. First, static inefficiencies increase because more patents and greater patent breadth make monopolisation and its attendant deadweight losses more likely. Second, dynamic inefficiencies increase because it will become more difficult for others to invent without infringing someone else's patent. An "anticommons", or patent gridlock, arises when so many patents have been awarded that the difficulty of identifying which licences are needed, and negotiating and paying for them, is so great that further innovation is discouraged or even halted. Third, a larger number of broader patents might encourage socially wasteful rent-seeking behaviour, such as patent trolling. Fourth, enforcement costs are higher since there are more patents to enforce. Finally, it is possible that overbroad patent rights and easier patentability will lead to inefficient overinvestment in R&D.

In practice, the effects of patents on innovation vary substantially from industry to industry. A stronger patent system, or one in which patents are easy to obtain, does not always favour innovation, particularly because outcomes are uncertain, since many inventions are patented but relatively few are valuable. A difficulty for policy makers is that it is virtually impossible to quantify the net value of the innovation that will be gained or lost if they opt for a tighter or more permissive patent policy. Nonetheless, the conviction that patents are good for innovation has helped bring about important changes in many patent regimes during the past quarter century or so. In general, patent rights have been broadened and strengthened through expanded coverage into new fields, the increased scope of individual patents, the curtailment of research exemptions, and the increased protection granted to patent rights by courts (Martinez and Guellec, 2004).

However, some contemporary commentators argue that too many patents are now issued, that the claims allowed are too broad, and that the rights conferred on patent holders are too strong. The result, the critics claim, is that innovation is being discouraged because it is difficult and costly to identify the patents that might be relevant to an invention and to pay for any necessary licences. Instead, it is argued, patents rights should be more limited, to reflect the original conception of patents as a limited exception to what was supposed to be the prevailing paradigm: competition (Lemley, 2005; Langenfeld, 2001).

Many empirical studies have analysed the effects of these changes in patent policies. Some conclude that while stronger patent rights contribute to a significant increase in the number of patents granted, they have little effect on R&D expenditures, which suggests that they do not boost innovation significantly (Jaumotte and Pain, 2005b; Bessen and Hunt, 2004). There is sound empirical evidence that the availability of patents is an important factor in firms' decision to invest in R&D in certain industries; these industries include a number of sectors in which KBC is an important factor, such as computing and pharmaceuticals (Levin et al., 1987; Cohen et al., 2000).

Most national patent systems incorporate a version of the generally accepted principle that use of a patented invention for purely experimental purposes does not imply infringement. The experimental use exemption is important not only because it may ease the effects of any eventual anticommons, but also because it can lead to greater competition, depending upon how liberally it is interpreted. At the same time, the experimental use exemption must be used judiciously; it may discourage innovation if used too readily.

Competition issues in IPR markets

IPRs do not convey total immunity from competition law. The main objective of patent laws is to encourage the advancement of scientific knowledge, rather than to enrich patent owners. Moreover, the patenting process and subsequent licensing arrangements can create opportunities for anticompetitive conduct by patent holders and/or licensees. However, the extent to which enforcement of competition law is an appropriate way to correct market failures stemming from IPR is much disputed. The following sections consider competition problems that may arise with pending and granted patents, including those relating to KBC-focused innovation.

Patent pendency problems: Patent ambush

There has been a significant increase in the number and complexity of patent applications filed in the world's major patent offices, and it has resulted in growing backlogs and substantially longer pendency periods. The increase is due to a more globalised patent system, with multiple applications at various national or regional patent offices; to the increased technological development of emerging markets; and to the expanded range of technologies for which patents can be granted. More applications pending for longer periods have increased uncertainty about which inventions are and will be protected by patent rights.

Some firms have adopted strategies that are potentially harmful to competition and innovation in order to take advantage of the uncertainty created by growing backlogs and longer pendency periods. Most of these strategies rely on a procedural device known as a "divisional" application in some jurisdictions and a "continuation" application in others. Some divisionals are mandatory while others are filed voluntarily, but they all derive from an earlier, related application and they all take on a life of their own once they come into existence. This means they are examined separately and have their own, separate publication schedules. It is possible to file divisionals repeatedly, so that a whole series may spring from a single original application. Among other things, divisionals make it possible for companies to keep their patent applications pending longer than would otherwise be the case. They also make it possible to keep pending patents hidden from public view longer. That makes them potentially valuable tools for a company that wishes to engage in anticompetitive conduct. This may include: i) ambushing a standard-setting organisation (SSO); ii) forcing a rival to cross-license its technology for free, or on more

favourable terms, by using the leverage obtained from a patent flooding strategy; and iii) keeping applications pending and unpublished through divisionals, then modifying the application in an additional filing so that it describes a rival's new product perfectly, thereby ensuring that the rival will be liable for infringement.

Standard-setting activities generally have pro-competitive effects because they can increase the number of suppliers in the market, reduce the cost of producing goods, allow customers to use components from different suppliers instead of having to rely on a single source for an entire product line, and reassure customers that compatible products will be available and supported in the future. However, SSOs can be "ambushed" by a company that conceals granted or pending patents that are relevant to the standard being developed until it has been set and then sues for infringement. Once the standard has been widely adopted and implemented, switching to another standard tends to be very costly. In this manner, companies might acquire dominant positions that they would not otherwise have had and, as a result, they may be able to collect royalties that are higher than would otherwise have been possible. The result can be a chilling effect on further standard setting, a decline in interoperability of products, higher prices for consumers, and delays, or even a complete halt in further implementation of the ambushed standard.

To avoid pending patent ambushes, competition authorities may need to engage in advocacy efforts to help SSOs to design and improve their procedural rules so as to minimise opportunities for patent ambushes without offending competition laws against co-ordinated conduct. Three types of rules have been proposed for that purpose: FRAND licensing terms, disclosures and joint *ex ante* negotiations (Box 3.3).

Box 3.3. Avoiding patent ambushes: Options for standard-setting organisations

- **FRAND commitments**: One strategy for fighting ambushes, which has already proven popular among SSOs, is to require members to make an *ex ante* commitment that if any technologies on which they hold patents or pending patents are included in the SSO's standard, they will license those technologies on (fair), reasonable and non-discriminatory (FRAND or RAND) terms. FRAND commitments are typically broadly worded and do not specify the actual terms of a licence. The precise terms of each licence are usually negotiated bilaterally outside the SSO setting. While the "non-discriminatory" component of FRAND is generally deemed to be a useful concept, the "fair" and "reasonable" aspects have been controversial, with critics arguing that FRAND commitments provide little or no protection against price gouging (e.g. Ohana et al., 2003; Lemley, 2002).
- Disclosure: Another strategy is to require ex ante disclosures by participants in any standard-setting exercise. Two main types of disclosures could be required or encouraged. First, SSOs may find it helpful to create rules that impose obligations on their members to make accurate disclosures of any patents and pending patents they have that could overlap with the standard under development. Second, SSOs could oblige their members to disclose the maximum fees and most restrictive licensing terms they would demand for such patents if their technology were to be incorporated into the standard. While there are reasons to doubt the effectiveness of FRAND commitments, disclosure requirements do not have the vagueness problem that FRAND has. SSOs could enforce compliance with disclosure rules, if necessary, by relying on contract law.
- Ex ante negotiation: The third anti-ambush strategy that has been proposed builds on disclosure requirements and calls for joint ex ante negotiations between all the SSO members that are prospective licensees of a technology and the member who is a prospective licensor of that technology over the royalties that the latter would charge if the technology were incorporated into the SSO's standard. However, such commitments and discussions may also raise competition concerns of their own. SSO members are often competitors and discussions among competitors about the prices they are willing to pay or the terms they are willing to give sellers obviously have the potential to be deemed unlawful. For that reason, some SSOs' policies forbid discussions of royalty rates and terms among members.

Some have questioned whether patent ambushes can ever amount to a breach of competition law. Although several competition authorities have undertaken enforcement action under the theory of abuse, one view is that such behaviour is purely a patent law problem, or else a form of fraud based on deception, rather than a competition law problem. Of the cases taken by competition authorities to date, an important theme is that for patent ambushes to amount to a problem under competition law they must harm competition. Dishonest conduct is not necessarily the same as unlawful conduct because it is exclusionary, and the way to distinguish these types of behaviour is by looking at the conduct's effect on competition.

From a competition policy perspective, it is difficult to understand why maintaining a patent pending for extended periods with cascading divisionals has been tolerated. Regrettably, some major patent offices lack effective tools to control this behaviour at present. The optimal solution is to make changes in the patent regime itself, to allow patent offices to take steps such as placing limits on the number of times and the period in which applicants are allowed to use divisionals.

Competition and granted patents

Competition problems may also arise after a patent has been granted, particularly in regard to licensing arrangements for exploitation of the IPR.

A *grant-back obligation* is a provision in a licensing arrangement that requires the licensee to grant a licence on any improvements it patents related to the original invention back to the licensor. Grant-backs may encourage efficient licensing by serving as a form of financing for cash-poor licensees who are willing to share some of the fruits of their research with licensors in lieu of an upfront payment. Some grant-back arrangements, however, are more likely to damage incentives to innovate and/or cause competitive problems than others, depending on whether they encompass severable improvements and whether they are exclusive. Severable improvements can be used by licensees without infringing the original invention, whereas non-severable improvements cannot be used without infringing the original invention. Because licensors already have a measure of authority over non-severable improvements, even exclusive grant-backs of non-severable innovations are relatively less likely to cause competition concerns. In contrast, grant-backs of severable improvements may damage incentives for follow-on innovation because they are not otherwise legally dependent on the licensor. They may also serve as a means of prolonging the licensor's market power by nullifying or reducing the threat of what would otherwise become rival products. Therefore, these types of grant-backs should be subjected to relatively more scrutiny, particularly if they are exclusive.

A uniformly tough competition policy towards grant-backs would be counter-productive. First, a distinction should be made between non-exclusive licences (where the follow-on inventor retains rights to its invention), and assignments (where no rights are retained). There is a much lower risk of competitive harm when licences are non-exclusive. In fact, such licences may be pro-competitive because they allow more than one firm to use the follow-on technology. Second, if competition authorities sought to enjoin all grant-backs, they would probably encourage inefficient refusals to licence. A better result overall may be achieved by exempting grant-backs to non-profit entities and permitting other grant-backs as long as they do not give the original licensor either an assignment of follow-on rights or an exclusive licence to them. This policy could ease licensors' fears about losing market share to licensees while leaving licensees with at least some incentive to innovate.

Patent pools are formed when two or more parties collaborate and arrange to license their patents as a package. Patent pools, like most licensing arrangements, are usually beneficial to competition. They may occasionally reduce or eliminate competition, however, particularly if the pool includes patents that are substitutes for each other and/or non-essential technology, as opposed to complementary and/or essential patents. More specifically, they can create risks for competition by reducing competition in horizontal technology markets, by facilitating collusion in downstream product markets, by foreclosing competing technologies, or by reducing incentives to innovate. In these circumstances, patent pool arrangements may merit competition law scrutiny.

Cross-licensing agreements give two parties the right to use each other's patents. The agreements may also include rights to pending patents, and they may be grouped together to form a licensing pool for the purpose of sharing complementary technologies held by several parties. Cross-licensing agreements and licensing pools are usually efficient and pro-competitive. There are, however, a number of ways in which pending patents can be used anti-competitively in these arrangements. These include entry deterrence and patent flooding scenarios, whereby a dominant firm files a large number of poor quality patent applications that are at the margins of the other company's patent, with the aim of either keeping a rival out of the market or forcing it to cross-license its valuable technology, often on a royalty-free basis. These strategies depend on the fact that even weak pending patents can have powerful effects on competition. The victim will probably not have the time or resources to determine the validity of so many pending patents, and there is a very good chance that at least some will be granted. Furthermore, the risk of infringing even a pending or granted patent that appears to be weak can be extremely high because if its validity is upheld, the owner may obtain very substantial damages or injunctive relief.

Sometimes a *unilateral refusal to license IP* may raise competition concerns. However, there is some disagreement as to whether such refusals should be deemed anticompetitive for competition law purposes, and if so, how to remedy the problem. EU competition law admits the possibility of compulsory licensing remedies when unilateral refusals to license prevent the emergence of a new product, are unjustified, and exclude any competition in a secondary market. Conversely, the US Supreme Court's decision in *Verizon Communications Inc. v. Trinko* (540 U.S. 398 [2004]) suggests that there can be no antitrust liability for such conduct and thus, no mandatory licensing remedy (under antitrust law, at least).

Another potential competition problem in IPR markets relates to the *strategic accumulation of standard-essential patents* by individual firms. Generally, standards incorporate the best available technology, regardless of whether or not the technology is under patent. If patents are included in a standard, FRAND licensing commitments are employed to ensure, at least in theory, that the standard remains available to all developers on adequate terms. However, an emerging problem is the deliberate accumulation of standard-essential patents by individual firms and subsequent strategic use of patent litigation against competitors. This development raises two issues: the extent to which patent holders are respecting FRAND commitments agreed during standard-setting processes, and the potential scope for competition enforcement to address any resulting hold-up problems. Merger control is also relevant to determine whether patent acquisitions will substantially reduce competition.

Competition and IPRs: The role for competition authorities

What is the appropriate role for competition authorities in the IPR area? Traditionally, patent and competition law authorities have carried out their work separately. However, they share the goal of promoting innovation and are therefore quite complementary. It is

generally accepted that competition authorities should not become involved in the IPR-granting process, but they can encourage intellectual property agencies to consider competition issues during their approval procedures. Moreover, in an environment of "easy patentability", competition authorities and the courts may compensate by using competition laws to limit the negative effects of over-patenting. Given that competition law is a relatively blunt instrument for that purpose, however, it is preferable to fix such problems within the patent system.

Because they lack the relevant technical expertise and limited resources, it does not appear prudent for competition authorities to take any responsibility during the review of IPR applications. Nonetheless, beyond the patent-granting process itself, there is significant scope for competition authorities to improve the impact of patents on competition. They have the expertise to identify the anticompetitive effects of overly broad or invalid patents. They could therefore collaborate with IPR-granting agencies to make them aware of competition issues and begin to take any necessary steps to improve the IPR approval process. Collaborative possibilities might include discussions with patent offices to improve mutual understanding of the two fields, expert reports on a nation's patenting system to determine whether there are undue competition problems, and/or seminars or hearings in which academics, public- and private-sector practitioners, and industry participants examine the overlap between IPR and competition policies.

Over the last few years, co-operation between competition authorities and patent offices has improved in jurisdictions such as the United Kingdom and the United States. Increased dialogue and cross-agency activities aim to improve information exchange and understanding. Examples include competition advocacy programmes targeted at the IPR community, issuing of joint agency reports, establishment of monitoring networks, high-level symposiums on the interface between IPR and competition, and secondment of experienced patent office staff to competition authorities to assist in the preparation of sector-specific reports. Another potential harmonising strategy would be reciprocal training programmes carried out by officials from both agencies. In addition, statutory changes could be made to enable a greater flow of information between patent offices and competition authorities.

Competition authorities are well placed to examine the effects of restraints, market conduct and rules on consumer welfare, especially when based on empirical research and conducted by economists. Because competition authorities have experience in effects-based methods, they can play a meaningful role in advising patent policy makers on the impact of current laws and on recommended reforms.

With respect to businesses, competition authorities should consider publishing a set of guidelines describing how they analyse licensing agreements and other conduct involving intellectual property. Such guidance would assist businesses in structuring their IPR arrangements so as to ensure that these are consistent with competition law. This would have the further benefit of increasing legal certainty in many KBC-focused markets. Whatever IPR-related initiatives competition authorities may take, they should strive to limit the anticompetitive aspects of IPR while respecting its necessity.

Competition policy in the digital economy

The digital economy, an umbrella term that describes markets focused on digital technologies, is at the heart of KBC's growing importance to economic activity in OECD countries. It typically involves the trade of information goods or services through electronic commerce. It operates on a layered basis, separating the transport (physical) and applications (intangible) segments. This vitally important sector of the economy is

the source of significant growth in recent years. Moreover, its impact extends beyond the information goods and services provided directly to other areas of the economy (such as the entertainment industry) as well as to lifestyles more generally.

Competition in digital markets typically takes a distinctive form. First, competition between business models or platforms tends to be more important than competition within business models because platform competition often leads to a winner-takes-all outcome in which monopoly is the nearly inevitable outcome of market success. Second, digital markets are often characterised by strong network effects and economies of scale, which are largely responsible for the winner-takes-all outcomes. Third, many digital markets are two-sided, so that two or more user groups benefit from use of the digital platform. For example, search engines are used both by individuals to access information on the Internet and by advertisers to access viewers. Fourth, as the digital economy becomes increasingly interconnected, a degree of co-ordination and co-operation between firms is unavoidable and indeed pro-competitive. Fifth, digital markets (like other KBC-focused markets) are characterised by high rates of investment and innovation, which leads to rapid progress within the sector.

Consequently, competition in these markets has sometimes been cyclical in nature. Successful firms may acquire significant market power for a time, but their market power may prove vulnerable to displacement by the next cycle of innovation and therefore transient. Accordingly, dynamic competition considerations should be taken into account as much as possible, given the importance of preserving incentives to invest and innovate in the digital economy. Moreover, while "big" is not automatically "bad" in any market, successful competition in the digital context leads the market towards monopoly more often than in other sectors.

The scope for enforcement of competition in digital markets

The appropriate scope of enforcement of competition in digital markets is a controversial question. Given the importance of preserving incentives to invest and innovate, digital economy firms sometimes say that regulatory intervention, including enforcement, should be avoided. In particular, excessive or inappropriate intervention may damage competition by diminishing dynamic efficiency. Under this view, it is better to rely on self-regulation by the industry or simply the disciplining effects of the competitive process in digital markets. The nature of platform competition may give platform owners strong incentives to self-regulate and ensure effective competition within their systems.

However, at the OECD's 2011/12 hearings on competition in the digital economy, the broad consensus was that competition law retains a significant role in the digital economy, particularly as these markets stabilise and mature. The precept that competition law should protect the competitive process and not competitors holds true in digital markets. However, enforcement may be necessary to eliminate and deter anticompetitive behaviour that would inhibit dynamic competition. For example, competition law might be used to address potentially anticompetitive mergers or acquisitions by digital firms, hold-up problems caused by dominant platforms or the misappropriation of an applications developer's investment by a platform owner.

The appropriate timing of any public intervention in digital markets is a difficult issue. Once again, dynamic considerations are important, with the need to balance the risk that premature intervention may inhibit further pro-competitive developments against the risk that dominance may become entrenched. In view of these considerations, an approach based on *ex ante* monitoring by competition authorities could prove more effective than an *ex post* enforcement strategy, although competition authorities have historically been reluctant to take on such a quasi-regulatory role.

Another issue concerns the point at which a firm can be considered dominant or possessing a monopoly. Although many key players in the digital economy are large and profitable, vigorous competition among them and the dynamic or cyclical nature of competition in some digital markets may render durable dominance elusive. At the OECD's digital economy hearings, a panellist suggested as a broad rule of thumb that intervention for abuse of dominance (or unlawful maintenance of monopoly) should occur only if a firm has been dominant for five to seven years, has survived several challenges, and is profitable.

Where dominance cannot be established, an alternative approach is to address significant instances of anticompetitive behaviour by a non-dominant firm through provisions regulating unfair trade practices by firms, such as paragraph 5 of the US's Federal Trade Commission Act. Conduct may also run afoul of provisions against attempted monopolisation, if such prohibitions are included in a jurisdiction's competition rules.

In general, the ordinary competition rules are sufficiently flexible to be used for digital markets. However, certain recurrent difficulties arise for enforcement in this sector. First, competition authorities may lack adequate technical knowledge. Moreover, given the fast-moving nature of the digital economy, there is a risk that knowledge will quickly be out of date. Options for increasing an authority's technical expertise include the use of expert advisors, sector inquiries into digital markets, and participation in industry co-ordination processes.

Second, as the digital economy is inherently worldwide in scope, problems of jurisdiction or territoriality may arise. It may be difficult to identify an entity with responsibility for anticompetitive behaviour located in the national territory, for example, or a restraint may apply in or seek to divide numerous markets, a recurring issue in e-commerce. As a result, there is a particular need for international co-ordination and co-operation by competition authorities relating to digital markets.

Third, there may be some difficulty for applying established competition law concepts in the digital context. Convergence, cross-subsidies, platform competition and constant cycles of innovation may complicate the task of market definition. The assessment of whether conduct is anticompetitive frequently turns on highly technical questions of product design or coding. Furthermore, structural remedies may become rapidly obsolete, so that behavioural remedies may be preferred, although regular monitoring is then required.

Characteristics of digital markets: Network effects and switching costs

Network effects occur when the value of a product to its users is related to the number of additional users of the product. Network effects are direct when users of the product interact with each other and greater numbers of users facilitates greater interaction. The social network is a quintessential example: connection to greater numbers of users on the network increases its utility and attractiveness to individual users. Network effects are indirect when high usage rates for one product increase the attractiveness of that network for another group, which in turn results in indirect benefits for users of the original product. For example, the widespread adoption of an operating system (OS) attracts applications developers, who produce new applications that are compatible with that OS, to the benefit of its users. Although network effects are not unique to digital markets, they can be especially strong in them. Network effects can be conceptualised as a variety of demand-side economies of scale. Supply-side economies of scale may also occur in digital markets, most notably in the context of search engines, where increased data from users allows for the development of more accurate search algorithms.

Network effects function as a positive externality and render a product more valuable to its users or to other groups. A higher market share therefore improves product quality, a pro-competitive outcome. At the same time, network effects may also have a detrimental impact on competition, as they may make entry more difficult and increase switching costs for consumers. The fear is that users will become locked into a product that benefits from network effects and will lead to a snowball effect or "tipping point" towards market dominance for that product.

Certain market features militate against the occurrence of a tipping point in the digital economy, however. Diminishing returns to scale, congestion effects, low switching costs, and per-transaction charges all weaken the competition-suppressing effects of cross-group externalities. Yet, as digital markets mature, network effects may strengthen with the entrenchment of market dominance. While network effects are not *a priori* a competition problem, a firm that benefits from network effects should not seek to strengthen its market position through exclusionary behaviour. Network effects must therefore be assessed on a case-by-case basis in order to determine the competitive implications.

Switching costs, such as exit charges or learning costs, are incurred when a user moves from one product to another. Although switching costs can strengthen the anticompetitive impact of network effects, the extent to which switching costs present a competition concern in the digital economy varies between products.

Additionally, multi-homing is common in digital markets. That is, it is not unusual for consumers to affiliate with two or more platforms, e.g. with both Facebook and Twitter. Accordingly, participation in one network does not prevent the user from participating in and benefiting from other networks. This may reduce the likelihood of tipping.

Characteristics of digital markets: Open versus closed platforms for applications development

The winner-takes-all mode of competition in digital markets takes place between competing platform models. Conventionally, a distinction is made between open and closed platform models. Increasingly, however, digital markets present a spectrum or continuum of approaches, from more or less fully open (Google's Android OS), to partially open (the Apple system), to largely closed (the Blackberry system). Moreover, there is an increasing move towards integrated technology ecosystems, with a platform and bundled product offerings. This development has raised barriers to entry in the platform market, as new entrants must now compete in two or more markets from the outset. Nonetheless, vibrant competition is still the norm in the platform sector.

Well-designed platforms catalyse innovation by facilitating the development of interoperable follow-on technology. Information technology platform owners make their facility accessible to other entrepreneurs, sometimes even potential rivals, to enable third-party innovation. The platform model is therefore a key driver of the high rates of innovation and growth in the digital economy.

Inter-platform competition refers to competition between competing platforms. It is the predominant source of competitive pressure in the digital economy at present. Competition occurs between more open and more closed approaches to platform development, with pros and cons for each approach. On a more closed platform, the platform owner exerts greater control over issues such as security and the quality and pricing of applications and avoids free riding on its investment. Open models are more successful at attracting investment and applications developed by third parties.

Nonetheless, they still require on-going management input from the platform owner in order to maintain quality and confidence in the platform and its applications. Although a dominant mobile platform may eventually emerge, the selection of a dominant platform should be made by the market through competition rather than by a top-down decision by government agencies. However, governments retain an important supervisory role in this process, whether through sector-specific regulation or enforcement of competition, in order to safeguard a level playing field and ensure that dominance emerges solely as a result of competition on the merits rather than through exclusionary firm conduct.

Intra-platform competition is competition *within* a platform, and in particular, the relationship between the platform owner and applications developers. Although in a sense subsidiary to inter-platform competition, significant investment and innovation nonetheless take place at the intra-platform level. Competition problems arising at this level may negatively affect both static and dynamic efficiency in digital markets. First, there is a risk that the platform owner may seek to exclude third-party applications developers, either to protect its own vertically integrated applications subsidiary or to prevent the emergence of a potentially competing platform. Second, the platform owner may initially encourage significant investment by third-party developers in applications for its platform, but then attempt to misappropriate the developers' investment by copying or cloning the applications produced. The extent to which intra-platform competition is an area for competition law enforcement remains controversial. The issue of investment incentives is central to this debate, with a need to balance incentives for platform development against incentives for applications development. Although applications developers should endeavour to protect their investments *ex ante* through contractual means where appropriate, there remains scope for competition authorities to intervene *ex post* to protect the competition process in these markets.

Interoperability, standardisation and patents in the digital economy

In an increasingly integrated and converging digital economy, *interoperability* allows different platforms and applications produced by different developers to connect and communicate, thereby increasing value for users. Interoperability increases the value of products for users by facilitating access to a far broader range of functions and content through a single platform. At present, interoperability is facilitated primarily through voluntary disclosures by single firms and industry-wide standardisation. Because interoperability increases the attractiveness of a product for consumers, developers have incentives to facilitate interconnection, particularly for new products seeking to gain a foothold in the market. For established platforms, however, the incentives of the platform owner may shift away from interoperability in order to protect a downstream subsidiary or eliminate a potentially competing platform.

Data portability refers to the capacity to move or reuse data between different platforms and applications. This facilitates switching by users. It is a technologically complex task that developers have limited incentives to facilitate. Nonetheless, several leading technology firms have committed to improving data portability within their platforms.

Unilateral voluntary disclosure of a product's application programming interface (API) is frequently used to share interoperability information. Voluntary disclosure facilitates rapid follow-on innovation. However, by placing this information in the public domain, the disclosing firm relinquishes a large measure of control over the development of interoperable products. Conversely, the receiving firm must comply with the design choices, good or bad, made by the disclosing firm, and moreover, becomes dependent on the latter for timely disclosure and is vulnerable to subsequent alterations of the original platform.

The potential use of competition law to address failures to voluntarily disclose interoperability information is much disputed. On the one hand, failures to disclose may create hold-up problems and inhibit intra-platform competition. On the other hand, the refusal to supply doctrine is rarely applied in competition law generally, particularly in markets where investment and innovation are important and incentives may be damaged by imposing a duty to supply. It is fair to say that enforcement is rarely the best way to address unilateral interoperability disclosure problems.

Standardisation provides an industry-wide alternative to individual disclosures of interoperability information. Under this approach, industry participants collectively identify the best technology for a particular function and establish it as the generally applicable standard for the sector. This facilitates interoperability while lowering barriers to entry for small firms that can build to the established standard. Moreover, the market benefits from increased network effects without the risk of a snowball effect towards monopoly. In this sense, standardisation, like platforms, functions as an innovation catalyst.

However, standardisation is not a panacea for interoperability or other competition problems in digital markets. First, the standard-setting process itself must be open and transparent. Second, although many digital standards have been adopted, few are successful in practice. An effective standard must be well designed, meet a genuine need and be widely implemented. Third, innovation based on standardisation works more slowly than single-firm innovation. Moreover, it tends to inhibit product differentiation, which may be a desirable feature for certain products, particularly for the user interface. Fourth, and of increasing importance, if the standard incorporates patented technology, licensing must be available to all on FRAND terms. However, as noted above, while FRAND commitments may secure access to the technology for rivals, such arrangements may not always be effective at preventing price gouging by patent holders. Moreover, the strategic accumulation of digital patents and potential hold-up through patent litigation has become an increasing concern in the digital economy in recent years.

Conclusions

Innovation is the lifeblood of industries that are based on KBC, driving product development and fostering market growth. Accordingly, optimal competition policy for KBC-intensive markets should be innovation-focused. Ambiguity regarding the precise relationship between competition and innovation, which exists both in theory and at an empirical level, complicates the task of determining the proper role for competition law in such markets. The evidence suggests, however, that, at the very least, there is scope for strategic, well-targeted intervention by competition authorities to support and augment the process of innovation. Eliminating unnecessarily anticompetitive regulation further facilitates innovation.

This chapter has reviewed some of the common features of KBC markets and the competition problems that may arise. Industry standard setting is a frequent practice, yet it is vulnerable to both anticompetitive collusion and single firm manipulation. The importance of IP, particularly patents, in KBC-based markets highlights the issue of the optimal scope of patents for encouraging investment and innovation without deterring beneficial competition. In digital economy markets, where inter-platform competition seems to be of great importance to innovation, one question concerns the extent to which intra-platform competition should be actively protected through competition law mechanisms. Mergers, and in particular the scope for resulting dynamic efficiencies, are another consideration, with the strategic aggregation of patents through mergers and

acquisitions an issue of increasing concern. Nonetheless, existing competition laws are sufficiently flexible to be applied in intangible asset markets, as long as enforcers and courts take due account of the specific market context and the importance of innovation in spurring growth in such sectors.

The following considerations should be taken into account when formulating and applying competition policy in KBC-intensive markets:

- Innovation is a primary concern of KBC-focused industries, so that promoting and encouraging dynamic efficiencies should be prioritised. Although the economic evidence on the relationship between competition and innovation is somewhat ambiguous, it is increasingly clear that a moderate degree of competition tends to foster innovation most effectively. However, KBC-heavy markets are just as susceptible (if not more so) to competition problems as other types of markets. Accordingly, robust enforcement of competition law is necessary to create space for innovation and growth in KBC markets.
- Elimination of anticompetitive governmental regulation also tends to encourage greater innovation. The OECD's Competition Assessment Toolkit provides a comprehensive framework for identifying and assessing potentially restrictive regulatory arrangements.
- Governmental interventions, by means of regulatory measures or subsidies, may be helpful in overcoming situations in which company initiatives to bring about the desired level of innovation are insufficient owing to market failures. It is important, though, that such interventions do not restrict competition and trade.
- Intellectual property rights are commonly owned and used by firms in KBC-focused markets. Competition policy must balance the innovation that IPR can stimulate against the risks that they might be abused to reinforce or acquire dominance through anticompetitive means. Arguably, reforming the patent system might be the best way to address certain problems that affect competition in IPR-intensive markets. Nonetheless, in certain circumstances, measured use of enforcement of competition law against IPR abuses is appropriate to tackle competition problems that threaten innovation and consumer welfare.
- The risk of patent ambushes has emerged as a danger in standard-setting processes, which are common in KBC-focused industries. Competition authorities can work with standard-setting organisations to reduce the risk of patent ambush and other potential competition problems by implementing appropriate rules and conditions, such as ex ante licensing commitments, disclosure obligations or negotiation.
- In the digital economy, certain market characteristics – including inter-platform competition, two-sided markets, and strong network effects – may complicate the enforcement of competition law. Although it is generally acknowledged that competition laws remain fully applicable in such markets, the digital context is important. The timing of any intervention can be especially tricky: although it is necessary to act before dominance is entrenched, competition enforcers should be wary of intervening too readily in still-competitive markets. Their challenge is to keep digital markets open and innovative without inhibiting the process of "creative destruction" that has driven much of the technological progress in these markets to date.

References

Aghion, P., N. Bloom, R. Blundell, R. Griffith and P. Howitt (2005), "Competition and Innovation: An Inverted-U Relationship", *The Quarterly Journal of Economics,* Vol. 120(2), p. 701.

Arrow, K. (1962), "Economic Welfare and the Allocation of Resources to Invention" in R. Nelson (ed.), *The Rate and Direction of Economic Activity,* Princeton University Press, Princeton NJ.

Bessen, J. and R. Hunt (2004), "The Software Patent Experiment", in OECD (2004), *Patents, Innovation and Economic Performance*, OECD publishing, Paris. http://dx.doi.org/10.1787/9789264015272-en

Bower, J. and C. Christensen (1995), "Disruptive Technologies: Catching the Wave", *Harvard Business Review*, Vol. 73(1), p. 43.

Cohen, W., R. Nelson and J. Walsh (2000), "Protecting Their Intellectual Assets: Appropriability Condition and Why US Manufacturing Firms Patent (Or Not)", *NBER Working Paper* No. 7552.

DeSanti, S. and W. Cohen (2001), "Competition to Innovate: Strategies for Proper Antitrust Assessment", in R. Dreyfuss, D. Zimmerman and H. First (eds.), *Expanding the Boundaries of Intellectual Property*, Oxford University Press, Oxford.

Jaumotte, F. and N. Pain (2005a), "From Ideas to Development: The Determinants of R&D and Patenting", *OECD Economics Department Working Pape*r No. 457. http://dx.doi.org/10.1787/707375561288

Jaumotte, F. and N. Pain (2005b), "Innovation in the Business Sector", *OECD Economics Department Working Pape*r No. 459. http://dx.doi.org/10.1787/688727757285

Kamien, M. and N. Schwartz (1982), *Market Structure and Innovation,* Cambridge University Press, New York.

Langenfeld, J. (2001), "Intellectual Property and Antitrust: Steps Towards Striking a Balance", *Case Western Reserve Law Review*, Vol. 52(1), p. 91.

Lemley, M. (2002), "Intellectual Property Rights and Standard-Setting Organisations", *California Law Review*, Vol. 90(6), p. 1889.

Lemley, M. (2005), "Property, Intellectual Property and Free Riding", *Texas Law Review*, Vol. 83(4), p. 1031.

Levin, R., A. Klevorick, R. Nelson and S. Winter (1987), "Appropriating the Returns From Industrial Research and Development," *Brookings Papers on Economic Activity,* Vol. 3, p. 783.

Martinez, C. and D. Guellec (2004), "Overview of Recent Changes and Comparison of Patent Regimes in the United States, Japan and Europe" in OECD (2004), *Patents, Innovation and Economic Performance*, OECD publishing, Paris.

Ohana, G., M. Hansen and O. Shah (2003), "Disclosure and Negotiation of Licensing Terms Prior to Adoption of Industry Standard: Preventing Another Patent Ambush?", 24 *European Competition Law Review*, Vol. 24(12), p. 644.

OECD (2002), Merger Review in Emerging High Innovation Markets, *OECD Policy Roundtables*. Available at: www.oecd.org/daf/competition/roundtables.htm

OECD (2007), Dynamic Efficiencies in Merger Analysis, *OECD Policy Roundtables*. Available at: www.oecd.org/daf/competition/roundtables.htm

Scherer, F.M. (1967), "Market Structure and Employment of Scientists and Engineers", *American Economic Review*, Vol. 57(3), p. 524.

Scherer, F.M. and D. Ross (1990), *Industrial Market Structure and Economic Performance*, 3rd ed., Houghton Mifflin, Boston.

Schumpeter, J. (1942), *Capitalism, Socialism, Democracy*, Routledge Classics, London (republished 2010).

Symeonides, George (1996), "Innovation, Firm Size and Market Structure: Schumpeterian Hypotheses and Some New Themes", *London School of Economics, Economics Department Working Paper* No.161.

Chapter 4.

Measuring knowledge-based capital

This chapter describes recent advances in the measurement of knowledge-based capital (KBC) and the contribution of the OECD to this work. Important areas of progress relate to the international harmonisation of estimates and methodologies and the publication of comparable figures at the macroeconomic and industry levels. The OECD has also addressed the measurement of assets for which guidelines do not exist, and proposed an experimental task-based methodology to estimate investment in organisational capital (OC). Results suggest that investments in OC are almost twice as large as previously estimated and that many occupations, in addition to managers, contribute to its accumulation. OECD work on research and development (R&D) has focused on aligning the various existing measures of investment and on proposing output-based measures that capture the economic and technological value of inventions through the use of patent data. The results point to the sources of differences in investment estimates and show that the quality of R&D output varies substantially within and across technologies and industries. Finally, the OECD has estimated depreciation rates for R&D and OC and found that these assets remain valuable for longer than previously assumed. Overall, the estimates suggest the growing importance of investments in KBC assets and their relation to productivity growth, although causal links, complementarities and spillover effects remain to be addressed.

Modern economies rely heavily on knowledge and on complex production systems, and economic actors need to know how to navigate these dense and interconnected systems. While certain businesses have quickly understood the importance of knowledge and knowledge-based assets, and have thrived in this challenging environment, others have struggled to embrace new economic models and to keep up. To recover from the crisis and achieve sustained economic growth and job creation all economic actors need to make a smooth transition to knowledge-intensive production systems. At a time of constrained public and private resources, this will require carefully targeted investments, notably in knowledge-based assets.

It has often been said that knowledge is to the economy of the 21st century what coal was to that of the 19th century and oil to that of the 20th century. Yet, defining and measuring a unit of knowledge is not as straightforward as weighing tons of coal or counting barrels of oil. Properly measuring knowledge and the value added that its use and transfer may generate has significant implications for understanding economic activity and for the design of policies aimed at fostering productivity and economic growth. This point was also stressed by Ben Bernanke, chairman of the United States Federal Reserve, at the opening conference of the New Sources of Growth project, held in Washington DC in 2011: "As someone who spends a lot of time monitoring the economy, let me put in a plug for more work on finding better ways to measure innovation, R&D activity, and intangible capital. We will be more likely to promote innovative activity if we are able to measure it more effectively and document its role in economic growth."

In recent years there have been important advances in the measurement of knowledge-based capital (KBC), from the standpoint both of methodology and data availability. These advances have helped shed light on a wide array of policy issues, and have improved understanding of many important issues, including the role of investment in KBC in economic growth. As certain countries start to invest more in KBC than in physical capital, understanding the determinants and effects of such investments becomes a priority for formulating evidence-based policy. Therefore, the OECD has sought to develop metrics that will provide policy makers with sounder estimates of how much is invested in knowledge assets and how these investments shape economic activities, performance and competitiveness.

This chapter first recalls the conceptual and measurement breakthroughs of Corrado et al. (2005, 2009), and then discusses the main questions that their analytical framework left unanswered and how recent advances have addressed them. In particular, it focuses on the international efforts of recent years to improve the international harmonisation of methodologies and estimates, to develop disaggregated estimates at the industry and firm levels, to produce guidelines to measure assets for which guidelines were lacking, and to refine modelling parameters. On each of these fronts, significant advances have helped to paint a much clearer picture of the role of knowledge-based assets in economies worldwide. Concerted international efforts have resulted in the publication of KBC investment estimates that are comparable across countries, at both the macroeconomic and industry levels.

The OECD's work has focused on better measuring assets recognised as central to innovation and economic growth for which no guidelines exist, such as organisational capital (OC). To this end, Corrado et al.'s manager-focused approach has been refined, based on an experimental task-based methodology that identifies OC-related occupations on the basis of tasks performed on the job by employees rather than on their occupational titles. The methodology was applied to data from the United States. The results suggest

that the long-term organisational capability of firms rests on a much wider array of occupational categories than previously thought, and that OC is not exclusively about managers. Once all of these are taken into account, the overall size of investment in OC is almost double previous estimates. Moreover, industry-specific patterns of investment show that services are large investors in OC.

The OECD has also made efforts to reconcile measures of a single asset, research and development (R&D), collected on the basis of different methodologies. Part of this work has focused on reconciling R&D investment estimates made in the framework of the System of National Accounts (SNA) and the survey-based figures collected following the guidelines provided by the OECD *Frascati Manual* OECD, 2002). Expenditures based on the *Frascati Manual* are recorded on the basis of the performers and funders of R&D activities, whereas SNA estimates relate to the producers and owners of R&D assets. The data coverage also varies in terms of time frames and countries for which data are available. Reconciling these figures helps to improve comparability across countries and over time.

In addition, the OECD has investigated the possibility of measuring KBC in terms of outputs as well as inputs to see what investing in KBC assets may lead to. It has proposed a number of metrics for assessing the economic and technological value of patented inventions. They have the advantage of relying on a homogenous body of information contained in patent documents and can therefore be computed for every patent. Results suggest that patent quality and value – and hence the value of the R&D contained in them – varies greatly among technological fields and countries and over time. They provide quantitative evidence about differences in R&D output in terms of economic importance and future technological developments.

Finally, and to obtain a more complete picture of the role of KBC in shaping economic performance, efforts have been made to learn for how long investments in R&D and OC continue to prove useful for economic agents. This work relates to depreciation rates and suggests that both OC and R&D depreciate much more slowly than previously thought and that there are industry-specific patterns. Overall, the main findings emphasise the key role of human capital, and of skilled labour in particular, in the organisational and research capabilities of firms. Moreover, investment in this type of human capital is much longer-lived than previously thought.

Before concluding, this chapter describes the picture of KBC investment that emerges from these measurement efforts. There is little doubt about the growing importance of KBC investments in many OECD economies or about the fact that investments in KBC have increased steadily in most countries, sometimes surpassing investments in physical capital. If KBC investments are included in models of economic growth, they are likely to account for a large share of productivity growth. However, the modelling and analytical frameworks available so far uncover correlations but not causal links. This means that it is not known whether investment in KBC leads to productivity growth or is simply associated with it. The ability to judge whether a causal link exists along with improvements on various measurement and methodological fronts will help provide the evidence that policy makers need.

The framework developed by Corrado, Hulten and Sichel

In their seminal work, Corrado, Hulten and Sichel (Corrado et al., 2005, 2009; henceforth CHS) made a number of ground-breaking contributions that have led to a better understanding of the importance of KBC in OECD economies. First, they proposed to classify expenditures on KBC into three broad categories: computerised information, innovative property and economic competencies. Each of these categories covers a number

of assets of a similar nature. Second, they developed an expenditure-based approach to measuring these assets: quantifying the monetary value of the resources devoted by firms to these assets on a yearly basis. Third, they argued that these annual investments feed into production for a number of years and should thus be capitalised rather than counted as current expenditures that are consumed within a year. They also constructed capital stock series from their investment figures and made explicit assumptions about the proportion of investments that are used from one year to another and about the extent to which they depreciate. Finally, they used these capital figures in a growth accounting framework to assess the contribution of the different factors of production – namely labour, physical capital and knowledge-based capital – to productivity and economic growth.

Box 4.1 presents the main features of the CHS measurement framework. It synthesises and briefly discusses the knowledge-based assets considered, and summarises some of the key aspects of the CHS methodology in a table that lists the different types of assets included in the framework, the data sources used for the investment series, and the measurement assumptions (what these items include) and the depreciation rates used.

Outstanding measurement and modelling issues

The CHS framework was initially conceived for, and experimented on, data for the United States. A number of academics in other OECD countries then endorsed the CHS approach and used it to estimate investments in KBC and their contribution to output and productivity growth. However, use of the methodology in other economies relied on different data sources and measurement parameters, adapted to fit country-specific features, and, more generally, on differences in the way definitions are operationalised. The research community has sought to provide common guidelines in order to harmonise national estimates in recent years. This has led to the publication of international datasets such as the INTAN-Invest dataset, which covers 27 countries of the European Union, plus Norway and the United States.

To obtain fully comparable international figures will require further methodological work aimed at more accurate definitions and measurement of assets for which no guidelines currently exist. This is the case for items like brand equity, which remains very hard to measure, especially in an expenditure-based approach that focuses on the amount of spending required to produce a certain asset, rather than on the value the asset has once it is created. This is also the case of databases related to customers' purchasing behaviour, which are collected as a by-product of retail activities and may have great value (for streamlining supply processes and targeting prospective consumers, for example). The need for definitions and measurement guidelines is even more urgent for assets that play a central role in economic activities. In the case of organisational capital, for example, recent advances have been made by examining how its generation and accumulation relate to various dimensions of human capital.

Another important outstanding issue relates to measuring investment in KBC at the sector and the firm levels. While the CHS framework was developed as a macroeconomic approach, many of the effects of investment in KBC are best observed and understood at more disaggregated levels. This creates the need for robust sectoral and micro-level figures that would be extremely useful for policy-making purposes. Understanding the patterns of industries' and firms' investments in knowledge-based assets could help in the design of more effective policies – especially new industrial policies – and in the identification of the most suitable policy tools. Sectoral estimates have recently been produced for a handful of countries, but measurement of investment in KBC at the firm level remains exploratory.

Box 4.1. Details of the CHS measurement framework

The asset categories of the CHS framework are the following:

- *Computerised information*: Knowledge codified in computer programmes and computerised databases recorded in the official System of National Accounts since 1993. The emergence of "big data" (see Chapter 8) has raised new challenges for the measurement of resources used to create this asset and of the economic value that can be obtained from it.
- *Innovative property:* Knowledge assets that are protected through intellectual property rights (IPR), such as patents, designs, copyrights and to some extent trademarks. These assets result from spending on R&D and mineral exploration, but also from a range of expenditures on creative and inventive activities, artistic originals, architectural designs and new financial products. While most of these expenditures are recorded somewhere in official national accounts, few are explicitly reported as investments in KBC.
- *Economic competencies:* Knowledge embedded in a firm's human and structural resources, such as firm-specific training, organisational capital, and brand equity and measured mainly by using secondary sources of data and a set of provisional assumptions. This asset category represents the biggest challenge in terms of definition, measurement and modelling.

Assumptions and data sources, investments in knowledge-based assets

Asset type	Data sources	Measurement assumptions	Depreciation rate (%)
Computerised information			
Software	Recorded in SNA	Includes own use, purchased and custom made software	33
Databases	Included in SNA estimates of software investment		33
Innovative property			
Science and engineering R&D	R&D surveys, business expenditures on R&D (BERD) estimates	BERD	20
Mineral exploration	Recorded in SNA	R&D in the mining industry	20
Artistic originals, usually leading to copyrights and licences	Recorded in SNA		20
New product development in the financial services industry	Input-output and supply-use tables	20% of intermediate purchases of the financial industry	20
New architectural and engineering designs	Services Annual Survey and supply-use tables	50% of purchases of architectural and consulting engineering services	20
R&D in social sciences and humanities	Included in BERD estimates		20
Economic competencies			
Brand equity	Surveys of advertising expenditures; Services Annual Survey; supply-use tables	*Advertising*: purchases of advertising services *Marketing*: outlays on marketing services Doubled to take into account production costs and own account component	60
Training	Surveys of employer-provided training	Direct costs and wage costs of employee time in training for market-sector industries	40
Organisational capital	Employment and earnings data; Services Annual Survey	*Own account*: 20% of managerial wages *Purchased*: 80% of services purchased from the management consulting industry	40

Source: Based on: Corrado, C., C. Hulten and D. Sichel (2005), "Measuring Capital and Technology: An Expanded Framework", in C. Corrado, J. Haltiwanger and D. Sichel (eds.), *Measuring Capital in a New Economy*, National Bureau of Economic Research and University of Chicago Press, Chicago, IL; Corrado, C., C. Hulten and D. Sichel (2009), "Intangible Capital and US Economic Growth", *Review of Income and Wealth*, Vol. 55(3), pp. 661–685; and Barnes, P. and A. McClure, (2009), "Investments in Intangible Assets and Australia's Productivity Growth", Australia Productivity Commission.

Assessing how investment in knowledge-based assets relates to productivity and economic growth also requires refinement of a number of analytical parameters, in particular asset prices and asset service lives. First, price information is important to capture the quantity of assets purchased. For instance, the general reduction in the price of information and communication technologies (ICT), including software, means that the same amount of money can buy much more and much better ICT goods today than ten years ago. Another example relates to the cost of R&D personnel: in countries and fields where specialised researchers are in short supply, an increase in R&D expenditures may simply reflect the higher salaries that firms may have to pay to retain researchers, rather than an increase in the number of scientists hired. Second, it is important to know how long firms expect to benefit from their investments in different assets. Hence, quantifying the service life of KBC is crucial. This requires determining the mechanisms that lead to discarding an asset that is no longer needed (e.g. a new generation of technologies that makes previous ones obsolete), and those affecting its loss of productivity as it ages. Many assumptions underlying price deflators and depreciation rates are now being developed and tested worldwide. Making significant progress in these areas will nevertheless require sustained efforts over the medium to long term.

Finally, understanding the role of KBC in productivity and economic growth raises some important questions. They relate to the analytical framework generally used and to the type of information it can provide. Growth accounting models have shown that KBC, which was previously omitted from the analysis, relates significantly to productivity growth. However, these models cannot determine the direction of causality in the relationship between KBC and growth, nor can they account for possible complementarities, substitutabilities or spillover effects. Moreover, while specific assets have been the object of tailored modelling strategies, each emphasising a particular causal link or interaction,[1] the lack of a general model for KBC and growth hinders the ability to identify market failures for which government intervention could be warranted, and to design effective policies and avoid possible distortive effects.

Recent advances and the work of the OECD

Over the last decade, the research community has worked to advance the KBC measurement agenda by proposing, refining and testing definitions, assumptions, and estimation strategies in order to inform policy making. The four main measurement challenges addressed concern the international harmonisation of methodologies and estimates, the development of estimates at disaggregated levels, the drafting of measurement guidelines for assets that are less well measured, and the refinement of modelling parameters. The OECD has focused on two broad issues: i) the measurement of KBC at the microeconomic and sectoral levels, with implications at the macroeconomic level; and ii) the measurement of two CHS asset categories, innovative property and economic competencies, in terms of investment and depreciation.

The measurement of innovative property has been approached both from an input and an output perspective. Efforts to measure the inputs to the construction of innovative property have focused on reconciling survey-based R&D expenditure measures with the SNA R&D investment series at both the sectoral and the macroeconomic levels. On the output side, OECD work has concentrated on designing and building measures related to the "quality" of the innovative property of firms, intended as the technological and economic value of patented inventions. Patent data have also been used to calculate sector-specific depreciation rates of R&D capital, given evidence showing patents to be highly correlated with R&D expenditures, and patent renewals to be linked to returns to R&D investment.

The OECD work to measure economic competencies has focused on the definition and measurement of organisational capital at the sectoral level (see Squicciarini and Le Mouel, 2012[2]). The experimental methodology proposed relies on information about the tasks performed by employees in different occupations to identify those who contribute to the generation and accumulation of OC. Investment in OC is then estimated on the basis of the earnings of the personnel who – as indicated in task-level information – genuinely contribute to the accumulation of OC.[3] Sector-specific depreciation rates are calculated on the basis of the mobility of these employees, as a firm's organisational capability may be disrupted when such employees leave the firm.

Moving towards internationally harmonised investment series

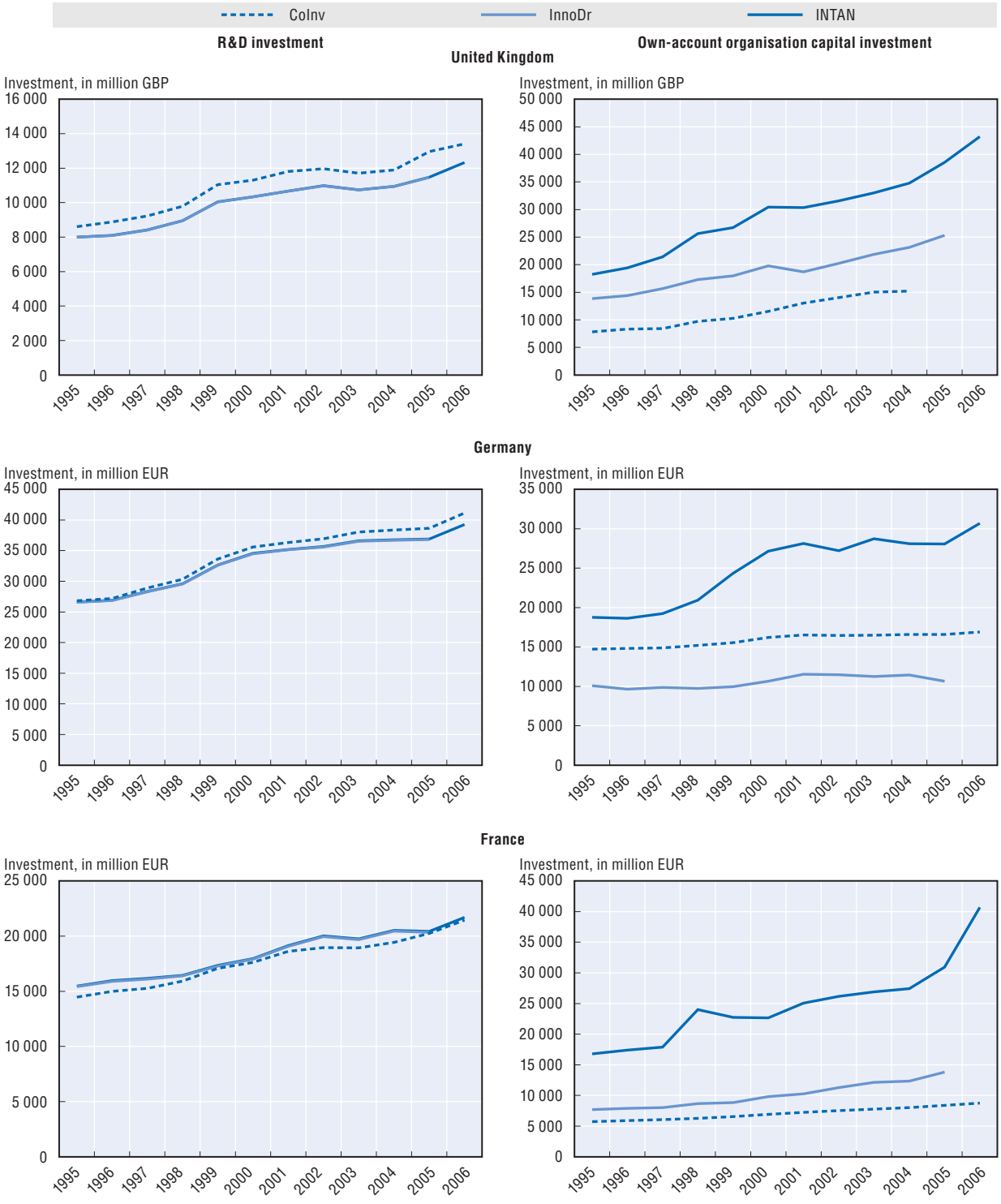
The work of Corrado, Hulten and Sichel has made clear the growing importance of KBC in terms of the magnitude of the investments involved and their contribution to growth. Motivated by these findings, researchers worldwide have compiled comparable estimates of investments in KBC for most OECD countries. Table 4.1 lists the countries for which such estimates are available at the macroeconomic level, along with the sources and the time coverage.

Table 4.1. Investment in KBC – available macroeconomic level estimates

Country	Reference	Coverage
Australia	Australia (2012)	1974-2011
	Barnes and McClure (2009)	1974-2006
Austria	van Ark et al. (2009)	1995-2006
Canada	Baldwin et al. (2012)	1976-2008
	Belhocine (2009)	1998-2005
China	Hulten and Hao (2012)	1995-2008
Czech Republic	van Ark et al. (2009)	1995-2006
Denmark	van Ark et al. (2009)	1995-2006
EU 27	INTAN-Invest (2012)	1995-2010
	Piekkola (2011)	1995-2006
Finland	Jalava et al. (2007)	1975-2005
France	Delbecque and Bounfour (2012)	1980-2008
	Hao et al. (2008)	1991-2004
Germany	Hao et al. (2008)	1991-2004
Greece	van Ark et al. (2009)	1995-2006
Italy	Hao et al. (2008)	1991-2004
Japan	Chun et al.(2012)	1980-2008
	Fukao et al. (2009)	1980-2005
Korea	Chun et al. (2012)	1980-2008
Netherlands	van Rooijen-Horsten et al. (2008)	2001-2004
Norway	INTAN-Invest (2012)	1995-2010
Slovakia	van Ark et al. (2009)	1995-2006
Spain	Hao et al. (2008)	1991-2004
Sweden	Edquist (2011)	1995-2006
United States	INTAN-Invest (2012)	1995-2010
	Corrado et al. (2005, 2009)	1950-2003

Source: Based on national studies, see References for full URLs. Australia (2012), www.innovation.gov.au/; Barnes and McClure (2009), www.pc.gov.au/; van Ark et al. (2009), www.eib.org; Baldwin et al. (2012), www.statcan.gc.ca; Belhocine (2009), www.imf.org; Hulten and Hao (2012), www.nber.org; INTAN-Invest (2012), www.intan-invest.net; Piekkola (2011), www.innodrive.org; Jalava et al (2007), www.etla.fi; Delbecque and Bounfour (2012), www.chairedelimmateriel.u-psud.fr; Chun et al (2012), www.rieti.go.jp; van Rooijen-Horsten et al. (2008), www.cbs.nl; Edquist (2011), www.snee.org/; Corrado et al. (2009), www.conference-board.org/, accessed in February 2013.

Figure 4.1. Investment in R&D and OC: Comparing estimates from INNODRIVE, COINVEST and INTAN-Invest, 1995-2006



Note: INNODRIVE estimates are marked as "InnoDr" in the charts. COINVEST data are shown as "CoInv" and the harmonised estimates of INTAN-Invest are shown as INTAN.

Source: Based on COINVEST and INNODRIVE (www.innodrive.org) databases, October 2011, and the INTAN-Invest database (www.intan-invest.net), accessed in July 2012.

In Europe, two projects financed by the European Commission, INNODRIVE and COINVEST, have been particularly important.[4] Under the INTAN-Invest umbrella, the results of these two projects, along with those of the Conference Board for the United States, have led to the publication of harmonised macroeconomic estimates, covering the 27 European Union (EU) countries, Norway and the United States.[5] Canada and Australia have also built on previous initiatives and recently published KBC-related figures. Finally, remarkable efforts at measurement have been made in Japan[6] and are currently under way in Korea.

Efforts at international harmonisation have proven relatively straightforward for assets such as software and R&D for which measurement guidelines exist,[7] but have proven more difficult for other assets, especially those in the economic competencies category. For example, estimates for investments in training had to be revised to include apprenticeships, which had previously been omitted (see Corrado et al., 2012, for a detailed discussion of the methodology).

Figure 4.1 illustrates the sensitivity of estimates to the use of different data sources or approaches in the same CHS framework. It compares the initial INNODRIVE and COINVEST estimates of investment in R&D and OC for France, Germany and the United Kingdom with the corresponding figures in the more recent INTAN-Invest database. The R&D series appear almost identical, whereas there are differences in the OC-related series, not only in the level of investment but also, and more importantly, in the path of investment over time. Such differences lead to a different interpretation of the importance of the various assets for productivity growth and call for more accurate definition and measurement of assets for which no general guidelines exist.

Measuring KBC at the industry and firm levels

Discovering the role of knowledge-based assets in economic performance and growth requires understanding the investment decisions of individual firms and the way different industries behave. Firm- and sectoral-level data might directly inform the design of industrial policy: they help identify the most suitable policy tools and the contexts in which these are likely to be effective. Sectoral-level data might help show, for example, whether and how employment protection legislation (EPL) and the degree of competition shape the ability of firms to make the best use of investments in KBC. Firm-level data may also be used to identify the profile of firms, young or old, small or large, that are most affected by such framework conditions.

Various initiatives have followed the CHS framework to estimate KBC investment series at the sectoral level. Country-specific sectoral-level investment series have been calculated for the following economies: Australia (Barnes, 2010); France[8] (Delbecque and Bounfour, 2012; Delbecque et al., 2012); Germany (Crass et al., 2010); Japan (Chun et al., 2012); Korea (Chun et al., 2012); the Netherlands (van Rooijen-Horsten et al., 2008); Sweden (Edquist, 2011); and the United Kingdom (Gil and Haskel, 2008; Haskel et al., 2011). In addition, O'Mahony et al. (2012)[9] estimate and compare investment in KBC for 11 sectors in 14 EU countries. They find that in most countries, manufacturing industries account for the largest share of KBC investment[10] and have benefited the most in terms of KBC-induced labour productivity growth. This is in line with the results of Chun et al. (2012) for Japan and Korea, who suggest that the significant and positive effect of KBC investments on total factor productivity (TFP) growth at the economy-wide level has been driven by the manufacturing sector. They further argue that the productivity gap between manufacturing and services, observed in Japan in the early 2000s, was likely due to slow

growth in investment in knowledge-based assets and their possibly ineffective utilisation in the services sector. Table 4.2 lists the countries for which sectoral estimates exist and the relevant sources, as well as the time period covered by the estimates.

Two main approaches have been pursued to collect KBC investment data at the firm level. On the one hand, efforts have been made to improve the disclosure of KBC investments in firms' corporate reporting, i.e. in periodic performance- and finance-related communications to stakeholders. However, these initiatives remain voluntary and have not been systematically implemented. On the other hand, a few initiatives have aimed at collecting KBC investment data through surveys. The first of such surveys, the UK Intangible Assets survey, was carried out by Awano et al. (2010) in 2009, 2010 and 2011. It covers all asset types in the CHS framework and asks firms to provide information about spending on both own-account assets (assets produced in-house) and purchased assets, as well as service lives. Building on this pioneering work, a similar pilot survey was performed in Italy in 2010 as a joint initiative by ISFOL, the Italian Institute for the Development of Vocational Training, and ISTAT, the Italian National Statistics Office. A full survey is to be carried out in 2013.[11] In other countries, attempts have been made to include questions on KBC investments in regular innovation surveys. Finally, in Australia, methodological work has been undertaken to obtain firm-level financial measures of KBC by mapping business accounting records to measures of innovation following definitions of the Frascati and Oslo (OECD, 2002, 2005; manuals Talbot et al., 2012).

Table 4.2. Investment in KBC at the sectoral level – available estimates

Country	Reference	Coverage
Australia	Barnes (2010)	1993-2006
Austria	O'Mahony et al. (2012)	1995-2007
Belgium	O'Mahony et al. (2012)	1995-2007
Czech Republic	O'Mahony et al. (2012)	1995-2007
Denmark	O'Mahony et al. (2012)	1995-2007
Finland	O'Mahony et al. (2012)	1995-2007
France	O'Mahony et al. (2012)	1995-2007
	Delbecque and Bounfour (2012)	1980-2008
Germany	O'Mahony et al. (2012)	1995-2007
	Crass et al. (2010)	1995-2006
Hungary	O'Mahony et al. (2012)	1995-2007
Ireland	O'Mahony et al. (2012))	1995-2007
Italy	O'Mahony et al. (2012)	1995-2007
Japan	Chun et al. (2012)	1980-2008
Korea	Chun et al. (2012)	1980-2008
Netherlands	O'Mahony et al. (2012)	1995-2007
	Van Rooijen-Horsten et al. (2008)	2001-2004
Spain	O'Mahony et al. (2012)	1995-2007
Sweden	O'Mahony et al. (2012)	1995-2007
	Edquist (2011)	1995-2006
United Kingdom	O'Mahony et al. (2012)	1995-2007
	Haskel et al. (2011)	1997-2007
	Gil and Haskel (2008)	1997-2004

Source: Based on national studies, see References for full URLs. Barnes (2010), www.pc.gov.au; O'Mahony et al. (2012), http://indicser.com; Delbecque and Bounfour (2012), www.chairedelimmateriel.u-psud.fr; Crass et al. (2010), www.coinvest.org.uk; Chun et al (2012), www.rieti.go.jp; van Rooijen-Horsten et al. (2008), www.cbs.nl; Edquist (2011), www.snee.org; Haskel et al. (2011), www.nesta.org.uk, accessed in February 2013.

Potential scaling up of firm-level surveys will require co-ordination on the design of questionnaires and the harmonisation of definitions. The OECD has been operating as a clearinghouse for proposals and pilot experiences on questions about a wider range of expenditures on knowledge-based assets and is working towards the development of international measurement guidelines in this area.[12] The OECD has also been collaborating with Eurostat's Community Innovation Survey Task Force to identify the potential for convergence of measures of innovation expenditures and of KBC-related expenditures. An initial round of tests aimed at assessing how survey respondents understand the questions has provided satisfactory results, and further work is planned. As work at the sectoral and firm levels would greatly benefit from the harmonisation of methodologies and estimates, the OECD has been actively engaged in fostering co-operation with a view to enhancing international comparability.

Developing guidelines for hard-to-measure assets

Many assets included in the CHS framework have not been a focus of definitional and measurement work, and no official methodological approach or agreed guidelines exist in relation to their measurement. These types of KBC – in particular some assets in the categories of economic competencies and innovative property – are not included in official statistics such as national accounts, and researchers have been devising methods to estimate such investments using other data sources. By contrast, R&D has received much attention in recent decades and measurement has progressed steadily. However, while a number of official data collections for this asset now exist, they take different measurement approaches and result in figures that are diverse in terms of the elements of the asset captured and hence in the amount of R&D investment measured. In particular, the R&D figures that statistical offices collect following the guidelines and definitions set out in the OECD *Frascati Manual* (2002) differ from the official R&D investment figures currently provided in so-called "satellite" national accounts.

The OECD has tried to address some of the problems arising from the absence of asset-specific measurement guidelines and to bridge methodological differences when existing estimates vary. In both cases, it has focused on R&D and organisational capital, two assets widely recognised as central to firms' innovation activities and broader performance. For R&D, the work has sought to measure R&D as an input into innovation and to assess the output of R&D activities in terms of patenting and the quality of inventions protected through Intellectual Property Rights (IPR). For organisational capital, the OECD has proposed a new approach to measuring investment in this type of human capital-related asset. It relies on information about the tasks employees accomplish in their job and the extent to which they contribute to the long-term organisation and functioning of the firm.

In addition, in the category of innovative property, the OECD and other institutions have tried to better understand the role of design. Their efforts should lead to the publication of international guidelines for the definition and measurement of this asset. In the category of economic competencies, the INDICSER project has proposed estimates of investment in firm-specific training at the industry level for a number of EU countries. Under the INTAN-Invest umbrella, estimates of training-related spending that include apprenticeship expenditures have been proposed.

Investing in innovative property: Measuring R&D expenditures

In 2008, the System of National Accounts agreed that from 2013 R&D expenditures would no longer be treated as current expenditures but as investments that accumulate over time. Efforts have been made to bridge these new R&D investment estimates with existing

survey-based figures (collected over a number of decades on the basis of the OECD *Frascati Manual* guidelines). The need for reconciliation is due to the fact that under the *Frascati Manual* guidelines, R&D expenditures are recorded according to the performer and the funder of the R&D activity, whereas the SNA estimates record the producers and owners of the R&D assets. To give one example, publicly funded R&D activities carried out by private firms represent a case in which assigning ownership may be non-trivial. The United States and Australia, for instance, have for some time maintained satellite accounts for R&D to complement official national income and production accounts. Australia has now incorporated R&D in its accounts and the inclusion of R&D as a capital asset has raised Australian gross domestic product (GDP) by between 1% and 1.25% in recent years.

Box 4.2 highlights some of the main conceptual differences between the R&D figures based on the *Frascati Manual* and on the SNA and shows how SNA investments may be derived from *Frascati Manual*-based expenditures. It summarises the OECD's recent work to help identify the possible sources of cross-country variation and to facilitate international harmonisation.

Box 4.2. Bridging *Frascati Manual* (FM) and System of National Accounts (SNA) R&D figures

The *OECD Handbook on Deriving Capital Measures of Intellectual Property Products* (2010) provides guidelines on how to bridge FM-based R&D expenditure figures with SNA R&D investment series. The Handbook also highlights some of the main challenges. In particular, moving from FM to SNA-consistent numbers requires addressing the following issues:

- Mapping FM-based R&D expenditures related to performers and funders to SNA measures of R&D output reflecting ownership. This is necessary as the FM is not always clear about whether the funder is also the ultimate owner of the asset produced. Assumptions have to be made, for instance, when allocating the R&D performed or funded by the higher education sector to one of the SNA sectors, which include corporations, non-financial corporations, government and non-profit institutions serving households.
- Determining which R&D expenditures qualify as R&D gross fixed capital formation (GFCF), to avoid double counting. Most countries – with the exception of the United States – include all capital costs in FM-based R&D expenditure figures. However, the SNA definition of R&D output and R&D GFCF requires the sole inclusion of capital services provided by non-R&D capital. An example is the adjustment needed for expenditures on software used to produce R&D, as these expenditures may have already been capitalised under a separate category.
- Accounting for exports and imports of R&D in GFCF estimates. This requires additional information about the industrial and institutional sectors involved, and can usually be obtained from supply-use tables detailing the flow of goods and services between producing and using sectors.
- Constructing R&D capital stock series, i.e. capitalising the R&D investment series obtained following the steps above. This has to be done for both market and non-market producers of R&D. A key challenge is to disentangle changes in quantities (i.e. volumes) from changes in prices (due for instance to inflation). This is challenging for many knowledge-based assets, partly because products may be unique and partly because prices are often not observed. In the absence of such data, price indexes have traditionally been estimated using input-cost price indexes and adjusted for labour productivity.
- Obtaining sector-specific figures further requires paying attention to the unit of analysis on which the initial numbers rely. FM-based figures are typically reported at the enterprise level, while SNA estimates are often based on establishment-level data, which may lead to an incorrect attribution to particular industries.

Valuing innovative property output: The economic and technological value of patents

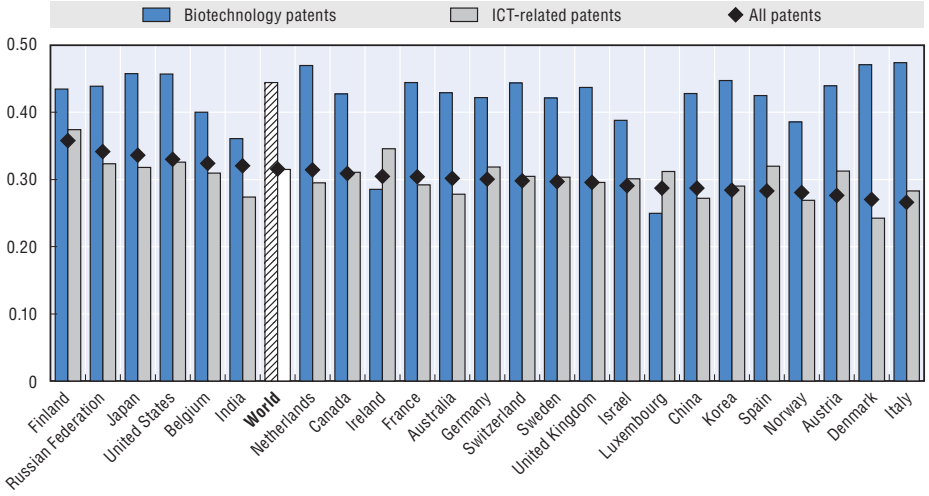
An often-cited caveat to the input-based approach to measuring knowledge-based assets is that it gives little indication of the value of the resulting assets produced. Some light has been shed on this issue through the analysis of R&D outputs, such as patents. The work is based on evidence that patents are highly correlated with R&D expenditures,

and that changes in R&D expenditures are typically paralleled by changes in patenting behaviour (Griliches, 1998). Moreover, R&D appears to be contemporaneous to patenting and possible lag effects are small and not well estimated (Hall et al., 1986).

However, measuring R&D output on the basis of simple patent counts does not suffice, as patents differ substantially in their economic and technological value. Only a small number are very valuable, and most bring little value to their owners. Recent work by the OECD's Working Party on Industry Analysis has aimed to address this issue through better definition and measurement of "patent quality", i.e. the technological and economic value of patented inventions (for instance in terms of their potential impact on subsequent innovations). Information contained in patent documents has been used to construct indicators that rely extensively on recent literature and on earlier OECD work. Such measures can be constructed for all patents and have the advantage of relying on a homogeneous set of information. This makes them generally comparable across countries and over time, and therefore suitable for cross-country analysis.

Among the many indicators of quality proposed are patent family size, patent generality and whether the patent represents a breakthrough invention. In the case of patent families, the value of an invention is held to be associated with the geographical scope of patent protection, that is, with the number of patent offices at which it is protected, as this gives an indication of the markets it targets. Patent generality instead refers to the range of later inventions that benefit from a patent, i.e. the range of technology fields and consequently industries that cite that patent. Finally, breakthrough inventions are defined as high-impact innovations that serve as a basis for future technological developments. Breakthrough inventions are strongly associated with entrepreneurial strategies and with further technological development.

Figure 4.2. Generality of patents: Average index, by country of applicant, patents filed at the European Patent Office, 2000-04



Note: Only OECD and BRIICS countries (Brazil, Russian Federation, India, Indonesia, People's Republic of China, South Africa) with at least 200 patent applications filed in 2000-04 are reported.
Source: OECD, Patent Statistics (database), DOI: http://dx.doi.org/10.1787/patent-data-en, accessed in February 2013.

Figure 4.2 shows the country-specific level of patent generality. Biotechnology patents typically have a relatively higher generality than patents in ICT and in other fields. This may be due to the fact that biotechnology inventions tend to spur developments in a wide array of areas.

Research undertaken at the Catholic University of Leuven (KUL) and at the Ecole des Hautes Etudes Commerciales (HEC) in Paris has drawn on information in patent applications to identify radical patents. The tools developed use citation relationships between patents to identify inventions that differ substantially from existing technologies and that heavily influence subsequent innovation patterns.

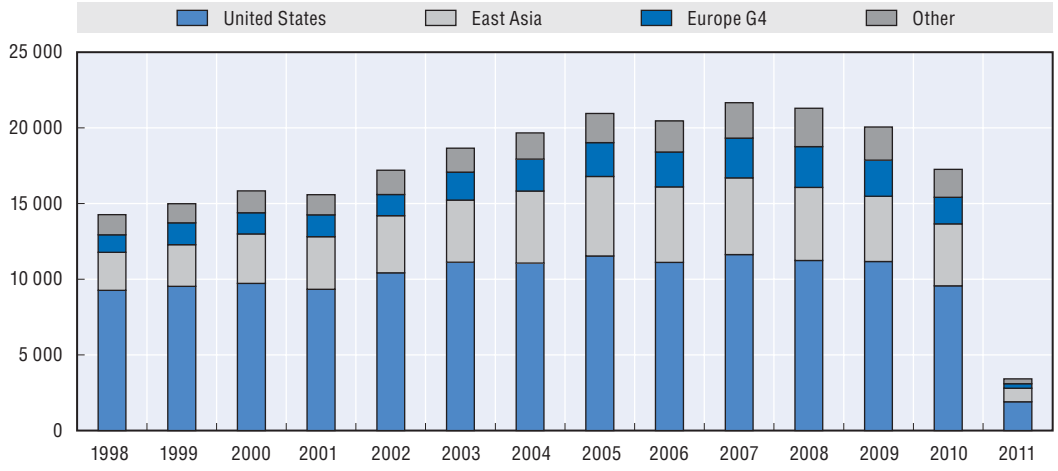
The OECD's work on patent quality seeks to develop harmonised metrics able to capture the economic value of R&D output and go beyond simple patent counts. The ultimate aim is to construct measures that capture the long-term value of the innovative property of firms and to inform policy making in areas such as taxation, innovation support policies and the worldwide mobility of key knowledge-based assets.

Defining and measuring design to capture creativity

Design is perceived as an important driver of business competitiveness. The need to define and measure design accurately has recently attracted considerable policy attention, given that no existing metrics reflect the broad range of activities and outputs associated with design. Design-related assets may be created through R&D and technology-based forms of innovation as well as non-technological, creative and experience-focused activities, and may be appropriated in different ways, including via several types of IPR protection. For example, design patents granted by the United States Patent and Trademark Office (USPTO) aim to protect the distinctive look of a product and to avoid confusion with a similar-looking product. The recent conflict between Apple and Samsung has showcased the importance of design assets. Damages were awarded to Apple for the violation of its utility and design patents; for the design patents alone for three products the damages amounted to USD 154.6 million.[13]

Figure 4.3 illustrates the growing importance of design patents in the United States from 1998 to 2011 (figures for the most recent years may be incomplete owing to delays in disclosure of administrative data). The figure also shows the increasing share of design patents belonging to non-resident applicants, especially East Asian countries.

Figure 4.3. Number of USPTO design patents granted, by application year and origin of applicant, 1998-2011



Note: East Asia includes Japan, Korea, China (mainland and Hong Kong) and Chinese Taipei. Europe G4 includes France, Germany, Italy and the United Kingdom.

Source: OECD compilation based on USPTO data, online USPTO Design Patent Report, www.uspto.gov/web/offices/ac/ido/oeip/taf/design.htm, accessed in February 2013.

The definition and measurement of design has recently been the object of significant research, especially in the United Kingdom. Following the encouraging results of a design-focused survey conducted in 2008 by the UK Art and Humanities Research Council and the Engineering and Physical Sciences Research Council, the design component of the UK Innovation Survey was greatly improved. The survey now better captures the somewhat ambiguous position of design as an asset between R&D and marketing. Experimental expenditure figures for the United Kingdom suggest that design spending amounts to GBP 1.7 billion, around 5% of total innovation expenditures. This is similar to the sum spent for the acquisition of external knowledge. It gives an indication of the importance of design activities, and highlights the need for better understanding creativity and how it can be harnessed.

The OECD has recently investigated the possibility of producing guidelines for the measurement of investment in design. Based on experience in asking questions about design in innovation surveys, *ad hoc* intangibles surveys and other sources, the project aims to co-ordinate the formulation and testing of a set of concepts and questions targeted at incorporating design in existing measurement frameworks for R&D and innovation.[14] The "Value creation by design" project led by the Barcelona Design Centre has also recently committed to producing guidelines for the compilation of design-related data by 2014.

Firms' economic competencies and the importance of organisational capital

Organisational capital is one of the assets in the category of economic competencies that has proven hardest to measure. While its importance is widely acknowledged – especially as an enabling asset that complements other innovation-related investments – there is no consensus regarding its definition and measurement. Some initiatives have taken a managerial perspective and have proposed to approach OC as a set of work practices, such as decentralisation of decisions or autonomous performance of tasks on the job. Others have tried to use information on investment in a specific type of human capital, managerial occupations, to estimate the organisational capability of firms.

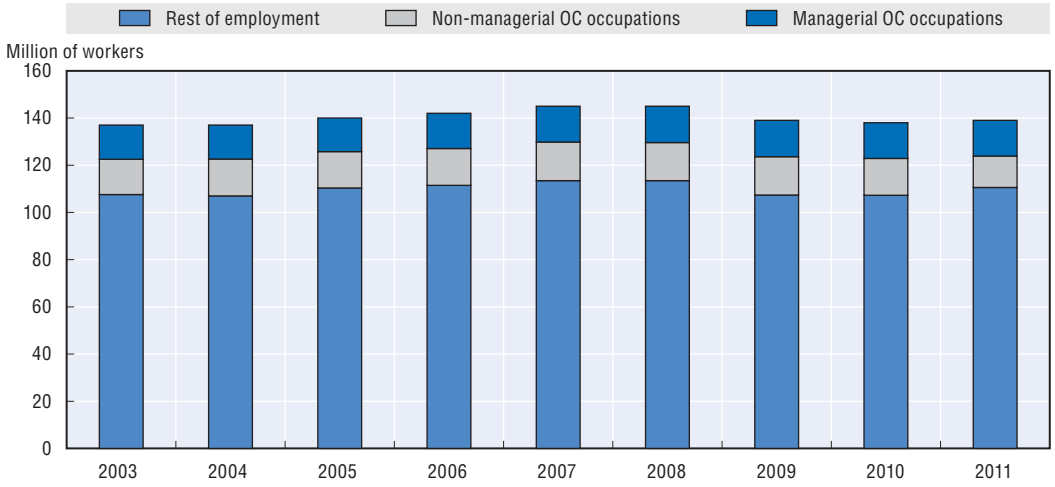
This is the approach followed by the OECD, which focuses on improving the methodology based on labour costs of the CHS framework by identifying the full spectrum of human capital involved in the generation and accumulation of firms' organisational capital. The CHS approach assumes that organisational capital is solely the result of managerial activities, and considers 20% of managers' wages to represent investment in organisational capital. The OECD work relies on recent studies suggesting that organisational capital is created by and embedded in several categories of employees, including but not limited to, managers. It can be defined in terms of the tasks that contribute to the long-term functioning of the firm and are performed by employees, irrespective of their occupational title. These tasks relate to: developing objectives and strategies; organising, planning and prioritising work; building teams, matching employees to tasks and providing training; supervising and co-ordinating activities; and communicating across and within groups.

The experimental approach proposed by the OECD relies on data from the Occupational Information Network (O*NET) of the United States Department of Labor. It identifies OC-relevant occupations based on the tasks performed by employees on the job. Results confirm that managerial activity is an important part of organisational capital, but also underline the necessity to broaden the array of occupations considered OC-relevant. Among these are business support staff, scientists and engineers, health and

education occupations, which do not have a "manager" component in their definition but help to ensure the long-term functioning of firms (see Squicciarini and Le Mouel, 2012). On this basis, investment in OC over time at both the macroeconomic and sectoral levels has been calculated using employment and earnings data from the Current Population Survey of the United States' Bureau of Labor Statistics.

Figure 4.4 shows the overall employment in the United States during 2003-11 and the number of OC-related persons employed in both managerial and non-managerial occupations. The figures indicate that non-managers who contribute to OC outnumber managers. However, in monetary terms, managers contribute more than non-managers, as shown in Figure 4.5. These patterns may reflect salary differences in the different occupations as well as the number of workers in each occupational category.

Figure 4.4. Managerial OC employment, non-managerial OC employment, and other employment in the United States, 2003-2011

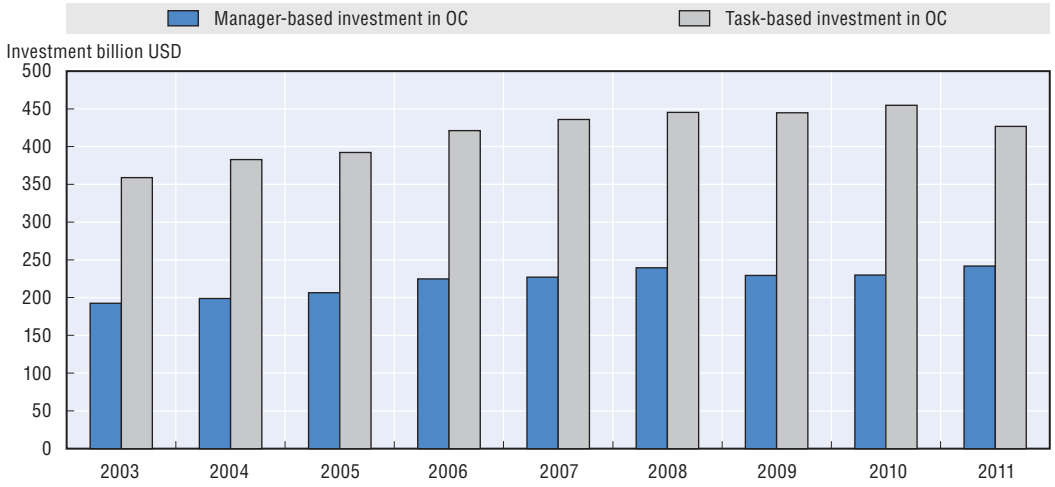


Source: OECD calculations based on employee and earnings data from the Annual Social and Economic (ASEC) supplement of the Current Population Survey (CPS), US Bureau of Labor Statistics, 2003-11, www.bls.gov/cps/ , accessed in February 2013.

Figure 4.5 compares the size of measured investment in organisational capital based on managers only with estimates based on the experimental task-based methodology proposed by the OECD. It clearly indicates that overlooking non-managerial occupations omits about half of the overall investment in organisational capital. At the aggregate level, overall investment in OC appears to have increased steadily over the whole period 2003 to 2011, with a slowdown in 2009 and a fall in investment in 2011.

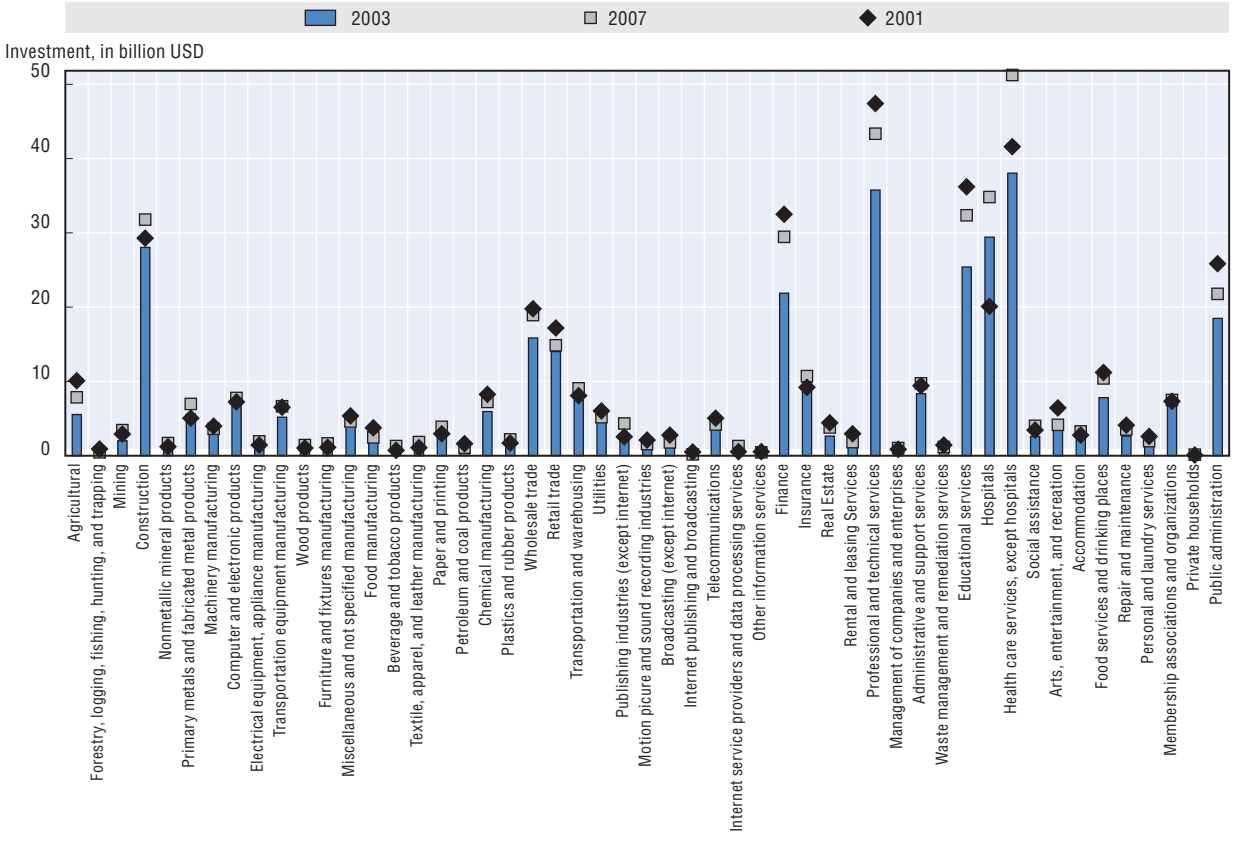
At the sectoral level, large differences emerge, with services – especially health, professional and technical services, educational services and finance – clearly large investors in organisational capital. Differences also appear in the sectoral responses to the crisis, as shown in Figure 4.6, which compares investment in OC in 2003, 2007 and 2011. On the one hand, forestry, food manufacturing, petroleum and coal product manufacturing, broadcasting services, rental and leasing services and arts and entertainment services saw increases in investment in OC of over 40% between 2007 and 2011. On the other hand, textile manufacturing, beverages and tobacco manufacturing, publishing, internet services and data processing services and hospitals saw a more than 40% drop in investment in OC over the same period.

Figure 4.5. Investment in organisational capital, United States, 2003-11



Source: OECD calculations based on the earnings data by occupation and industry from the Annual Social and Economic (ASEC) Supplement of the Current Population Survey (CPS), US Bureau of Labor Statistics, 2003-11, www.bls.gov/cps/ , accessed in February 2013.

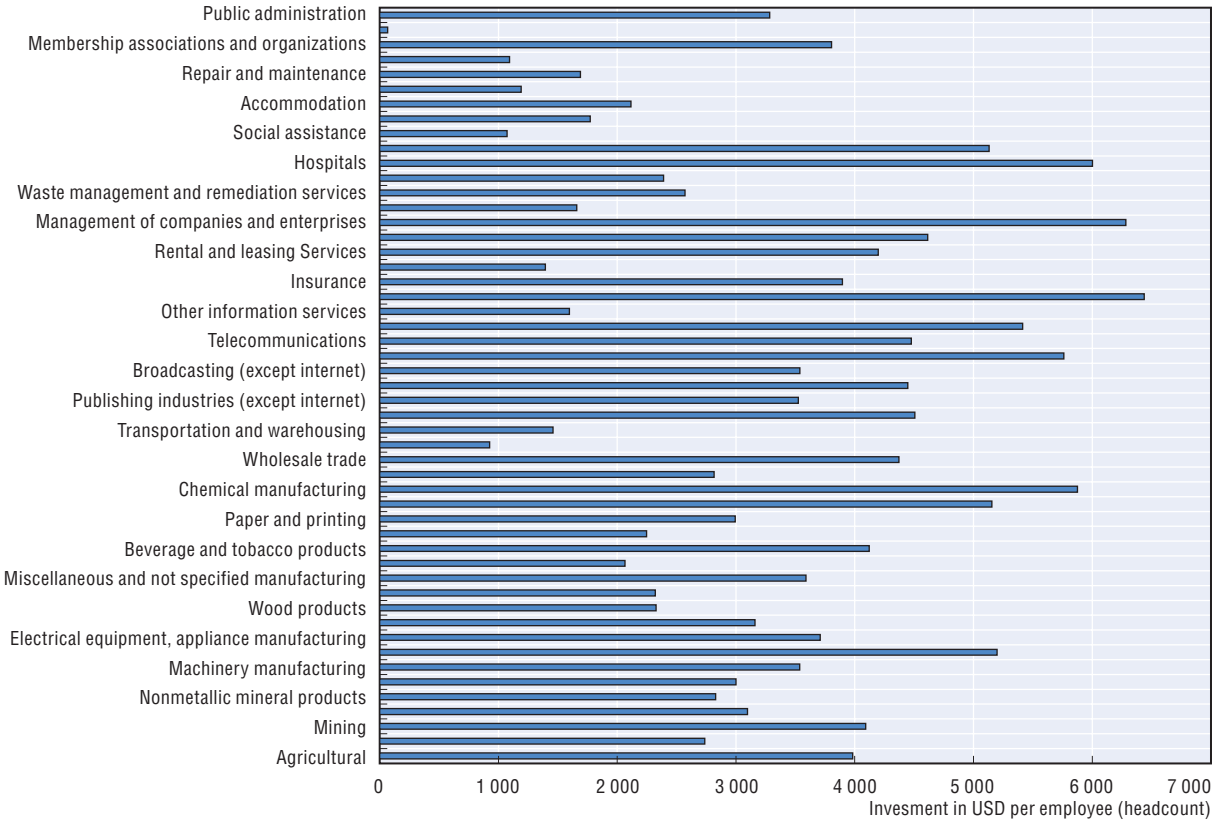
Figure 4.6. Investment in organisational capital at the sectoral level, United States, 2003, 2007 and 2011



Source: OECD calculations based on the earnings data by occupation and industry from the Annual Social and Economic (ASEC) Supplement of the Current Population Survey (CPS), US Bureau of Labor Statistics, 2003-11, www.bls.gov/cps/ , accessed in February 2013.

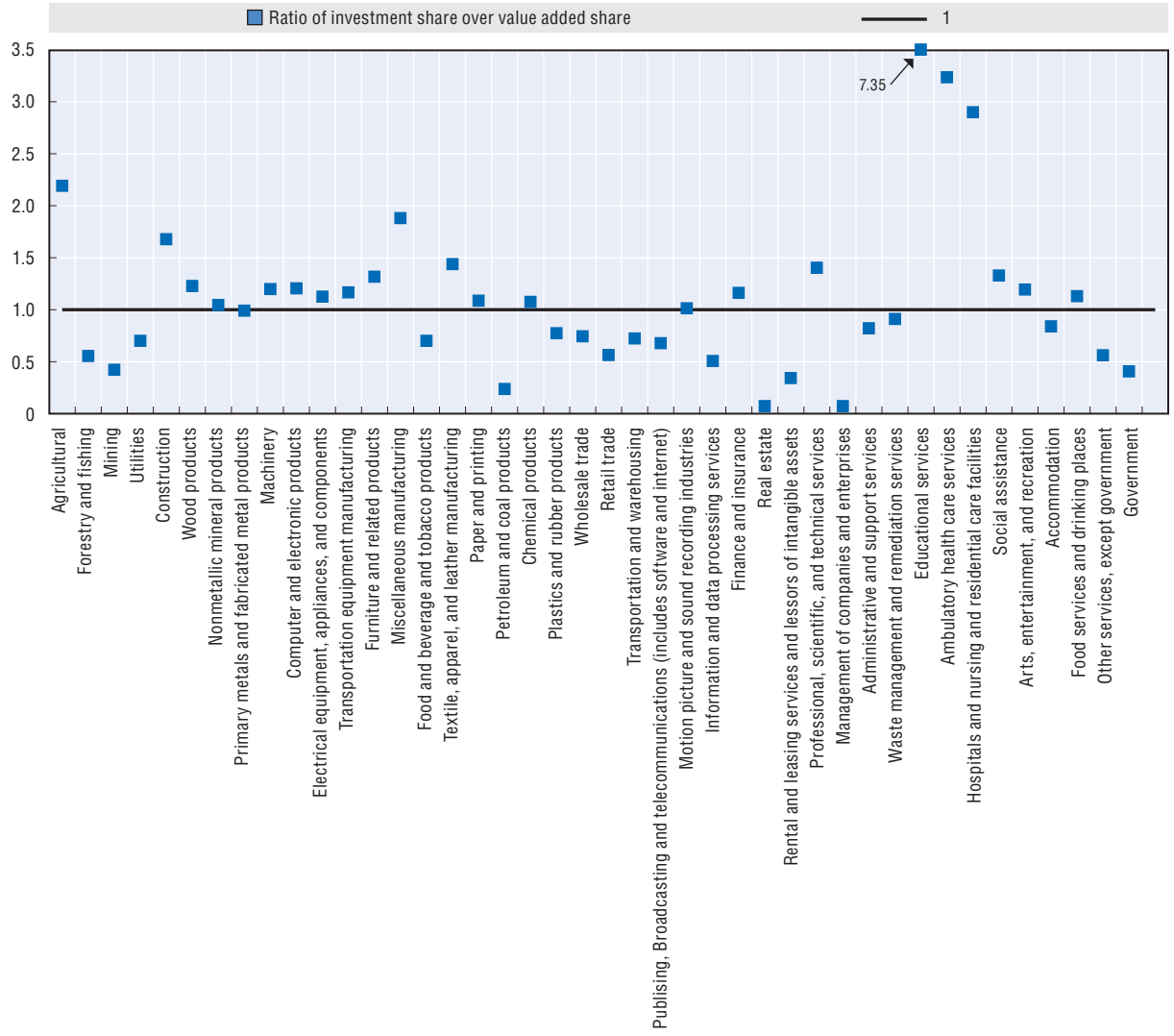
Figure 4.7 shows investment in organisational capital per person employed at the industry level in the United States. Figure 4.8 depicts the ratio of each sector's share of total investment in OC over the sector's share of value added, or its investment intensity in OC. On a per-person basis, the sectors that invest most heavily in OC appear to be finance, hospitals, chemical products manufacturing, Internet publishing, petrol and coal products manufacturing, and computer and electronic products manufacturing. In terms of OC investment intensity, most manufacturing industries invest more in OC than would be expected on the basis of their share of value added. Conversely, most services sectors – with the notable exception of the education and health sectors – invest proportionally less than their share in value added. These estimates align relatively well with the industry-level figures proposed in studies of France, Japan and Korea, where manufacturing industries appear to be more intensive investors in KBC than services.

Figure 4.7. Organisational capital investment per person employed (headcounts), United States, yearly average by industry, 2003-11



Source: OECD calculations based on the earnings data by occupation and industry from the Annual Social and Economic (ASEC) Supplement of the Current Population Survey (CPS), US Bureau of Labor Statistics, 2003-2011, www.bls.gov/cps /, accessed in February 2013.

Figure 4.8. Sectoral OC investment compared to value added, United States, yearly average, 2003-11



Note: The squares represent the ratio of the industry's share of investment in OC to the industry's share in value added. Industries with a ratio above one (line) invest relatively more in OC than their share in value added would imply.

Source: OECD calculations based on the earnings data by occupation and industry from the Annual Social and Economic (ASEC) Supplement of the Current Population Survey (CPS), US Bureau of Labor Statistics, 2003-11, www.bls.gov/cps/ , accessed in February 2013, and GDP-by-Industry data from the US Bureau of Economic Analysis, www.bea.gov/industry/index.htm#annual, accessed in February 2013.

The OC-related experimental methodology proposed by OECD has so far only been applied to US data. Extended to other countries, it would help to shed light on the role of human capital, in particular skilled employees, in the organisation and long-term functioning of firms, as well as their performance. This would facilitate the design of policies to improve industry performance based on human capital. It is also important to understand the role played by training in (re)skilling human resources and in optimising the long-term organisational capacity of firms and their productivity. Efforts have recently been made to measure investment in training more carefully, and to include apprenticeships, to account for the characteristics of employees that benefit from training (see O'Mahony, 2012), and more generally, to assess how training relates to aggregate economic performance.

Refining capitalisation parameters

Fully appreciating the role of KBC for economic growth requires learning about the share of investment that remains in production from one year to the next and is capitalised and about the length of time during which specific KBC continues to be economically useful. Moreover, comparing investments across countries and over time requires translating monetary values into real values and accounting for changes in prices that may have occurred. Many hypotheses about depreciation rates and price indices are being developed and tested worldwide, and recent OECD work has contributed by estimating the depreciation of organisational capital and R&D at the industry level.

The depreciation of organisational capital

The CHS framework considers that the accumulation of organisational capital over time is shaped by two complementary dynamics. On the one hand, as a result of learning by doing, organisational capital is codified in the structure of firms and depreciates in a fashion similar to R&D capital. On the other hand, organisational "forgetting" may lead to rapid OC depreciation, similar to what happens for advertising activities. This leads to a depreciation rate for organisational capital of 40% a year. However, recent survey-based estimates for the United Kingdom (Awano et al., 2010) and preliminary results from the Italian ISTAT-Isfol Survey (Perani and Guerrazzi, 2012) suggest that the average life of business process improvements is much longer than that implied by Corrado et al. (2009). According to these survey results, the average estimated life of business-related firm-specific resources, including organisational capital, is between 4 and 5.4 years. This would mean linear depreciation rates of 18% to 25%.

Building on these findings, exploratory work by the OECD proposes to calculate industry-specific depreciation rates for organisational capital based on labour mobility and job tenure data. The former reflects the extent to which workers move between jobs, occupations and geographical areas, whereas the latter refer to the time employees spend in a particular office or position. Many studies suggest that labour mobility, and in particular job separations in the form of voluntary departures, may have a disruptive effect on the accumulation of human capital, including organisational capital. Job tenure and employee turnover data for 2004-10 from the US Bureau of Labor Statistics were used to calculate industry-specific depreciation rates for OC in the United States (see Squicciarini and Le Mouel [2012], for details).

Table 4.3 presents the estimated life and associated linear depreciation rates for OC for different industries. These range between 10% and 20% and suggest that OC generally depreciates more slowly than previously assumed. In addition, OC seems to depreciate more slowly in manufacturing than in services. Exceptions to the 10-20% range are found in the agriculture and utilities industries, with linear depreciation rates of 5% and 7%, respectively, and in the arts and entertainment, food services and drinking places, motion picture and sound recording industries, and rental and leasing services, which show above 20% linear depreciation rates. The Internet publishing and broadcasting industry stands out with a particularly low median tenure of three years, and thus a linear depreciation rate of 33%. Taken together, these results appear significantly lower than those assumed by Corrado et al. (2009), but in line with those suggested by survey results, although somewhat lower in some cases.

Table 4.3. Estimated sectoral service lives and linear depreciation rates for organisational capital

Median tenure of OC occupations	Linear depreciation rate	Industry
11 - 20	5% - 9%	Agriculture; Forestry and logging; Utilities; Public administration
7- 10	10% - 15%	Manufacturing Machinery; Computer and electronic products; Chemicals; Electrical equipment and appliances; and ten other manufacturing industries Construction; Mining; Transportation and Warehousing; Wholesale trade Services Telecommunications; Insurance; and four other services industries
5 - 6	16% - 20%	Manufacturing Petroleum and coal products Services Finance; Retail trade; Professional and technical services; and ten other services industries
4	25%	Services Arts, entertainment and recreation; and three other services industries
3	33%	Internet publishing and broadcasting
2.5	40%	CHS assumption

Source: OECD calculations based on tenure data by occupation and industry from the January supplement of the Current Population Survey for the years 2004, 2006, 2008, 2010, Bureau of Labor Statistics, www.bls.gov/cps/lfcharacteristics.htm#tenure, accessed in July 2012.

The depreciation of R&D capital

Obtaining consistent industry-level depreciation rates for R&D investments is also a challenge. There is no agreement among the many studies that have calculated sector-specific depreciation rates for this knowledge-based asset. The figures proposed range between 12% and 29% for the overall business sector, and between -11% and 52% for industry-specific R&D depreciation rates (see Mead, 2007, for a survey). In most studies, however, the depreciation rate of R&D at the economy-wide level has been assumed to be 15% to 20% a year.

The wide variation in estimates, especially at the industry level, coupled with the importance of R&D as a knowledge-based asset, has motivated the OECD to investigate this question. It has taken what is technically called a "revealed preference approach", whereby the length of time for which R&D investment remains useful can be inferred by looking at the period of continued enforcement of the relevant IPR. The renewal of a patent can be interpreted as a signal that the R&D output described in the patent document is still useful for the firm, as no rational agent is willing to pay for an asset that is no longer needed. By the same token, the withdrawal of a granted patent can be considered an explicit signal that the R&D output contained in the patent document is no longer useful to the firm.

This idea has been the basis of patent renewal models, which use information on patent renewals to estimate the returns to R&D investment that firms can expect (e.g. Pakes and Schankerman, 1984). Such models rely on evidence showing that patents are highly correlated with R&D expenditures and that changes in R&D expenditures are typically paralleled by changes in patenting behaviour (Griliches, 1998).

R&D depreciation rates at the industry level are calculated using information on patent renewal data obtained from the European Patent Office (EPO) linked to commercial firm-level data. This is necessary to assign patents to industrial sectors, as patent documents do not provide such information. Sector-specific average and median patent lives are presented in Figures 4.9a and 4.9b, which show depreciation rates in the manufacturing and services sectors, respectively. The results indicate that patent lives vary widely and that in all sectors at least 1% of patents are renewed for the full 20-year period. The figures further suggest that average and median renewal figures differ across industries. Robustness tests to assess the sensitivity of depreciation rates to the inclusion or exclusion of big firms in the sample suggest that renewal behaviour is much more volatile when only small and medium enterprises (SMEs) are considered. Finally, the resulting average renewal period of 12.7 years for all sectors leads to a linear annual depreciation rate of around 8% rather than the 15% generally adopted in most studies and suggests that R&D depreciates at a much slower pace than previously thought.

Figure 4.9a. Duration of EPO patents granted in manufacturing industries, for applications filed in 1978-91

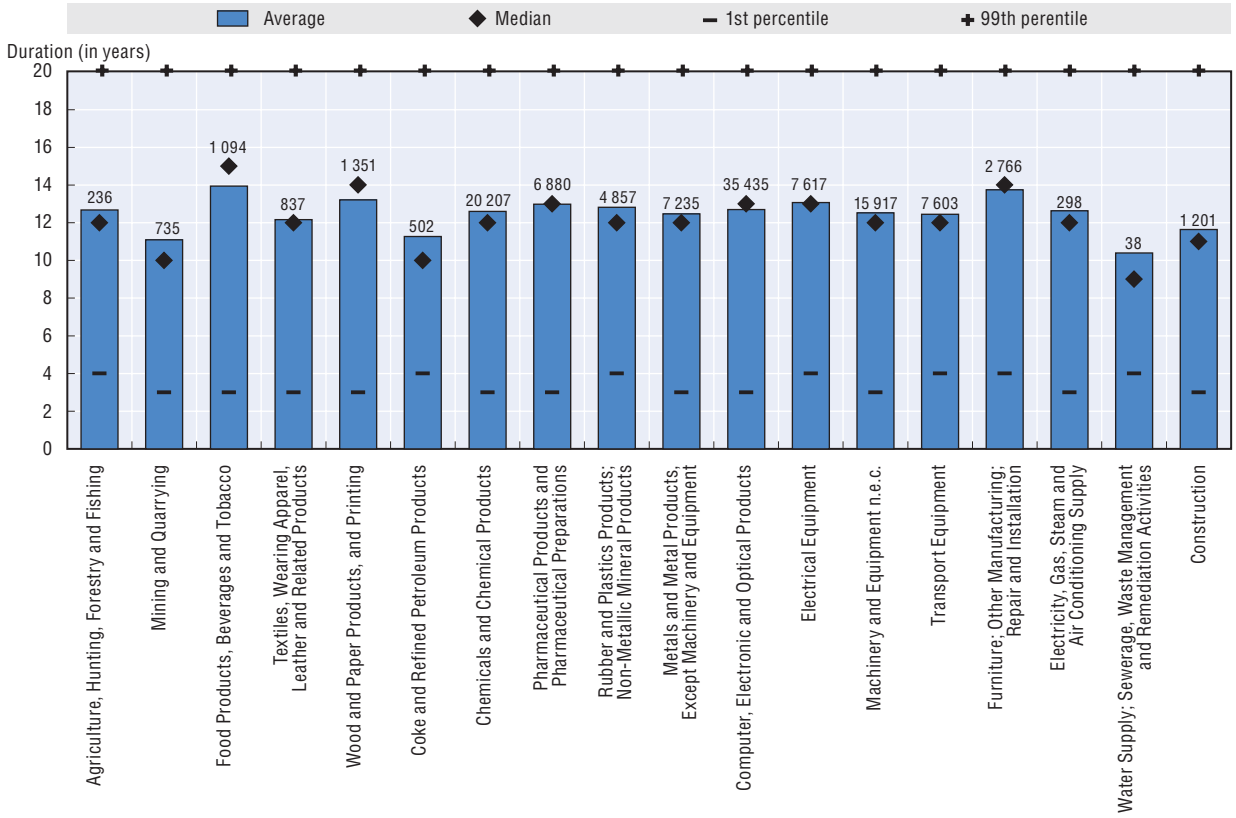
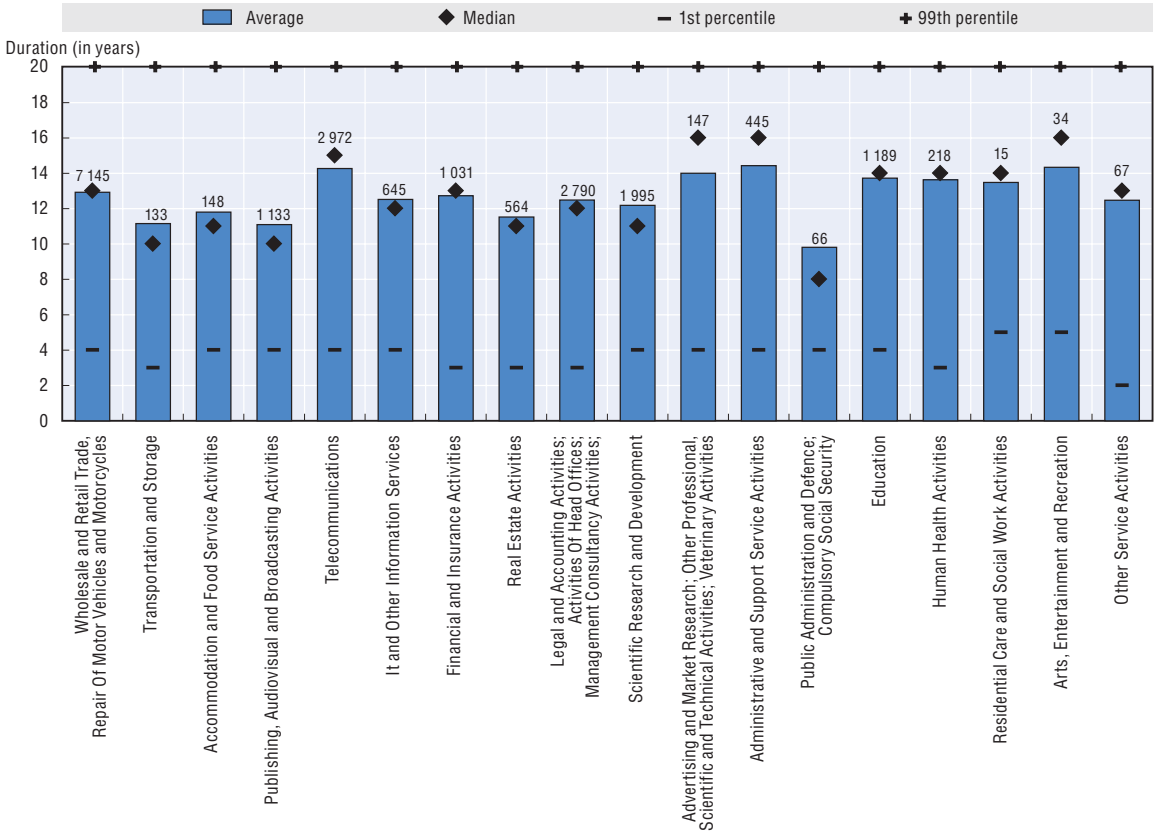


Figure 4.9b. Duration of EPO patent granted in services industries, for applications filed in 1978-91



Note: Number of patents considered by sector displayed on top of each bar. Sectors defined according to NACE Rev. 2. Calculations based on firms of 20 employees or more.

Source: OECD calculations based on the Worldwide Patent Statistical Database (PATSTAT) and Worldwide Legal Status Database (INPADOC), EPO, April 2012; and ORBIS© Database, Bureau van Dijk Electronic Publishing, June 2011; matched using algorithms in the Imalinker system developed for the OECD by IDENER, Seville, 2011.

Deflating investments in R&D

Building internationally comparable estimates of stocks and service flows of KBC requires adopting harmonised price deflators in order to capture and compare the true quantity of assets purchased. While quality-adjusted price indexes for computer hardware and software have been calculated for some time, this issue has only recently been raised for R&D, motivated by the SNA recommendation to capitalise R&D in national accounts. In a joint initiative of the Conference Board, members of the COINVEST project and researchers from UK National Endowment for Science, Technology and the Arts (NESTA), Corrado et al. (2011) developed a model for the production and use of knowledge. They argue that the price of R&D should be calculated, not from input prices as is currently done, but from final output prices, factor costs and TFP. This is necessary to reflect the presence of monopoly rents and productivity gains in the knowledge-producing sector. Empirical results for the United Kingdom suggest that the price of R&D has fallen from 1985 to 2005 and that R&D investment has been significantly underestimated.

Understanding the extent to which investment in KBC may have been over- or under-estimated will require calculating price deflators for all the assets concerned, including R&D. Making significant progress in this area will require a sustained effort over the medium to long term to address the important role played by prices in shaping investment dynamics.

Investments in knowledge-based assets are important and growing

Following a number of recent national and international initiatives, a picture that places knowledge-based assets at the centre of economic activity has begun to emerge. The resources devoted to investments in KBC appear to have increased steadily for some decades in all countries for which information is available and now correspond to a significant proportion of GDP, sometimes equalling or even surpassing the size of investments in physical capital. Evidence further suggests that investment in KBC has increased not only in absolute size but also in terms of annual growth rates.

The figures presented in this section were calculated following the CHS approach and would differ if other approaches, such as the OECD experimental methodology for measuring organisational capital, were used. They nevertheless represent a useful basis for comparing investments across countries and over time and appear to mirror structural differences that may exist.

In Australia, investment in KBC increased steadily between 1980 and 2000 to reach around 9% of adjusted value added,[15] and has since remained at around this level. The levelling off during the 2000s seems due to a decline in investment in software and in economic competencies starting in the late 1990s, which has not been compensated by equivalent increases in investments in innovative property.

In France, KBC investments more than doubled as a share of adjusted value added from 5% to 12% from 1980 to 2008, with a sharp acceleration between 1995 and 2000, driven by investments in software (Delbecque et al., 2012).

In Japan, KBC investment increased from 5.9% of adjusted value added in 1985 to 9.6% in 2008, with two periods of stagnating or declining investment, from 1992 to 1995 and from 2001 to 2006. The stagnation of KBC investment during the latter period seems to have been driven by the steady decline in investments in economic competencies during the 2000s, which Chun et al. (2012) argue is the result of deep restructuring following the financial crisis of 1997.

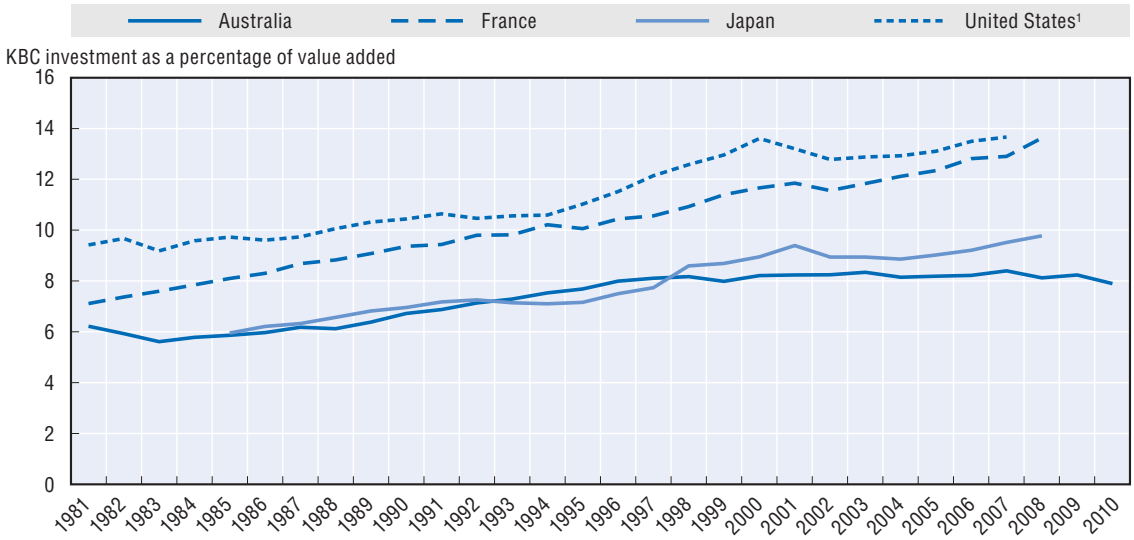
In the United States, investment in KBC has been increasing steadily since the 1950s and reached around 13.7% of adjusted value added by 2007. In the 1990s the rate of investment in KBC picked up significantly, led by investment in software, and surpassed investments in tangible capital (Corrado et al., 2009).

These long-term patterns are shown in Figure 4.10, which shows the evolution of total KBC investment as a share of adjusted value added for Australia, France, Japan and the United States for 1981-2010.

In Canada, a similar secular increase in investment in KBC has been reported and the share of investment in KBC reached 12% of adjusted value added in 2008. While investment in KBC rose faster than investment in tangible assets from 1974 to 2008, it did not surpass it and in 2008 stood at 66% of tangible investment (Baldwin et al., 2012).

In the United Kingdom, investment in KBC increased throughout the 1990s but declined slightly during the 2000s to 12% of adjusted value added. In contrast, tangible investment fell very sharply over this period and by 2009 investment in KBC was 34% higher than tangible investment (Goodridge et al., 2012). Figure 4.11 compares investment in tangibles and in KBC for 2010 for a number of OECD countries.

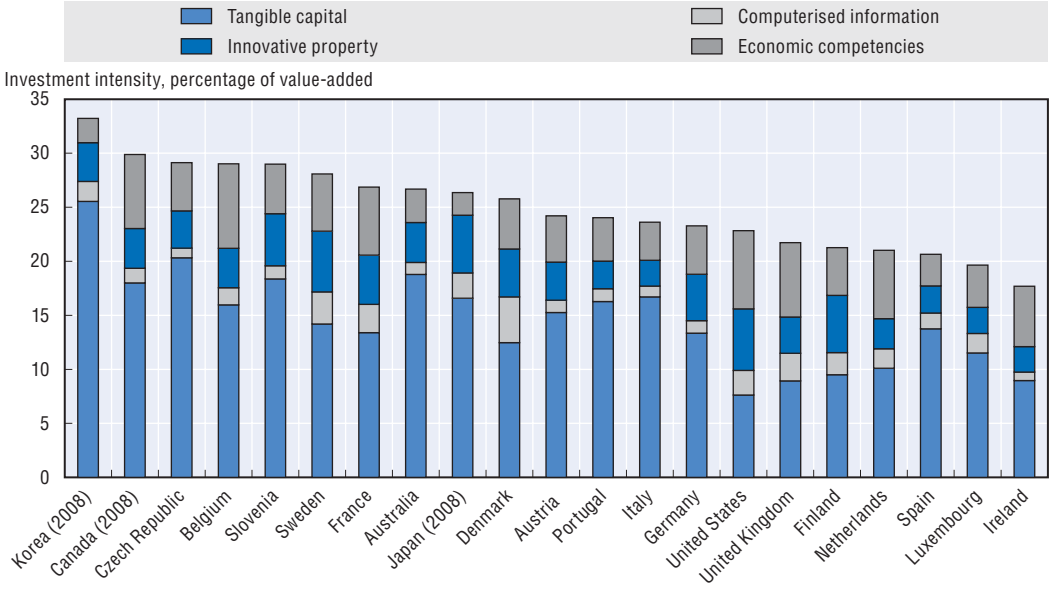
Figure 4.10. KBC investment as share of market-sector adjusted value added, 1981-2010



Note: Values for the United States refer to the non-farm market sector; for the other countries, agriculture is included.

Source: KBC investment data for Australia are from Australia (2012), for France from Delbecque et al. (2012), for Japan from the Japanese Industrial Productivity (JIP) Database, and for the United States from van Ark et al. (2009). Market-sector adjusted value added is based on OECD calculations from the Main Science and Technology Indicators (January 2013 release), Bureau of Economic Analysis (November 2012 release) and JIP Database.

Figure 4.11. Investment intensity in KBC and tangible capital, as percentage of adjusted value added, 2010



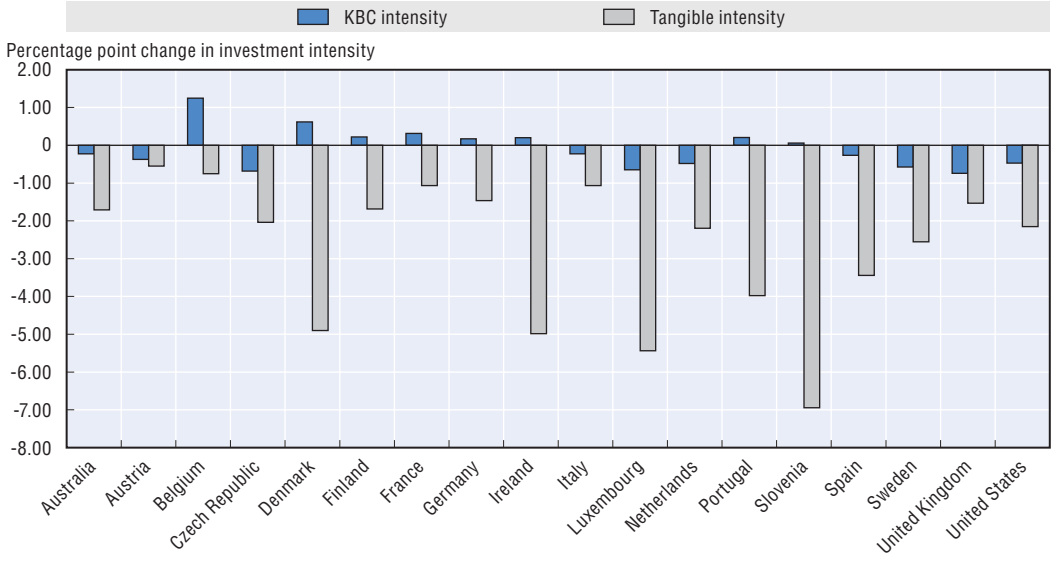
Note: Figures refer to the market economy, which excludes real estate, public administration, health and education, with the exception of Korea, where figures refer to the whole economy.

Source: Based on INTAN-Invest (www.intan-invest.net, KBC investment for EU27 and United States), OECD Main Science and Technology Indicators (www.stastats.oecd.org, Korea, Luxembourg and Portugal market-sector value added and Korea tangible investment), National Accounts from Eurostat (http://ec.europa.eu/eurostat, Austria, Denmark, Finland, France, Ireland, Italy, Luxembourg, Netherlands, Spain and Sweden tangible investment), Australian Innovation System Report (2012, KBC investment), National Accounts from the Australian Bureau of Statistics (www.abs.gov.au, value added and tangible investment), the Japanese Industrial Productivity (JIP) Database (www.rieti.go.jp/en/database/JIP2011/, all data for Japan), Chun et al. (2012) (Korea KBC investment), and Baldwin et al. (2012, all data for Canada), accessed in June 2013.

A higher level of investment in KBC appears to be associated with better economic performance, both in the short run and over the long term. In particular, investment in knowledge-based assets seems to be positively related to labour productivity growth and to the level of GDP per capita. In addition, estimates suggest that, during the recent crisis, investment in KBC proved more resilient to the downturn in GDP than investment in physical capital. This is suggested in Figure 4.12, which shows the change in the intensity of business investment in both KBC and tangible capital during 2008-10.

Growth accounting analyses bring out the fact that the main source of growth has shifted from TFP to knowledge-capital deepening (the intensity of knowledge capital per worker). Moreover, investments in KBC have led to significant changes in the nature of work: more knowledge-intensive economies have labour markets very different from those of more traditional economies, in particular in terms of employment possibilities and earnings of different skill groups. Inequalities among workers have increased: both high-skilled and low-skilled employees have seen their earnings increase – although to a different extent – whereas medium-skilled employees carrying out routine tasks have not.

Figure 4.12. Change in business investment from 2008 to 2010, in percentage points



Source: Based on INTAN-Invest (www.intan-invest.net, KBC investment for EU27 and United States), OECD Main Science and Technology Indicators (www.stastats.oecd.org, Korea, Luxembourg and Portugal market-sector value added and Korea tangible investment), National Accounts from Eurostat (http://ec.europa.eu/eurostat, Austria, Denmark, Finland, France, Ireland, Italy, Luxembourg, Netherlands, Spain and Sweden tangible investment), Australian Innovation System Report (2012, KBC investment), and National Accounts from the Australian Bureau of Statistics (www.abs.gov.au, value added and tangible investment), accessed in June 2013.

Most studies concerned with the measurement of knowledge-based capital and with the effect of KBC on productivity and economic growth remain at the level of correlations and are unable to show the extent and direction of causality. This has important consequences for policy making: it may be, for instance, that investment in KBC and productivity growth are determined by specific framework conditions.

Building on recent work to advance the KBC measurement agenda

Knowledge and knowledge-based capital are essential for competing in the economy of the 21st century, yet measuring these assets remains a challenge. Properly assessing the value of the knowledge that is created, used and transferred within and across economies has significant implications for a better understanding of the sources of employment, productivity and economic growth, and for the design of evidence-based policies.

In recent years, a number of initiatives worldwide have estimated investment in knowledge-based assets, mainly following a measurement framework conceived for and tested on data for the United States. This has inevitably resulted in differences in the sources of information used and in the way definitions have been applied. Researchers in different countries have relied on alternative sources of data and have used a wide range of measurement parameters. Efforts to harmonise these national-level estimates have mobilised the research community and have led to the publication of comparable macro-level data for a number of countries.

Discovering the role of knowledge-based assets in the economic performance and growth of countries nevertheless requires deeper understanding of the investment decisions of individual firms and of the behaviour of different industries. Firm- and sectoral-level data might feed directly into the design of industrial policy by helping to identify the most suitable policy tools and by determining the framework conditions under which they are likely to be effective. Recent work has tried to adapt the KBC macroeconomic framework to obtain industry-level estimates for 17 countries. Although this constitutes a major advance in understanding industry-specific patterns of investment in KBC, differences remain in the number of industries and assets covered and therefore in the international comparability of these figures. At the firm level, the main recent development has been the integration of questions on KBC in surveys on the innovative activities of firms. These initiatives have provided a wealth of policy-relevant information; their scale-up would allow for more targeted firm- and industry-specific policies and cross-country comparisons.

In the past, certain KBC-related assets were overlooked in definitional and measurement work, and there is neither an official methodological approach nor agreed guidelines for measuring them. These assets, particularly some in the categories of economic competencies and innovative property, are not included in official statistics such as national accounts. Researchers have therefore devised methods to estimate investment in these assets by using other data sources. The measurement of firm-specific training, for example, remains hotly debated. Recent evidence for the European Union suggests that taking appropriate account of the qualifications of employees receiving training can lead to estimates of investment in continuous training amounting to around 2% of GDP, which is equivalent to 35% of total expenditures on general education. Design – which has recently attracted considerable policy attention – is another asset for which measurement guidelines are lacking.

The OECD has addressed some shortcomings related to the absence of asset-specific measurement guidelines and the lack of cross-country harmonisation of measurement methodologies. In both cases, it has given priority to R&D and organisational capital, which are widely recognised as central to firms' innovation activities and broader performance.

Organisational capital is recognised as a central and enabling asset for firm performance. The experimental methodology proposed by the OECD defines it as the set of tasks performed by a firm's employees that contribute to the long-term functioning of a

business. The occupations that contribute to the generation and accumulation of organisational capital are identified by using information about the tasks performed by employees in different occupations. Building on these results, investment in organisational capital is estimated as a fraction of the earnings of these employees. Results suggest that such investments are almost twice as large as when assuming organisational capital to correspond to managerial activities alone. Industry-level estimates point to large differences in the intensity of investment in organisational capital across industries. It appears to be an important asset in many manufacturing industries as well as in finance, education and health.

The importance of organisational capital for production depends not only on yearly investments but also on the number of years firms can expect to reap its benefits. Previous estimates of the life of this asset have relied on hypothetical assumptions about its speed of depreciation. The OECD, using labour mobility data related to resignations, has found that organisational capital is much longer lived than previously thought. Firms expect such investments to last on average four to six years in services industries and seven to ten years in manufacturing.

Assets such as R&D have received much attention in recent decades and their measurement has progressed steadily. This has however led to a number of official data collections and to a variety of methodologies. The resulting figures differ in terms of the part of the asset captured and therefore in the amounts. In particular, the two main sets of guidelines focus, on the one hand, on performers and funders of R&D activities, and, on the other hand, on the producers and owners of R&D assets. Reconciling these figures requires careful assignment of ownership; this in non-trivial, for example, for publicly funded R&D activities carried out by private firms. Recent OECD work has provided guidelines to help countries identify possible sources of cross-country variation and to facilitate international harmonisation and benchmarking, in particular to inform R&D and innovation policies.

An often-cited caveat of the input-based approach to measuring knowledge-based assets is that it gives little indication of the value of the assets produced. The OECD has therefore used information contained in patent documents to design and construct measures of the "quality" of firms' innovative property (i.e. the technological and economic value of their patented inventions). Such indicators are generally comparable across countries and over time, and therefore suitable for cross-country analysis.

Annual investment series are insufficient to understand the use that firms make of their different knowledge assets. It is also necessary to understand and measure the life of these assets. However, obtaining consistent industry-level depreciation rates for R&D investments has proven difficult, and there is no commonly agreed methodology. The OECD has used patent renewal data to estimate the length of time during which firms value their R&D output. In general, R&D appears to be much more long-lived than previously thought, with an aggregate 8% annual linear depreciation figure rather than the 15% figure that is usually used. There are also industry-specific differences, as R&D in manufacturing seems longer-lived than in services.

The growth accounting framework, the main analytical framework currently used, provides extremely valuable information about the role of KBC in productivity and economic growth. However, it only accounts for correlations and is unable to identify causal links. Therefore, in addition to improving measurement of the different assets at all levels – firm, industry, the whole economy – a more comprehensive understanding of the role of KBC would require an analytical framework able to reveal causal links and to account for interactions and spillovers between different knowledge-based assets, and

between investment in KBC and other types of investment. For example, the complementarities between organisational capital and ICT infrastructure and between R&D and human capital investments are well documented. This suggests that the effectiveness of certain policies in support of R&D or ICT investment might be diminished by framework conditions that hinder investments in complementary assets.

Achieving consistent investment estimates for all the assets included in the CHS framework will require sustained effort over the medium to long term. Monitoring and co-ordinating the efforts of research groups and national statistical offices worldwide, in particular by facilitating knowledge sharing, enabling peer review activities, and avoiding duplication of work, will help to reach this goal more quickly.

In addition, appreciation of the importance and role of knowledge-based assets for output and productivity growth is contingent upon improving the theoretical and modelling frameworks that guide empirical analysis. Measurement strategies should be anchored in theory and the insights afforded by theoretical work. The lack of a general model impinges upon the ability to identify market failures and the root causes of such failures and hence to design more effective policies.

Notes

1. For instance, the role of the ICT sector and its linkages with other sectors are addressed by Oliner et al. (2008); Oulton (2010); and Dahl et al. (2011); its complementarities with the organisational structure of firms are addressed by Bresnahan et al. (2002). Spillovers of R&D investments across sectors are analysed by Wolff and Nadiri (1993) and Wolff (1997, 2011), and spillovers of investment in organisational capital between upstream and downstream firms are studied by Javorcik (2004).

2. The paper is available at www.oecd-ilibrary.org/science-and-technology/defining-and-measuring-investment-in-organisational-capital_5k92n2t3045b-en.

3. CHS assumes that organisational capital is the product of managerial activity only, and count 20% of managerial wages as investment in this asset.

4. INNODRIVE and COINVEST were funded under the 7th Framework Programme to measure intangible assets for a number of EU countries. COINVEST (2008-10) covered eight European countries, whereas INNODRIVE (2008-11) covered the EU27 and Norway.

5. INTAN-Invest estimates are the authors' own elaboration of work previously conducted under three projects: INNODRIVE, COINVEST and on-going work by the Conference Board. Data are available at www.intan-invest.net/, accessed in May 2013.

6. Estimates of investments in KBC for Japan have been calculated as part of the Japanese Industrial Productivity Database and are published at www.rieti.go.jp/en/database/JIP2011/index.html, accessed in July 2012.

7. Software has been capitalised in the SNA since 1993, and R&D will be capitalised in the SNA from 2013.

8. Sectoral investment series for France are available online in the annex to the Centre de Recherche en Economie et Statistique (CREST) Working Paper 2012-26 by Delbecque et al. (2012), www.crest.fr/content/blogcategory/21/54/.

9. These estimates are part of the deliverables of the INDICSER project, financed by the European Commission under the 7th Framework Programme. For more information see indicser.com.

10. The United Kingdom is a notable exception, as KBC investment is highest in the business services and financial intermediation sectors.

11. See Perani and Guerrazzi (2012). More information about the pilot phase can be obtained at www.isfol.it/temi/Formazione_apprendimento/indagini-e-ricerche/intangible-assets-survey-sintesi-dei-risultati-della-rilevazione-pilota-1 (in Italian).

12. This work is led by the OECD National Experts on Science and Technology Indicators (NESTI) Working Party.

13. Damage award numbers from *Apple Inc. v. Samsung Electronics Ltd. Inc*., No. 11-1846, U.S. District Court for the Northern District of California. See the amended jury verdict of 24 August 2012
http://cand.uscourts.gov/filelibrary/1079/Amended%20Jury%20Verdict.pdf

Further documentation on the proceeding is available at
http://cand.uscourts.gov/applevsamsung/casedocs.

14. The project, carried out by the OECD NESTI Working Party is partly sponsored by a voluntary contribution from the European Commission (DG Enterprise) and will run until the end of 2013.

15. All the KBC investment series are calculated for the market economy, excluding the public and real estate sectors. As such, nominal investment series are compared to total value added of the market economy rather than the market economy. As spending on KBC is now considered investment rather than current expenditure, it is part of value added and has to be summed with official figures of value added.

References

Ark, B. van, J. Hao, C. Corrado and C. Hulten, (2009), "Measuring intangible capital and its contribution to economic growth in Europe" *European Investment Bank Papers*, Vol. 14, No. 1, www.eib.org/attachments/efs/eibpapers/eibpapers_2009_v14_n01_en.pdf.

Australia, (2012), "Australian Innovation System Report – 2012", Department of Industry, Innovation, Science, Research and Tertiary Education, Commonwealth of Australia, www.innovation.gov.au/innovation/policy/australianinnovationsystemreport/aisreport2012.pdf.

Awano, G., M. Franklin, J. Haskel and Z. Kastrinaki, (2010), "Investing in Innovation: Findings from the UK Investment in Intangible Assets Survey", *National Endowment for Science, Technology and the Arts (NESTA)* report, July.

Baldwin, J., W. Gu and R. Macdonald (2012), "Intangible capital and productivity growth in Canada", in *The Canadian Productivity Review Research Papers*, Statistics Canada, Ottawa, www.statcan.gc.ca/pub/15-206-x/15-206-x2012029-eng.htm.

Barnes, P. (2010), "Investments in Intangible Assets and Australia's Productivity Growth: Sectoral Estimates", Australia Productivity Commission, www.pc.gov.au/__data/assets/pdf_file/0007/99907/intangible-investment-sectoral-estimates.pdf.

Barnes, P. and A. McClure, (2009), "Investments in Intangible Assets and Australia's Productivity Growth", Australia Productivity Commission, www.pc.gov.au/__data/assets/pdf_file/0006/86496/intangible-investment.pdf.

Belhocine N. (2009), "Treating Intangible Inputs as Investment Goods: the Impact on Canadian GDP", *IMF Working Papers* 09/240, International Monetary Fund, www.imf.org/external/pubs/ft/wp/2009/wp09240.pdf.

Bresnahan, T. F., Brynjolfsson E., and L. M. Hitt (2002). "Information Technology, Workplace Organization, and the Demand for Skilled Labor: Firm-Level Evidence." *Quarterly Journal of Economics*, Vol. 117(1), pp. 339-376.

Chun, H., K. Fukao, S. Hisa and T. Miyagawa (2012), "Measurement of Intangible Investments by Industry and Its Role in Productivity Improvement Utilizing Comparative Studies between Japan and Korea", *RIETI Discussion Paper Series* 12-E-037, www.rieti.go.jp/jp/publications/dp/12e037.pdf.

Corrado, C., P. Goodridge and J. Haskel, (2011), "Constructing a Price Deflator for R&D: Calculating the Price of Knowledge Investments as a Residual", August 2011, available at SSRN: http://ssrn.com/abstract=2117802.

Corrado, C., J. Haskel, C. Jona-Lasinio and M. Iommi (2012), "Intangible Capital and Growth in Advanced Economies: Measurement Methods and Comparative Results", Working Paper, June 2012, available at www.intan-invest.net.

Corrado, C., C. Hulten and D. Sichel (2005), "Measuring Capital and Technology: An Expanded Framework", in C. Corrado, J. Haltiwanger and D. Sichel (eds.), *Measuring Capital in a New Economy*, National Bureau of Economic Research and University of Chicago Press, Chicago, IL.

Corrado, C., C. Hulten and D. Sichel (2009), "Intangible Capital and US Economic Growth", *Review of Income and Wealth*, Vol. 55(3), pp. 661–685, www.conference-board.org/pdf_free/IntangibleCapital_USEconomy.pdf.

Crass, D., G. Licht and B. Peters (2010), "Intangible Assets and Investments at the Sectoral Level – Empirical Evidence for Germany" CoInvest Project Report, Deliverable D 10, pp. 133-206, www.coinvest.org.uk/pub/CoInvest/CoinvestProjects/COINVEST_217512_D10.pdf.

Dahl, C. M., Kongsted H. C., and A. Sørensen (2011). "ICT and Productivity Growth in the 1990s: Panel Data Evidence on Europe." *Empirical Economics*, Vol. 40(1), pp. 141-164.

Delbecque, V. and A. Bounfour (2012), "Intangible capital and value creation: A comparative industry analysis" The European Chair on Intellectual Capital Management, *Working Paper Series*, No. 2012-1A, January, www.chairedelimmateriel.u-psud.fr.

Delbecque, V., S. Le Laidier, J. Mairesse and L. Nayman (2012), "L'évaluation des investissements incorporels en France : méthodes et premiers résultats", Centre de Recherche en Economie et Statistique (CREST) *Working Paper Series*, No. 2012-26.

Edquist, H. (2011), "Intangible Investment and the Swedish Manufacturing and Service Sector Paradox" *Research Institute of Industrial Economics (IFN) Working Paper* No. 863, www.snee.org/filer/papers/627.pdf.

Fukao, K., T. Miyagawa, K. Mukai, Y. Shinoda and K. Tonogi (2009), "Intangible Investment in Japan: Measurement and Contribution to Economic Growth", *Review of Income and Wealth*, Series 55, No. 3, September.

Gil, V. and J. Haskel (2008), *Industry-level Expenditure on Intangible Assets in the UK*, Coinvest Publication.

Goodridge, P., Haskel, J. and G. Wallis (2012), "UK Innovation Index: Productivity and Growth in UK Industries". *CEPR Discussion Paper* No. DP9063, July.

Griliches, Z. (1998), "Patent Statistics as Economic Indicators: A Survey" in Z. Griliches (ed.), *R&D and Productivity: The Econometric Evidence*, University of Chicago Press, Chicago, IL.

Hall, B. H., Z. Griliches and J. A. Hausman (1986), "Patents and R&D: Is There A Lag?", *International Economic Review*, Vol. 27(2), pp. 265-284.

Hao, J. X., V. Manole and B. van Ark (2009), *Intangible Capital and Growth – an International Comparison*, CoInvest Publications, Deliverable D 3.6.

Haskel, J., Goodridge, P., Pesole, A., Awano, G., Franklin, M., and Z. Kastrinaki. (2011). Driving Economic Growth. Innovation, Knowledge Spending and Productivity Growth in the UK, *NESTA Index Report*, available at www.nesta.org.uk/library/documents/Driving_Ecc_Growth_Web_v4.pdf.

Hulten C. and J. Hao (2012), "The Role of iIntangible Capital in the Transformation and Growth of the Chinese Economy", *NBER Working Paper* No. 18405, September, www.nber.org/papers/w18405.

INTAN-Invest (2012), www.intan-invest.net.

Jalava, J., P. Aulin-Ahmavaara and A. Alanen (2007), "Intangible Capital in the Finnish Business Sector – 1975-2005", *Elinkeinoelämän tutkimuslaitos (ETLA) Discussion Papers* No. 1103, www.etla.fi/wp-content/uploads/2012/09/dp1103.pdf.

Javorcik, B. S. (2004). "Does Foreign Direct Investment Increase the Productivity of Domestic Firms? In Search of Spillovers through Backward Linkages." *American Economic Review*, Vol. 94(3), pp. 605-627.

Mead, C. I., (2007). "R&D Depreciation Rates in the 2007 R&D Satellite Account". Bureau of Economic Analysis/National Science Foundation R&D Satellite Account Background Paper. Available at: www.bea.gov/papers/pdf/Mead_RD_Paper_wp.pdf .

O'Mahony M. (2012), "Human Capital Formation and Continuous Training: Evidence for EU Countries", *Review of Income and Wealth*, Vol. 58(3), pp. 531-549.

O'Mahony, M., T. Niebel, and M. Saam (2012), "Intangible Investment at the Industry Level: Growth Accounting", INDICSER Project Deliverables, D 2.3, December, http://indicser.com/images/dp33_omahony_et_al.pdf .

OECD (2002), *Frascati Manual 2002: Proposed Standard Practice for Surveys on Research and Experimental Development*, The Measurement of Scientific and Technological Activities, OECD Publishing. doi: http://dx.doi.org/10.1787/9789264199040-en.

OECD/Statistical Office of the European Communities, Luxembourg (2005),*Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data, 3rd Edition*, The Measurement of Scientific and Technological Activities, OECD Publishing. doi: http://dx.doi.org/10.1787/9789264013100-en.

OECD (2010), *Handbook on deriving capital measures of intellectual property products*, OECD publishing, Paris. doi: http://dx.doi.org/10.1787/9789264079205-en.

Oliner, S. D., Sichel D. E., and K. J. Stiroh (2008). "Explaining a Productive Decade". *Journal of Policy Modeling*, Vol. 30(4), pp. 633–673.

Oulton, N. (2010). "Long Term Implications of the ICT Revolution: Applying the Lessons of Growth Theory and Growth Accounting". *CEP Discussion Paper* No. 1027, November.

Pakes, A. and M. Schankerman (1984), "The Rate of Obsolescence of Patents, Research Gestation Lags, and the Private Rate of Return to Research Resources" in Z. Griliches (ed.), *R&D, Patents, and Productivity*, University of Chicago Press, Chicago, IL.

Perani, G. and M. Guerrazzi (2012), "The Statistical Measurement of Intangible Assets. Methodological Implications of the Results of the ISFOL 2011 Pilot Survey", mimeo (available upon request from the authors).

Piekkola, H. (2011), "Intangible Capital – Driver of Growth in Europe", *Proceedings of the University of Vaasa.* Reports, 167, Vaasan yliopisto, June, www.innodrive.org/attachments/File/Intangible_Capital_Driver_of_Growth_in_Europe_Piekkola(ed).pdf.

Rooijen-Horsten, M. van, D. van den Bergen and M. Tanriseven (2008), "Intangible capital in the Netherlands: A benchmark", *Statistics Netherlands Discussion Paper* No. 08001, www.cbs.nl/NR/rdonlyres/DE0167DE-BFB8-4EA1-A55C-FF0A5AFCBA32/0/200801x10pub.pdf.

Squicciarini, M, and M. Le Mouel, (2012), "Defining and Measuring Investment in Organisational Capital: Using US Microdata to Develop a Task-based Approach", *OECD Science, Technology and Industry Working Papers*, No. 2012/05, OECD, doi: http://dx.doi.org/10.1787/5k92n2t3045b-en.

Talbot, L, H. Toh, E. Kalenjuk, A. Lal and J Seol (2012), "Firm-level Financial Measures of Innovation: An Exploratory Project to Derive Financial Measures of Innovation Activity from the Accounting Records of Model Australian Firms", Australian Department of Industry, Innovation, Sciences, Research and Tertiary Education, Innovation Division, February.

United States Patent and Trademark Office (2013), *Design Patent Report,* www.uspto.gov/web/offices/ac/ido/oeip/taf/design.htm.

Wolff, E. N., and M. I. Nadiri (1993). "Spillover Effects, Linkage Structure, and Research and Development". *Structural Change and Economic Dynamics*, Vol. 4(2), pp. 315-331.

Wolff, E. N. (1997). "Spillovers, Linkages and Technical Change." *Economic Systems Research*, Vol 9(1), pp. 9-23.

Wolff, E. N. (2011). "Spillovers, Linkages, and Productivity Growth in the US Economy, 1958 to 2007". *NBER Working Paper* No. 16864, March.

Chapter 5.

Knowledge-based capital and upgrading in global value chains

The rise of global value chains (GVCs) has changed the nature of global competition. Economies and firms increasingly compete for high value-added activities within GVCs rather than for high value-added industries. The value created within a GVC is unevenly distributed among participants, and is concentrated in firms engaging in technologically-sophisticated, highly original activities that determine the total value the GVC can create. This chapter explores the role of knowledge-based capital (KBC) as the firm-specific resource that establishes the competitive advantage of economies and firms in those "high value-added" activities within GVCs.

The development of global value chains (GVCs) has changed the nature of global competition. Firms no longer compete simply for market share in high value-added industries. They increasingly compete in high value-added activities in GVCs. This competition is important because the value created by a GVC is unevenly distributed among participants and depends on their ability to supply sophisticated and hard-to-imitate products or services to GVCs.

This chapter explores the role of knowledge-based capital (KBC) in shaping economies' and firms' competitive advantages in high value-added (i.e. better remunerated, higher margin) activities within GVCs. It looks at the characteristics of the activities that create high levels of value-added in GVCs, considers how KBC helps firms (or economies) acquire the capabilities to compete in those high value-added activities, and discusses the kinds of policies that support or hamper upgrading of GVC activities based on KBC.

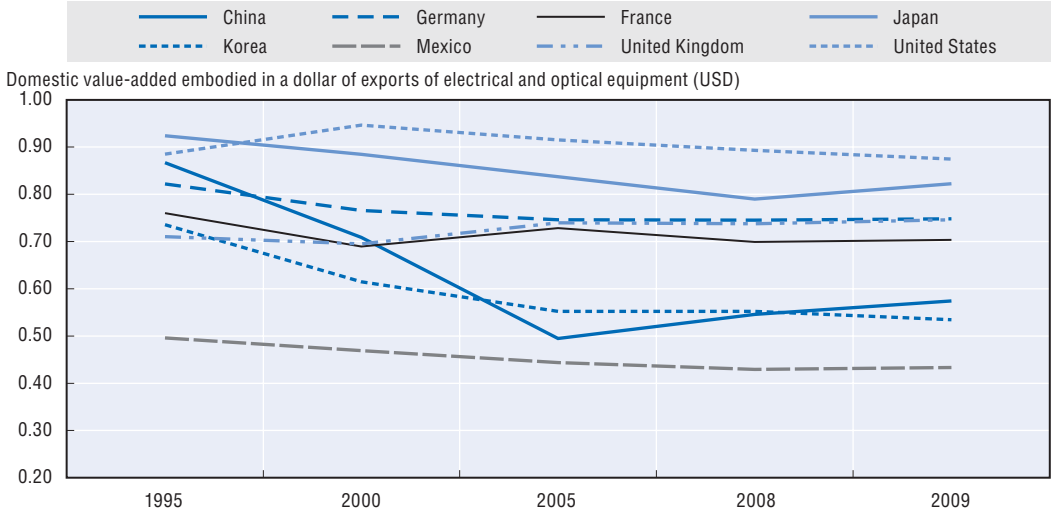
The chapter first describes how value added is created in GVCs and shows that, for a given activity, it depends on whether there are high barriers to entry for other firms. It defines the upgrading of activities within GVCs as the acquisition of capabilities that allow firms to supply superior processes, products or functions. The following section introduces the concept of KBC and discusses its role in underpinning a firm's or an economy's ability to upgrade its GVC activity. It also explores how the difficulty of replicating different forms of KBC determines the sustainability of the value created through upgrading. An empirical analysis of the role of KBC in value-creation within GVCs is then presented, before a final section draws policy implications.

Deriving more value from GVCs: The upgrading of GVC activity

Creating (or capturing) value in GVCs

With many economies undergoing a prolonged adjustment of their domestic markets, policy makers increasingly seek to derive more value from firms' international engagement. However, an economy's capacity to create significant value added through trade is determined not only by the structure of its export industries, but increasingly by its competitiveness in segments of GVCs that are associated with high value-added. Figure 5.1 shows the ratio of domestic value added embodied in exports of electrical and optical machinery to the actual exports, which can be interpreted as the value captured by an economy from a dollar of electronics exports. While this ratio declined between the mid-1990s to mid-2000s for many participants in GVCs, including China, it remained relatively stable for economies such as the United States and the United Kingdom. A decline in domestic value added embodied in exports primarily reflects an increase in the import content of exports brought about by the rapid development of GVCs. However, the uneven level and change in the ratio across economies suggests that US activities in the electronics value chain have shifted to segments associated with high levels of value added, while China, which engaged intensively in processing trade, shifted to lower value-added assembly operations. However, the recent rise in this ratio suggests that China improved its competitiveness in higher-value-added GVC activities (see also Box 5.1).

Figure 5.1. The share of domestic value added in exports of electrical and optical machinery, 1995-2009



Source: OECD/WTO (2013b), OECD-WTO: Statistics on Trade in Value Added, (database).
doi: http://dx.doi.org/10.1787/data-00648-en.

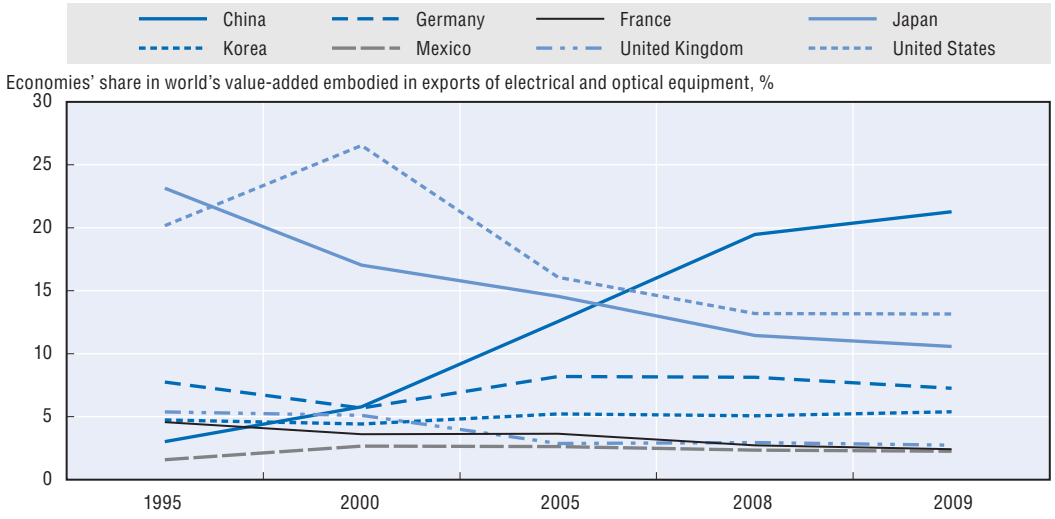
While China has a low share of value added in exports compared to advanced economies such as Germany, Japan and the United States, the large volume of its exports means that it accounts for nearly 25% of global value added embodied in electronics exports (Figure 5.2). Its growing share contrasts with those of Japan and the United States, which have seen steep declines since the late 1990s.

Figures 5.1 and 5.2 point to two different aspects of value creation (or capture) in GVCs. While some economies still focus on increasing their export market share, a growing number also focus on enhancing the value added earned per dollar of exports. Even China, which already accounts for a large share of the world's exports of manufactures, has shifted its focus from market share alone. A recent report authored jointly by the Development Research Centre of the State Council of China and the World Bank states that:

> China sees itself building its future prosperity on innovation in which everyone's creative potential is tapped. Its success will lie in its ability to produce **more value, not more products**, enabling it to move up the value chain and compete globally in the same product space as advanced countries. (World Bank and Development Research Centre of the State Council of People's Republic of China, 2012, p. 15)

On the basis of these considerations, this chapter infers an economy's ability to create larger value in GVCs by observing the ratio of domestic value-added embodied in its exports to its actual exports. Such a focus on value-added corresponds to the concept of "high value-added activity" in the GVC literature, a concept which refers to activities that are better remunerated (have higher margins) and have higher entry barriers because the skills required are difficult to obtain.

Figure 5.2. Country share in global value-added in exports of electrical and optical machinery, 1995-2009

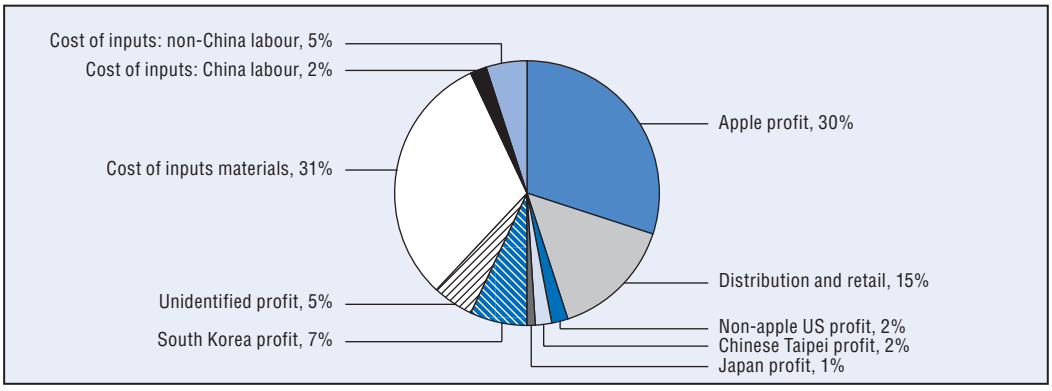


Source: OECD/WTO (2013b), OECD-WTO: Statistics on Trade in Value Added, (database).
doi: http://dx.doi.org/10.1787/data-00648-en.

What kinds of activities create high value in GVCs?

Case studies of specific value chains have shown that value creation by a GVC is distributed unevenly across activities. According to recent estimates by Kraemer et al. (2011), about 30% of the sales price (USD 499) of a 16GB, Wi-Fi only iPad is captured by Apple, 15% is attributed to the distribution and retail margin (part of which is also captured by Apple as the iPad is mainly distributed through Apple stores). About 7% is rewarded as gross profits to the Korean firms that provide the display and memory chips, and 1-2% of the sales price reverts to firms from Japan and Chinese Taipei (Figure 5.3). As in the case of the iPod and iPhone (Dedrick et al., 2010; OECD, forthcoming), final assembly in China accounts for only about 2% of the total value of an iPad.

Figure 5.3. The distribution of the unit sales value of an iPad (USD 499)



Source: Kraemer et al. (2011), "Who captures value in the Apple iPad and iPhone?", Personal Computing Industry Center (PCIC), University of California, Irvine.

The highest level of value creation in a GVC is often found in upstream activities such as new concept development, R&D or the manufacture of key parts and components and in downstream activities such as marketing, branding or customer service. These activities involve tacit, non-codified knowledge in areas such as original design and the creation and management of cutting-edge technology and complex systems. Such activities define the extent to which the final product can be differentiated in consumer markets and thus determine the total value the GVC can create. The tacit properties of these activities make them difficult to imitate or reproduce. Instead, activities characterised by well-established standards and high modularity, such as final assembly of electronics machinery, can be performed by many competing firms. Thus, the ability of a firm or an economy to create value in GVCs depends significantly on the kinds of GVC activity in which it has a competitive advantage.

The value a firm creates in a GVC depends crucially on the barriers to entry for firms supplying similar or substitutable products or services (Kaplinski and Morris, 2002). When barriers to entry are low, a firm that provides specific inputs to a GVC can easily be replaced by rivals. This weakens its position in the GVC and depresses the value added it can derive. Barriers to entry stem naturally from the tacit nature of certain activities and from exceptional capabilities, such as creativity or strong technological competencies, to undertake certain tasks. Sometimes, barriers to entry are due to institutional factors, such as government regulation of market entry or strong intellectual property rights (IPR) protection. To protect the value added of their activities, firms have incentives to increase barriers to entry by making their products or services difficult to replace. For instance, Dedrick et al. (2010) argue that Apple's significantly higher profitability as compared to Hewlett-Packard (with operating profits as a share of sales of 12% and 4%, respectively, in 2005) was partly due to Apple's introduction of original design and functions in its portable electronic products whereas Hewlett-Packard's notebook PCs were based on established designs and specifications.

Firms also enjoy high value added when they can provide inputs that are indispensable and non-substitutable in the whole GVC. Such firms can be described as the "bottleneck" of the GVC (Jacobides et al., 2006). Example of such bottlenecks are the so-called "hidden champions" (Simon, 2009): firms that capture high shares of the world market in specific products (Table 5.1). Hidden champions usually have state-of-the-art technology and superior product quality in niche products, both of which rivals find very hard to match.

Table 5.1. Examples of "hidden champions"

Company	Main Product	World Share
Dr.Suwelack	Collagen	100%
Skysails	Towing kite wind propulsion system	100%
Ulvac	LCD Panel coating	96%
Nivarox	Regulating mechanism for wristwatch	90%
GKD-Gebr.Kufferath	Metal Fabrics	90%
Saes Getters	Barium getters	85%
alki-Technik	Special screw systems	80%
Delo	Adhesives for chip modules on smart cards	80%
Nissha	Small touch panel	80%
Kern-Liebers	Springs for safety belts	80%
Weckerie	Lipstick machines	80%
Omicron	Tunnel-grid/tunnel probe microscopes	70%

Source: Simon (2009), *Hidden Champions of the 21st Century*, Springer Publishing.

A bottleneck firm enjoys the fruits of other GVC participants' innovations through increased demand for their products or services. For example, about Japanese firms producing highly specialised components, McKinsey (2010a) noted:

> In 30 different technology sectors with revenues of more than USD 1 billion, Japanese companies control 70% or more of global market share. They have done so by creating an array of "choke point" technologies on which much larger industries depend. Mabuchi Motor, for instance, makes 90% of the micro motors used to adjust car mirrors worldwide. Nidec makes 75% of the world's hard-disk drives. Japanese companies own nearly 100% of the global market for the substrates and bonding chemicals used in microprocessors and other integrated circuits.

Those Japanese firms have benefited from innovation and growth in various industries that depend on their components. Whether or not firms in a GVC capture significant value from their innovation depends on the availability of complementary inputs (Teece, 1986). If these are held by a "bottleneck" firm instead of a variety of competing firms, the bottleneck firm can capture a good portion of the value due to such innovation. However, bottleneck firms may lose their advantageous positions in GVCs if further innovations reduce other firms' dependency on the components they supply.

Service activities can also become bottlenecks in GVCs. Network industries, with strong positive feedback loops between competitiveness and the size of demand, are a good example. Providers of dominant systems such as Microsoft, Nintendo or Apple are bottleneck firms. They supply the infrastructure on which other GVC participants (e.g. programme developers) base their value creation. In the late 1980s, when Nintendo attracted many users in the US market, game developers wrote games for Nintendo Entertainment System (NES), thereby making the system even more popular. Because providing their games on NES rather than on rival systems increased demand for their games, these developers not only paid royalties to Nintendo but even promised not to make their games available on other systems for two years following release (Lev, 2001). A more general case of a service bottleneck is branding. In most industries, only a few firms successfully build recognised brands, and these tend to capture a large share of the value added generated by the GVC when they are a final product of a GVC (Gereffi, 1999).

A firm's position as a bottleneck is strategic and dynamic. As firms seek to enhance the barriers to entry in their GVC activity by adding originality and complexity to their products or services, they also try to enhance competition in the upstream or downstream activities that produce complementary inputs. By managing the industry's architecture so as to enjoy a quasi-monopolistic position in its own activity, while sourcing complementary inputs from many competing agents, a firm captures the value of its own innovation as well as that created by its suppliers and buyers (Jacobides et al., 2006). For instance, lead firms in electronics GVCs have deployed standards not only to enhance knowledge transfer to their suppliers, but also to lower the barriers to entry in the corresponding segment of the GVC and increase competition among suppliers (Shapiro and Varian, 1999).

Upgrading in GVC activities

Upgrading of GVC activities occurs when firms become able to supply products or services that are more difficult to reproduce. Although upgrading is closely related to innovation, it needs to go beyond incremental innovation that can be easily duplicated. Since firms compete constantly for higher value-added GVC activities, upgrading is a competitive process requiring successful innovation relative to rivals (Kaplinski and Morris, 2002).[1] The higher value added achieved through upgrading is rarely lasting because of rivals' catch-up efforts. When there is no longer much room for upgrading in some segments of a GVC, because all participants have similar capabilities, firms have incentives to shift their efforts to other segments of a GVC (or to other GVCs) with more tacit components and thus with room for upgrading.

Four types of upgrading of GVC activities have been identified (Kaplinsky and Morris, 2002):

- *Process upgrading* is achieved when firms can process tasks with significantly higher efficiency, lower defect rates and for more complex orders than rivals. For example, Hon Hai Precision, the world's largest original equipment manufacturer (OEM), is renowned for its ability to carry out large-scale production subject to short deadlines and highly specific requirements from major electronics brands such as Apple, Dell, Samsung and Sony.
- *Product upgrading* is achieved when firms can supply higher value-added products than rivals through superior technological sophistication and quality. It also involves the ability to introduce novel products faster than rivals. Examples include the "hidden champions" mentioned above, ASUSTek, an inventor of netbooks that captured demand for low-cost and easy-to-use portable PCs (Kawakami, 2012), or Toyota, which introduced the first mass-produced hybrid vehicle, the Prius.
- *Functional upgrading* is achieved when firms can provide competitive products or services in new segments of a GVC that are associated with higher value added. For firms previously specialised in production, this means becoming competitive in upstream or downstream activities such as design or marketing. For example, Lenovo acquired sophisticated R&D capability and the widely recognised ThinkPad brand through its acquisition of IBM's PC branch, while IBM upgraded its activity from PC manufacturer to technology and consultation services. Li and Fung, a consumer goods intermediary based in Hong Kong (China) upgraded its function as a supply chain management firm by acquiring product development, marketing and branding functions.
- *Chain upgrading* is achieved when firms are able to participate in, or switch their activities to, new GVCs that produce higher-value-added products or services. Such capabilities include managerial talent, referred to as "dynamic capabilities" (Teece et al., 1997), able to identify potential opportunities and threats and reconfigure a firm's tangible and intangible resources in a timely manner. In a recent example, Samsung, the world's largest semiconductor producer, decided to invest USD 20 billion over ten years in new industries such as solar panels, light-emitting diodes (LEDs) and electric-car batteries. Nestlé, the food industry giant, has invested intensively in health-oriented processed food associated with higher profit margins and larger room for disruptive innovation than conventional packaged foods (*The Economist*, 2009, 2011a).

Based on his observations of upgrading in the apparel value chain in Asian economies, Gereffi (1999) suggested that an upgrading trajectory starts from process upgrading (Table 5.2). Process upgrading is often considered the earliest stage of upgrading, as it is based on learning by doing. As firms build up technological capabilities, they become competitive in more sophisticated products (product upgrading). Functional upgrading is achieved as firms increase their capability for designing new products or establishing their own brand. Finally, chain upgrading occurs when firms possess sufficient technological background and business know-how to expand their activities to new and more profitable industries.

It is worth noting that upgrading is not always about "moving up the value chain" into higher-value-added segments (functional upgrading).[2] It is also about deepening capabilities to explore new and original features and varieties in each segment of the value chain (process and product upgrading); this requires substantial technological capability and skill (Pietrobelli and Rabellotti, 2011). Functional upgrading also feeds back into process and product upgrading since sophisticated R&D, design or competent marketing allow firms to enhance the efficiency of production processes and introduce successful new products. For example, electronics manufacturing firms in Chinese Taipei upgraded their functions from OEM to original design manufacturing (ODM) when they started to provide pre-production services in R&D and design. This functional upgrading allowed them to engage in product upgrading such as the invention of netbooks and a range of quality improvements in own-brand notebook PCs such as ASUS and ACER (Sturgeon and Kawakami, 2010; Kawakami, 2012).

Table 5.2. Upgrading of GVC activity

Upgrading Path by Gereffi (1999)

		Examples
Chain Upgrading	Participating in or shifting the locus of activitiy to other GVCs rewarding higher value-added	Samsung (From flat panel TV to semiconductor to solar cell), Nestle (from foodstuffs to functional food)
Functional Upgrading	Establishing competitiveness in higher value-added GVC activities through acquisition of new capabilities (ex: from production to R&D)	Lenovo (acquisition of IBM's R&D capability and brand), IBM (from PC manufacturing to Technology consulting), Li and Fung (from intermediary to supply chain organiser)
Product Upgrading	Supplying technologically sophisiticated and higher quality products than rivals. Introducing novel products or improving old products faster than rivals.	"Hidden Champions", ASUSTek (inventor of netbook), Toyota (introduction of the first mass-produced hybrid car)
Process Upgrading	Improving efficiency and productivity significantly faster than rivals and developing ability to process complex orders.	Hon Hai Precision Industry (world's largest OEM firm)

Source: Interpretation based on Kaplinski and Morris (2002), "A Handbook for Value Chain Research", retrieved from Institute of Development Studies, www.ids.ac.uk/ids/global/pdfs/VchNov01.pdf.

Integration into GVC does not guarantee upgrading

Integration in a GVC does not guarantee that a firm or an economy will be able to upgrade. The feasibility of functional and chain upgrading is determined by the way GVC activities are co-ordinated by lead firms. They may be co-ordinated in a decentralised way, e.g. through market transactions, or through vertical integration. In the latter case, functional upgrading is feasible only if lead firms are willing to transfer some functions to suppliers. Therefore, upgrading requires firms not only to develop new capabilities but also to be able to change relationships with buyers and markets (Humphrey, 2004). That is, firms must move from a hierarchical relationship with lead firms to a relationship in which they are free to use their competitiveness in newly acquired functions.

The co-ordination of GVCs is affected by the complexity of transactions, the "codifiability" of product information, and the availability of suppliers with sufficient capabilities (Gereffi et al., 2005). Transactions between a lead firm and its suppliers can be complex if they involve highly specific products or just-in-time supply of small batches, and often involve long-term relations with specific suppliers rather than simple market transactions. They may be less complex if lead firms rely on well-defined standards and modularised product design that codify important information on product details. In such cases, market-type transactions involving "full-package" suppliers such as OEMs are feasible, but only if the suppliers are able to process complex tasks. As many firms from developing economies participate in GVCs, they may have difficulty meeting requirements and standards that do not exist in their domestic market. GVC co-ordination then becomes a relational one involving technology transfer and other assistance to enhance suppliers' capabilities. However, these suppliers are often locked into exclusive transactions with specific lead firms and upgrading is confined to the kinds that result in more cost-competitive and higher-quality components. As a result, while such suppliers quickly improve their manufacturing skills when they operate in the value chain of global buyers, they are often unable to upgrade to the highest value-added functions (Navas-Alman, 2011).

In a hierarchical GVC, with suppliers integrated as subsidiaries of lead firms or in a captive relationship, knowledge transfer from lead firms may involve tacit information gained through the exchange of personnel. Co-ordination of GVCs through market transactions allows more room for functional upgrading but knowledge transfer may be limited to codifiable information (such as production standards). Here, the challenge for suppliers seeking to move into higher value-added segments of GVCs is to build stronger capabilities autonomously and to shape a less restrictive relationship with lead firms. An innovation system that supports absorption of new knowledge acquired through participation in GVCs plays an important role (Pietrobelli and Rabellotti, 2011). When suppliers possess strong capabilities in activities that determine the total value created by the GVC, the lead firm is induced to form a mutually dependent rather than a hierarchical relationship with them. This does not however hinder suppliers from developing new capabilities. A good example is the relationship between Apple and Samsung: the latter not only provides core inputs that represent 26% of the component cost of iPhone (*The Economist*, 2011b) but also competes fiercely with Apple in smartphone and tablet computer markets.

Box 5.1. China's upgrading in GVCs

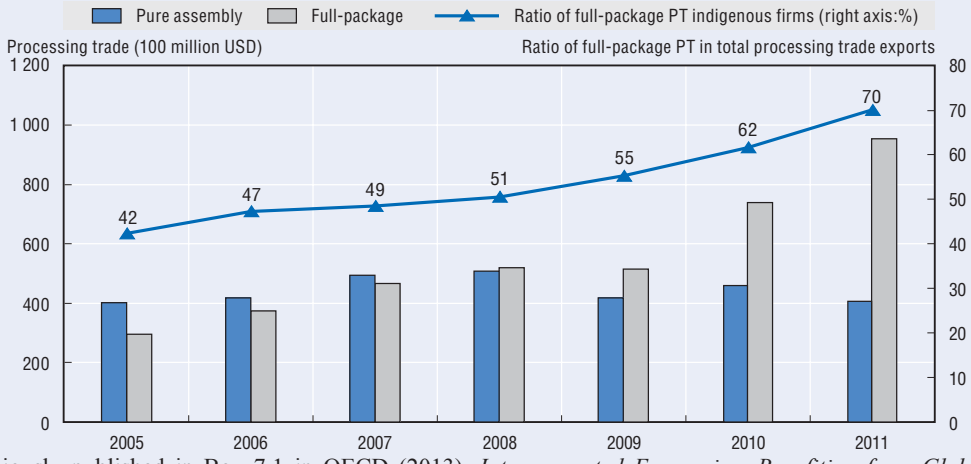
China's integration into GVCs has been essential to its emergence as the world's largest exporter. About half of China's exports between 1990 and 2010 concerned processing trade under a trade regime allowing the duty-free imports of intermediate inputs solely for the production of final goods for third markets. Hosting the production of multinational enterprises (MNEs) enabled China to tap into cutting-edge technology that was not available in domestic markets (Breznitz and Murphree, 2011). Processing trade also raised the skill intensity of China's exports and resulted in a pattern of export content similar to that of OECD economies (Amiti and Freund, 2010; Xu and Lu, 2009). China increased its share in world exports in high-technology industries such as computers as well as in mid- to low-technology industries such as textiles. The unit values of China's exported products have grown the most in industries importing intermediate goods with high unit values, suggesting that imports of higher-quality intermediate goods enabled China to upgrade the quality of its exported goods (OECD, 2011a).

However, China's competitiveness within GVCs is still concentrated in processing and assembling, which only generates limited value added. Koopman et al. (2008) estimated that the share of domestic value added created by China's total exports was about 50% (for processing trade exports this share was less than 20%). For China, upgrading into higher value-added activities in GVCs has been an important policy issue. A range of evidence suggests that China's upgrading is indeed on its way

Process upgrading

While China's processing trade is mostly done by foreign-invested enterprises (FIEs), the part due to Chinese firms is shifting from simple contract assembly to "full-package" manufacturing in which Chinese firms control processes from material procurement to product design. Figure 5.4 shows that until recently the majority of processing trade by Chinese firms consisted of simple assembly contracts for which material, equipment or product blueprints were transferred by foreign firms, but that Chinese firms now import parts and components themselves and decide on the quantity, price and specification of products to be exported to foreign firms. This upgrading into more autonomous multi-functional service providers such as OEMs or ODMs has also occurred in other Asian economies and is an important early stage of GVC upgrading.

Figure 5.4. The composition of processing trade by domestic Chinese firms



Source: Previously published in Box 7.1 in OECD (2013), *Interconnected Economies: Benefiting from Global Value Chains*, OECD Publishing. DOI: http://dx.doi.org/10.1787/9789264189560-en.

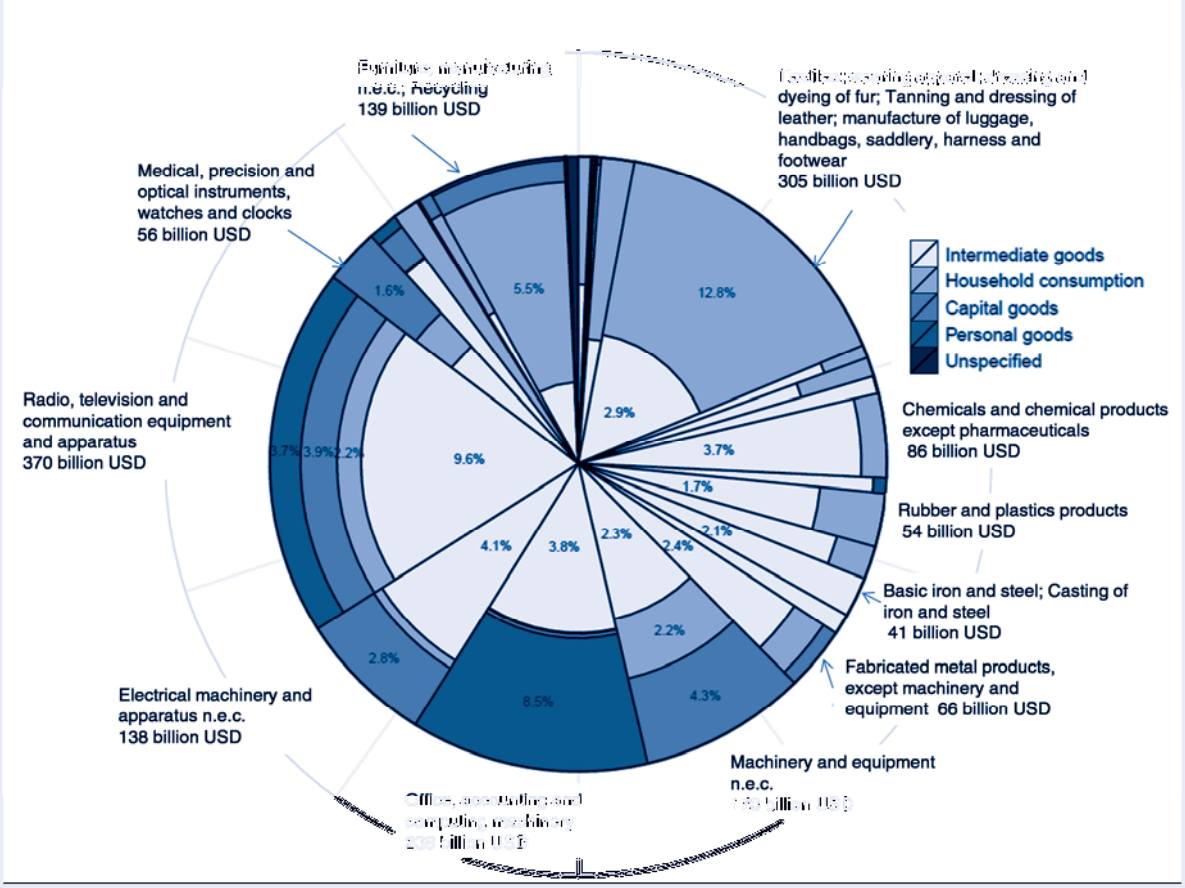
Functional upgrading: From assembler to parts provider

China has increased its share of world exports not only in final products but also in parts and components. Between 1995 and 2007, its share in world exports of parts and components increased by 9.2%, while those of the United States and Japan dropped by 6.3% and 7.1%, respectively. The recently developed STAN Bilateral Trade Database by Industry and End-use classifies trade flows by end-use categories such as capital goods, intermediate inputs and household consumption. Figure 5.5 illustrates the composition of China's manufacturing exports in 2010. A substantial portion of China's exports in radio, television and communication equipment, electronic machinery and office, accounting and computing machinery involves intermediate goods, indicating that China has become a key supplier of parts and components.

…/…

Box 5.1. China's upgrading in GVCs (*continued*)

Figure 5.5. China's exports by end-use, 2010



Source: OECD STAN Bilateral Trade Database by Industry and End-use.

A new role in the knowledge-intensive segments of GVCs?

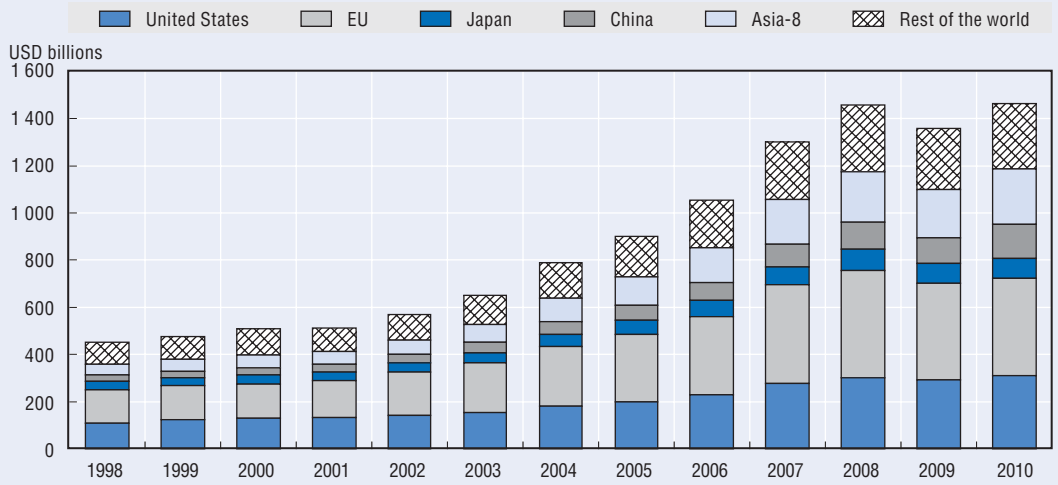
Several factors suggest that China is assuming a larger role in upstream activities of GVCs. For instance, in absolute (purchasing power parity [PPP]) terms, China is now the world's second largest spender on R&D after the United States (OECD, 2011b). The business sector's investments in R&D accounted for 73% of China's R&D in 2009. The number of triadic patents[1] held by Chinese residents also increased at an average annual rate of 29% between 1999 and 2009. However, Chinese firms' patents, especially in the United States, are highly concentrated in a handful of strongly export-oriented firms in computer, communication and consumer electronics industries, such as Foxconn, Huawei and ZTE (Eberhardt et al., 2011).

China's functional upgrading can also be inferred from the expansion of exports of commercial knowledge-intensive services (business, financial and communication services) that are important to GVCs' upstream and downstream activities. Figure 5.6 shows that while the United States and European Union economies still account for half of such exports at the global level, China had increased its share to nearly 10% of the world total by 2010.

…/…

Box 5.1. China's upgrading in GVCs (*continued*)

Figure 5.6. World exports of commercial knowledge-intensive services (USD billion)



Note: Asia-8 includes India, Indonesia, Malaysia, Philippines, Singapore, Korea, Chinese Taipei, and Thailand. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta and Slovenia. China includes Hong Kong.

Note by Turkey: The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the "Cyprus issue".

Note by all the European Union Member States of the OECD and the European Union: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

Source: Previously published in Box 7.1 in OECD (2013), *Interconnected Economies: Benefiting from Global Value Chains*, OECD Publishing. DOI: http://dx.doi.org/10.1787/9789264189560-en.

China's future upgrading

China's upgrading may differ from that of other Asian emerging economies in several ways. First, China has a large and fast-growing domestic market so that Chinese firms can upgrade GVC activities in domestic markets. Having absorbed advanced knowledge from foreign MNEs, Chinese firms can apply this knowledge to develop new capabilities and products for the domestic market. Acquisition of new capabilities, in turn, enables functional upgrading in GVCs. Second, unlike Japan and Korea, which fostered domestic technological capabilities under restrictive policy on foreign direct investment (FDI), China leveraged its large market to attract foreign investments embodying the latest technology and developed a rigorous import, absorption and innovation cycle. This strategy enabled Chinese firms to improve their capabilities drastically and keep up with the global technological frontier (Breznitz and Murphree, 2011). Knowledge spillovers from FIEs therefore contribute not only to production but also to the innovation capability of domestic firms (Ito et al., 2011). Competition and collaboration with FIEs are likely to remain important drivers of China's upgrading, as FIEs seeking further penetration of China's market are expected to localise wider segments of GVCs for the sake of cost competitiveness (Brandt and Thun, 2010). Third, fierce competition in the domestic market between FIEs and domestic firms gives Chinese firms strong incentives to invest in technology and other forms of KBC. Given the cumulative nature of KBC, stocks rather than flows of KBC investments will define China's future upgrading. However, these investments are concentrated in state-owned-enterprises (SOEs) and other state-controlled enterprises, which accounted for about 45% of R&D expenditure, 44% of expenditure on new product development and 70% of expenditure on technology renovation in China's business sector in 2009 (OECD, 2012a). State-affiliated enterprises also dominate China's outward FDI, which potentially plays an important role in acquiring foreign KBC. While this concentration may be partly due to strong pre-existing capabilities (Zhang et al., 2010), it may make China's upgrading less efficient by preventing a profit-oriented deployment of KBC.

1. Patents filed at the EPO and at the Japan Patent Office (JPO) and granted by the United States Patent and Trademark Office (USPTO), protecting the same invention.

How does KBC support upgrading in GVCs?

What is knowledge-based capital?

Knowledge-based capital is a stock of non-physical and non-financial capital, the creation of which entails foregoing consumption today in return for a higher level of production and consumption in the future (Lev, 2001). Corrado et al. (2005) group KBC into three main categories:

- *Computerised information*: software and databases
- *Innovative property*: science and engineering R&D, non-science innovation efforts such as product design, copyrights and trademarks.
- *Economic competencies*: brand equity, firm-specific technological and managerial skills, networks, organisational structure.

Investments in KBC differ from investments in physical capital in the following ways (OECD, 2012b):

- *Lack of visibility*: KBC lacks physical embodiment, which complicates the task of assessing the stock of KBC based on past investment flows.
- *Non-rivalry*: Many forms of KBC can be used simultaneously by many users without engendering scarcity or diminishing their basic usefulness, as in the case of software or new product designs.
- *Partial excludability*: Owing in part to their virtual nature, the property rights to many types of KBC cannot be as clearly defined and enforced as they can for tangibles. Insofar as they cannot preclude others from partly enjoying the benefits of these assets, owners do not have full control over them and may fail fully to appropriate the returns on their investment.
- *Uncertainty and perceptions of risks*: KBC investment occurs throughout the innovation process, but particularly in the stages of basic research, invention and experimentation where sunk costs can be large and failure is frequent (Lev, 2001).

KBC is comprised of various kinds of intangible assets with different characteristics, and the general observations listed above do not apply to all. For instance, firm-specific skills are often embodied in employees who cannot be deployed in several places at the same time.

Table 5.3 lists the types of KBC that are especially relevant for upgrading of GVC activities, the types of expenditure involved and the associated stocks of competency.

Table 5.3. Classification of knowledge-based capital and generated value

Knowledge-based capital	Type of investments (expenditure)	Stock of competencies (resource)
Computerised information		
Computer software	In-house development or acquisition of software	Computerised process, information and knowledge management system
Computerised database	In-house development or acquisition of database	Dataset assisting corporate strategy including new product development, marketing
Innovative property		
Scientific R&D	Science and engineering research (measured by in-house or outsourced R&D in manufacturing and selected industries)	Knowledge and intellectual property rights (IPR) leading to new or higher-quality products and production processes (see Box 7.2 for a discussion of innovative property in the pharmaceutical value chain)
Creative property	Development of entertainment or artistic originals (measured by non-scientific R&D: development cost in entertainment and book publishing industries)	Knowledge and IPR leading to sophisticated artistic and cultural creation
Design	Physical appearance, quality and ease of use of products and workspace layout (measured by outsourced architectural and engineering designs, R&D spending in social science and humanities)	Knowledge and IPR leading to better commercial appeal, product differentiation, improved efficiency
Economic competencies		
Brand equity	Spending on advertising and market research (measured by outsourced advertising and market research)	Reputation, image, customer recognition and relationship
Firm-specific human capital	On-the-job training, tuition payment for job-related education	Firm-specific and tacit manufacturing, processing and managerial skill
Organisational structure	Spending on organisational change (measured by outsourced management consulting services, etc.)	Flexible and competitive business organisation, network with other firms, universities, government, etc.

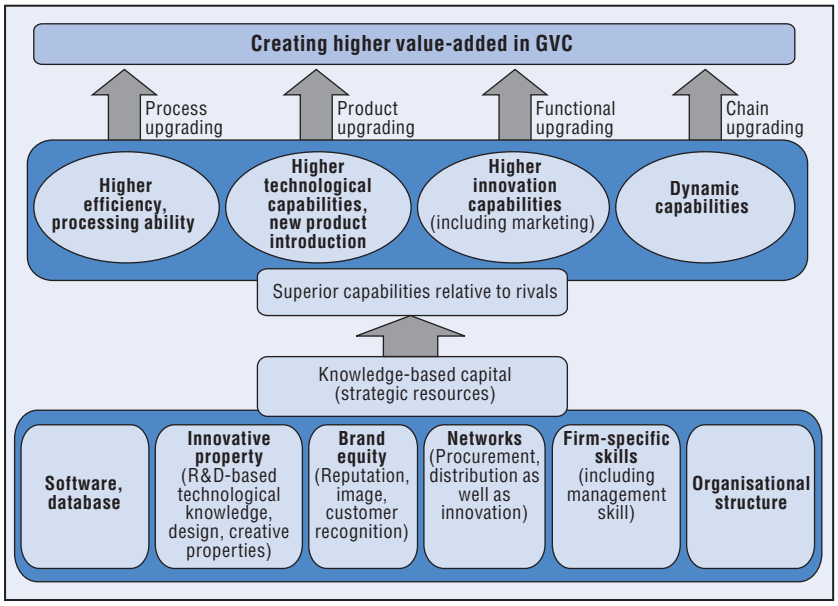
Source: previously published as Table 7.1 in OECD (2013), *Interconnected Economies: Benefiting from Global Value Chains*, OECD Publishing. DOI: http://dx.doi.org/10.1787/9789264189560-en.

KBC as a resource for upgrading GVC activities

How then do firms acquire capabilities that are superior to those of rivals? This study argues that such capabilities are related to firms' KBC. A time-honoured view in strategic management, often referred to as the "resource-based view", is that firms' competitive advantages differ, even within a narrowly defined industry, owing to firm-specific "resources" which are often intangible, non-tradable and difficult to replicate (Wernerfelt, 1984; Dierickx and Cool, 1989; Barney, 1991). A firm's ability to sustain performance that is superior to that of its rivals is determined by resources associated with the following characteristics (Barney, 1991): they must be valuable, that is, they effectively exploit opportunities or neutralise risks under current market and technology conditions; they must be rare; they must be difficult to replicate, otherwise even valuable and rare resources can be reproduced by rivals, in which case the advantage cannot be sustained; finally, they cannot be replaced by other resources that create strategically equivalent value and are neither rare nor hard to replicate. A resource's relevance in a given economic context, its relative scarcity and its non-substitutable nature are often shaped by factors exogenous to firms, such as diffusion of new technology or regulatory change. The difficulty of replicating a resource, however, can be strategically enhanced by firms.

Firm-specific resources are thought of as the "feedstock" of capabilities (Hall, 1993; Hoops and Madsen, 2008). That is, a firm's superior capabilities *vis-à-vis* rivals are embedded in its resources (Teece, 2010). In line with these theories of strategic management, KBC can be viewed as the set of resources that support a firm's upgrading of GVC activities. Figure 5.7 illustrates this relationship between KBC, capabilities and upgrading. The upper circle contains the core capabilities a firm must acquire for the four types of upgrading classified by Gereffi (1999). The lower circle covers the firm-specific resources in which those capabilities are embedded.[3] A firm's ability to create larger value-added in GVCs depends on its capabilities, as defined by its strategic resources, compared to those of its rivals.

Figure 5.7. A resource-based view of GVC upgrading



For instance, a firm's creation of value through superior productivity and processing capabilities (process upgrading) is supported by its computerised information, which enables it to manage production efficiently and more accurately. Process upgrading also relies on innovative property, such as know-how in designing efficient production lines, as well as economic competencies, such as competitive procurement networks. These several kinds of KBC contribute to superior process capabilities in integrated, complementary ways. For instance, Procter & Gamble uses computerised information such as modelling and simulation programmes to design efficient factory and production line layouts (Siemens, 2011).

Product upgrading is also supported by computerised information: computer-aided-design (CAD) software can enhance design capability and large, detailed databases on customer preferences or product sales can help firms to develop new products or services to capture customers' unmet needs. Large retail firms such as Amazon, Tesco or Zara leverage their supply chain network to collect data on consumer preferences. They exploit these databases (which are not available to rivals) to assess consumers' needs and introduce new products faster than rivals (McKinsey, 2010b). Product upgrading is also supported by innovative property, as state-of-the-art technology can raise quality and add more sophisticated functions. Sophisticated design also plays an important role, especially in industries in which technology is mature or firms compete on the basis of similar technology (the furniture industry is an example. See also Box 5.2 for the role of design in capturing value in the textile value chain).

Box 5.2. The role of design in the textile value chain

Design is increasingly recognised as a form of KBC that can shape a firm's competitive advantage. It is not only an essential input for new product development, along with R&D and marketing (Hertenstein et al., 2005). It can also help to create a firm's competitive edge by strengthening emotional connections with customers and establishing corporate identity and brand (Kotler and Rath, 1984; Noble and Kumar, 2008). It can be a source of product differentiation and allow firms to move away from cost-based competition. Design is acknowledged to have enabled Sony to charge 25% more than its competitors for the Walkman (Czarnitzki and Thorwarth, 2009). Good design also contributes to the formation of brand equity: for some products, brand and design are non-separable. Design can also make a significant contribution to corporate performance and innovation. Expenditure on design is positively linked to UK firms' productivity growth (Cereda et al., 2005) and to Dutch firms' sales of new products (Marsili and Salter, 2006). Incorporating design into the early stage of new product development also improves financial performance (Gemser et al., 2011).

Design can determine how value added is distributed among participants in a GVC. Vervaeke and Lefevre (2002) study the textile industry in the Nord-Pas de Calais region of France, an area long known for textile design. Until the 1960s textile design was carried out as a sub-function of the engineering section of manufacturing firms. Designs were created by mostly anonymous in-house designers or purchased from drawing shops in Paris and further developed by in-house designers. With the beginning of mass production, manufacturers established specialised design sections: stylists defined the trends for collection and draughtsmen/women made up the patterns and worked out the designs. This allowed manufacturers to establish their brands and increase value added through new product development.

However, since the mid-1990s, distributors such as chain stores, supermarkets and mail-order firms have developed their own design capabilities and brand strategy. By leveraging their access to consumers, they started to control product design by setting style-related specifications. As a result, many manufacturers lost their design capability and became subcontractors. Although they still engage in the intermediate stages between design and manufacturing, such as the production of prototypes, the value added related to product development has substantially shifted from manufacturers to distributors. Some manufacturers have maintained their own collections and mostly specialise in top-end products under registered trademarks. While this strategy has enabled them to profit from their investments in design, it is conditional on broad capabilities in design, production of top-end products and marketing.

Functional upgrading requires strong capabilities in non-production activities in the upstream and far-downstream segments of GVCs such as new concept development, basic R&D, product design, branding and marketing. These capabilities are part of a firm's innovation capability in that successful commercialisation of new ideas is as important as cutting-edge technology for successful innovation (Corrado and Hulten, 2010). Apple created value added by upgrading from electronics manufacturer to innovator and retailer on the basis of core technology, good product design, favourable brand image and the i-store network. Economic competencies such as good marketing skills, distribution networks and recognised brands also play an important role in introducing innovations into the market as new products. Collaboration networks are also crucial for firms specialised in R&D in the high-technology value chain (e.g. the pharmaceutical industry, discussed below in Box 5.3).

Box 5.3. The role of scientific knowledge and networks in the pharmaceuticals value chain

The pharmaceutical industry is a competitive, globalised and innovation-driven industry characterised by extensive co-operation and competition between large and small companies. The pharmaceuticals value chain activities range from exploration of new drugs, to testing and approval processes, to production, marketing and distribution. Biotechnology firms increasingly carry out upstream activities such as basic research and acquisition of patents for new discoveries. These are often spin-offs from university or other research institutions and conduct focused research. Traditional pharmaceutical companies, or "big pharma", take on the commercialisation stage of new discoveries as own-brand new drugs. That is, they identify promising new discoveries and take them through testing and approval by national authorities such as the US Food and Drug Administration (FDA). They acquire patents and commercialise the drug through their global sales and marketing network. Generic drug companies, another key player in the industry, usually do not conduct their own R&D but produce drugs that have the same active ingredients as the brand-name drugs once patents have expired. They supply such generic drugs at lower prices than the original drugs and thereby address the needs of health-care organisations seeking to lower medical costs. Therefore, biotechnology firms, big pharma and generic drug companies engage in different types of competition: biotechnology firms compete on addressing unsolved problems and providing innovative solutions; big pharma competes on identifying market potential and relevant discoveries and then quickly building systems to commercialise the new technology; generic firms compete on cost efficiency in production based on established technology.

Haanes and Fjeldstad (2000) discuss the kinds of KBC that support the competitive advantage of these players in the pharmaceutical value chain. The competitive advantage of biotechnology firms depends on advanced technological knowledge. This is accumulated not only through basic research but also through formal and informal R&D collaboration with universities, other biotechnology firms and other actors with relevant technological competencies. A rich research network is a crucial form of KBC for successful biotechnology firms. Big pharma's superior capabilities for identifying commercially promising breakthroughs stem from forms of KBC that include knowledge of the latest technologies and market environments, networks of biotechnology firms and other actors that produce novel solutions, and reputation as a reliable collaborator. Its ability to commercialise breakthroughs swiftly is supported by its knowledge of laboratory testing and regulatory approval procedures. Finally, large customer networks and recognised brand names are important for marketing drugs globally. Generic drug companies thrive on cost competitiveness and possess KBC such as efficient procurement networks that reduce material costs and a wide network of customers.

Biotechnology firms that discover or invent and pharmaceutical companies that commercialise innovations are expected to create more value added than generic drug companies. Indian pharmaceutical firms such as Ranbaxy or Dr Reddy's first entered GVCs as cheap suppliers of generic drugs in the Indian market, then upgraded to become generic drug suppliers to advanced economies. More recently, they have become pharmaceutical firms with capabilities for inventing and developing patented drugs. Bower and Sulej (2005) argue that this upgrading by Indian firms has been supported by advanced technological knowledge obtained through research alliances and joint ventures with firms from advanced economies and by a wide array of business-related skills and distribution networks obtained through the acquisition of western firms.

Chain upgrading requires capabilities in what is perhaps the hardest type of KBC to replicate: superior managerial skills and flexible organisational structures. Successful firms often respond rapidly to potential opportunities or threats. They also have an exceptional ability to co-ordinate and reconfigure their tangible and intangible assets to shift core competencies to new areas. According to Bernard et al. (2006), when US manufacturing firms are exposed to imports from low-income countries, they tend to switch to industries with higher capital, higher skill intensity and lower import exposure. These dynamic capabilities (Teece et al., 1997) are shaped by firm-specific management skills and flexible organisational structures.

The difficulty of replicating KBC determines the value of upgrading

The difficulty of replicating specific types of KBC can be viewed as a barrier to entry for GVC activities that use these types of KBC intensively. Therefore, for a firm to enjoy sustainable value added from upgrading, it must be based on KBC that is hard to replicate. The concept of KBC advanced by Corrado et al. (2005) includes various intangible assets with different degrees of replicability. Even in the same category (i.e. computerised information, innovative property, or economic competencies) replicability of KBC will differ depending on the degree of firm specificity and sophistication. The replication of different types of KBC is generally expected to be harder when it has the following characteristics:

Firm-specificity and non-tradability: Some types of KBC are inseparable from other firm characteristics. These forms of KBC therefore cannot be acquired easily through market transactions and have to be built in-house through strategic expenditure over a period of time.

Time lags: It is difficult to replicate KBC that has been built up through flows of investment over time. Latecomers will incur disproportionately large costs if they seek to build a certain level of KBC quickly. Also, if KBC provides increasing returns to scale, latecomers will be at a disadvantage for accumulating new knowledge with a given level of investments, compared to firms with larger initial KBC stocks (Dierickx and Cool, 1989).

Causal ambiguity: The link between KBC and competitive advantage can be ambiguous, so that rivals have difficulty identifying which types of KBC to replicate in order to catch up. The ambiguity is greater if the KBC is a highly tacit stock of knowledge, the complex integration of several different kinds of KBC, or is highly firm- or relationship-specific (Reed and Defilippi, 1990).

Path dependency: Certain types of KBC, such as state-of-the-art technology or organisational structure, reflect firms' unique history of technology investment choices, entrepreneurial efforts and successes or failures that are extremely difficult to replicate (Barney, 1991).

Computerised information (software, databases) that is readily available in markets is easily replicable. However, the data on customers and product sales that firms gather for marketing and new product development are protected as a valuable corporate secret. Exploiting these data also requires investments in new capabilities and organisational change and therefore takes time. The data will therefore not be replicable until the technology and skill needed to capture and analyse such data become generic. Moreover, computerised information is often integrated with a firm's organisational structure and is therefore firm-specific. As a result, rivals cannot acquire comparable capabilities simply by replicating computerised information. For example, the combination of ICT and organisational capital contributes more to a firm's productivity growth than investment in only one of these (Brynjolfsson et al., 2002).

In general, innovative property is expected to be replicable if it is well codified as standards or as well-defined routines. For instance, management know-how regarding production costs and quality is often transferred to suppliers (Javorcik, 2004). Innovative property is harder to replicate if it contains highly complex and abstract knowledge or is embodied in specific employees or in corporate systems as tacit knowledge. Some state-of-the-art technology can be embodied in factory workers as tacit knowledge that would require lengthy training to transfer. Such tacit components blur the scope of KBC that rivals must replicate to catch up, thereby increasing causal ambiguity. Firms facing high

risk of imitation by rivals have incentives to increase the share of tacit knowledge and non-codified know-how in their production process (Thoning and Verdier, 2003). Innovative property can also be highly path-dependent. For example, a long tradition of sophisticated design enables Italian firms from the Lombardy region to act as world leaders in their industrial segments (Czarnitzki and Thorwarth, 2009).

The replication of innovative property also depends on rivals' absorptive capacity. To reproduce successfully leaders' technology or design, a firm must be able to digest advanced knowledge and apply it to innovative ends. This depends on its stock of R&D investments and other innovative efforts, that is, on its own innovative property (Cohen and Levinthal, 1989). This implies that firms with a large stock of innovative property are better able to learn and build on the latest knowledge. Because of these characteristics, tacit and sophisticated innovative property has long time lags and first-mover advantages.

Many forms of KBC categorised as economic competencies possess the four characteristics described above. For instance, a firm's brand equity – its reputation or image – is built through flows of strategic expenditure and accumulated expertise. Because it is cumulative and path-dependent it is hard for rivals to replicate. Creating a brand is a complex process: it is not clear, for instance, how and to what extent expenditures on advertising or marketing result in a valuable brand image. Similarly, firm-specific skills and organisational structures are inseparable from a firm's other organisational features, which makes them non-tradable. They are also tacit by nature and are formed through a firm's history and its processes of entrepreneurial trial and error. Although their superficial components are documented and can be learned, it is impossible to formulate explicitly their contribution to superior competitive advantage.

Table 5.4 lists some of the most important forms of KBC that support the four types of upgrading, and estimates the size of the value associated with each from its degree of replicability. Although it is difficult to compare the replicability of different types of KBC, the observations above suggest that economic competencies such as superior management skill are generally harder to replicate than innovative property or computerised information. Since upgrading on the basis of difficult-to-replicate KBC is associated with higher entry barriers and thus higher value added, upgrading based on economic competencies is expected to ensure more value added than upgrading based on new technology or databases. Chain upgrading, which relies most heavily on economic competencies, is difficult to achieve but determines firms' long-run viability.

At the same time, the most important source of firms' competitive advantage is often a complex integration of various forms of KBC. Some firms deploy ICT to create a network that enhances collaboration and information flows across business units and functions (McKinsey, 2010b). Such networks are a form of KBC that improves a firm's product development process and its responsiveness to opportunities and threats. It is firm-specific because it incorporates the firm's organisational features.

The important message of Table 5.4 is that firms must build up forms of KBC that are difficult to replicate in order to derive significant value from their participation in GVCs. Even a novel technology does not yield sustainable value added if it can be easily replicated. The value a firm can create within a GVC also depends importantly on whether, or how much, it can leverage its most original resources (Wernerfelt, 1984). As mentioned above, when a firm participating in a GVC is subject to a strong hierarchy, it has limited opportunities for upgrading into new functions or into new value chains. GVC participants have to try to make the nature of their relationship to lead firms more flexible so that they can deploy their KBC.

Table 5.4. Upgrading of GVC activity and relevant KBC

Type of Upgrading	Essential Knowledge-based Capital	Replicability	Value created from upgrading
Chain Upgrading	Firm-specific management skill (acquired from entrepreneurial trial and error) , Flexible organizational structure	Low	High
Functional Upgrading	Sophisticated technology and design, Recognized Brand, Marketing ability, Retail and collaboration networks		
Product Upgrading	Advanced production technology and quality management skill, good design, "Big Data" on consumer preference		
Process Upgrading	Rich know-how in process management, Efficient procurement network, Software and other ICT processing complex tasks	High	Low

It is difficult to investigate empirically the effectiveness of different forms of KBC for creating value in GVCs. However, a survey recently conducted by Japan's Ministry of Economy, Trade and Industry (METI) finds that more firms consider economic competencies such as brand equity to be sources of competitive advantage than either cutting-edge technology or computerised information. The survey also found that Japanese firms consider agile and flexible organisation, a form of KBC that is highly difficult to replicate, to be the most essential form of KBC, especially for functional and chain upgrading (see Box 5.4). Yet the role of organisational capital in global competitiveness has rarely received attention from policy makers.

Box 5.4. Japanese survey on the forms of KBC that support the upgrading of GVC activities

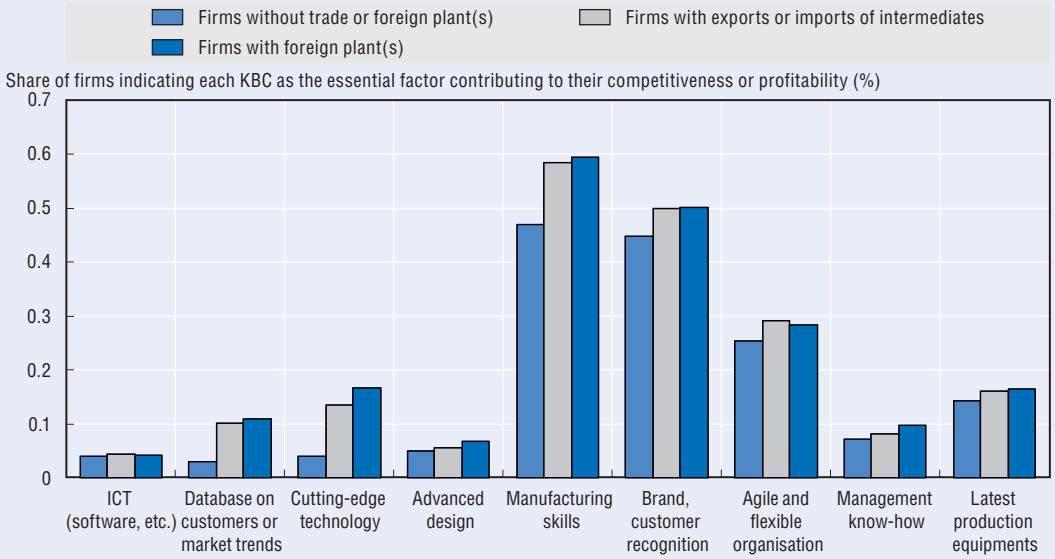
In November 2012, Japan's Ministry of Economy, Trade and Industry (METI) surveyed Japanese enterprises on their engagement in GVCs. It collected data from 2 269 firms (54% were manufacturing firms, 51% were exporters and 37% possessed offshore plants) on their activities in GVCs, their efforts to achieve higher profit margins and the forms of KBC they see as essential for upgrading.

Figure 5.8 shows the share of manufacturing firms citing each form of KBC as the primary source of their current global competitiveness and profitability. It shows that "manufacturing skill" is the most cited type of KBC, followed by "brand and customer recognition" and "agile and flexible organisation". While manufacturing skill has always been considered the core competency of Japanese manufacturing, there is an important policy implication in the fact that more firms regard brand and organisational structure as important than computerised information or innovative property such as "cutting-edge technology" or "advanced design". Furthermore, firms that are more likely to be engaged in GVCs, that is, firms with exports or imports of intermediate goods and firms owning offshore plants, are more likely to value economic competencies than firms without any trade or foreign plants. They also leverage cutting-edge technology and "big data" as sources of their competitive advantage more than firms oriented towards the domestic market. While it is widely documented that globalised firms display superior performance, such as higher productivity (Bernard et al., 2007), this result suggests that their advantage resides in the greater deployment of forms of KBC that are harder to replicate.

…/…

Box 5.4. Japanese survey on the forms of KBC that support the upgrading of GVC activities (*continued*)

Figure 5.8. Knowledge-based capital and the competitiveness of manufacturing firms in Japan



Note: The shares do not add up to 1 because firms are allowed to select multiple forms of KBC that they consider essential. The figure displays the share of firms that indicate the form of KBC concerned to be essential to competitiveness.

Source: previously published as Figure 7.3 in OECD (2013), *Interconnected Economies: Benefiting from Global Value Chains*, OECD Publishing. DOI: http://dx.doi.org/10.1787/9789264189560-en.

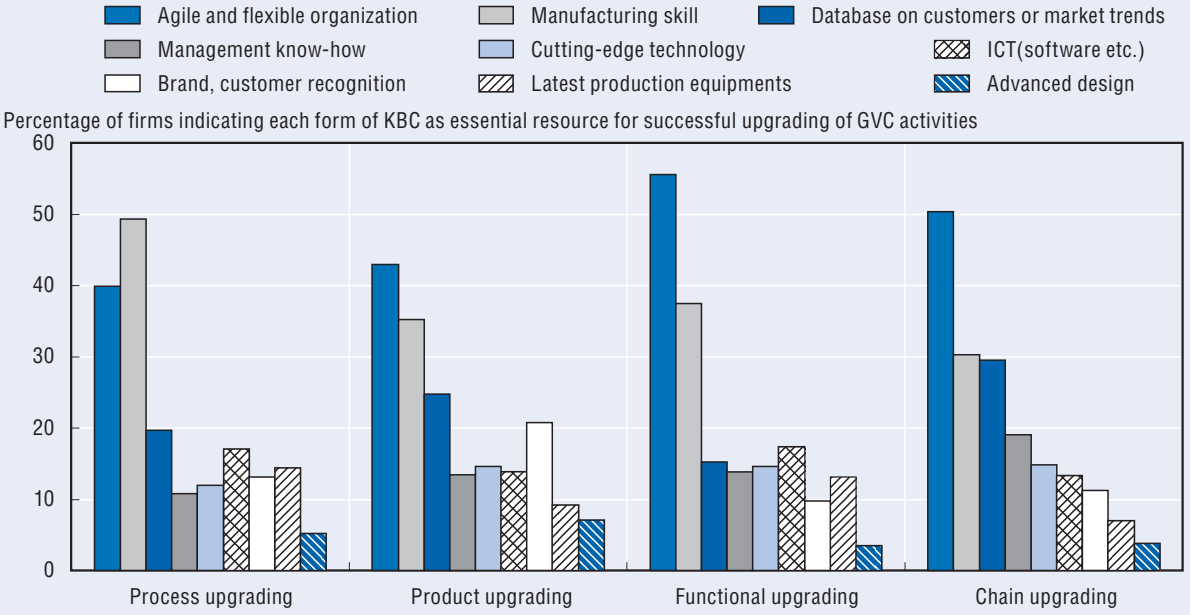
The survey revealed that many firms engage simultaneously in different types of upgrading, with process and product upgrading the most prevalent. Similarly, efforts to move the locus of activity to higher value-added segments (functional upgrading) and to enter new industries or value chains rewarding higher value-added (chain upgrading) are mostly combined with product or process upgrading. However, the share of firms engaging in functional or in chain upgrading (6% and 13% of the sample, respectively) is much lower than the share of firms engaging in process or in product upgrading (63% and 70% of the sample, respectively). This suggests that functional and chain upgrading may be significantly more challenging, most likely because of the large investments in the KBC required.

Figure 5.9 displays the KBC cited by the whole sample of firms (including non-manufacturing firms) as indispensable for successful upgrading. For instance, among the firms engaging in process upgrading, nearly 50% consider the accumulation of manufacturing skill as a pre-requisite. "Agile and flexible organisation" is considered the most important type of KBC by Japanese firms for all types of upgrading except process upgrading. While manufacturing skill is the second most important form of KBC for upgrading, many firms also see databases as essential. This suggests that firms increasingly recognise the need to make systematic use of "big data" in strengthening their competitiveness. The relevance of organisational structure – especially for functional and chain upgrading – is striking. The hardest forms of KBC to replicate, such as organisational structure and firm-specific manufacturing skill, are at the core of upgrading associated with the most value and greatest challenges. It is also likely that with the rise of emerging economies, flexible organisational structures that enable swift response and reconfiguration of firms' resources are an ever more important source of competitive advantage.

…/…

Box 5.4. Japanese survey on the forms of KBC that support the upgrading of GVC activities (*continued*)

Figure 5.9. Knowledge-based capital (KBC) and GVC upgrading in firms in Japan



Note: The shares do not add up to 1 because firms are allowed to select multiple forms of KBC as essential resources. The figure displays, for each group of firms engaging in specific types of upgrading, the share of firms that indicate each form of KBC to be essential for upgrading.

Source: Previously published as Figure 7.4 in OECD (2013), *Interconnected Economies: Benefiting from Global Value Chains*, OECD Publishing. DOI: http://dx.doi.org/10.1787/9789264189560-en.

An empirical analysis

The role of KBC in an economy's comparative advantage

What does the firm-level perspective on the role of KBC in GVC upgrading imply for economy-level value creation? An immediate supposition is that economies with a larger stock of KBC are likely to generate higher value added through GVCs owing to their ability to supply products or services that are harder to imitate. This section discusses an empirical analysis exploring how an economy's endowment in KBC determines its ability to create higher value added in GVCs.

The time-honoured Hecksher-Ohlin theory of international trade predicts that an economy should have a comparative advantage in sectors that use its abundant factors intensively.[4] This implies that KBC-rich economies have a comparative advantage in knowledge-intensive industries[5] and are likely to specialise in more knowledge-intensive GVC activities, according to the theory of the "quality ladder" proposed by Khandelwal (2010).[6] Khandelwal estimated the dispersion of quality for each 10-digit Harmonized System (HS) product imported by the United States.[7] He found that the quality dispersion of products varies widely and that it is significantly larger for industries with higher R&D intensity. Furthermore, employment in industries producing goods with a greater quality dispersion were less affected by increased imports from low-wage economies than industries with less dispersion. Based on such findings, Khandelwal argued that, in

industries with greater quality dispersion, advanced economies can specialise in higher-quality products further up the ladder that do not compete directly with low-wage economies. In the present analytical framework, quality dispersion can be interpreted as the scope of upgrading available in a GVC. The fact that quality dispersion is greater in knowledge-intensive industries implies that GVCs in industries with greater quality dispersion afford more room for economies to upgrade their process, products or function, thereby creating higher value added. This induces economies with a rich stock of KBC not only to specialise in knowledge-intensive industries, but also to seek to upgrade into more knowledge-intensive GVC activities.

KBC-rich economies can therefore be expected to achieve significantly more value added in industries with high knowledge intensity than in those with low knowledge intensity. However, such inter-industry differences in value creation are likely to be muted in economies with little accumulation of KBC, because their ability to upgrade their GVC activities in knowledge-intensive industries will be limited. If this is so, combinations of cross-industry and cross-economy differences in the value created from GVCs activities should be observed. This is tested empirically using two new data sets.

Data for analysis

Value added in exports

Because of the large flows of intermediate inputs in the production stages of GVCs, traditional measures of trade that record the full value of goods (which include imported intermediate inputs) present an inaccurate picture of the value created by global value chains. The economies that produce and export final goods appear to export all of the value of those goods when in reality they may have only marginally contributed to it by assembling imported components. The OECD and the WTO have recently published new measurements of trade expressed in value-added terms, that identify the domestic value added that is embodied in economies' exports.

The Trade in Value Added (TiVA) data are computed based on an inter-country input-output (ICIO) model which consists of harmonised I-O tables from different countries linked with bilateral trade flow data by end use. This model identifies country A's use of intermediates goods imported from country B as inputs to production in specific industries, as well as its imports of final consumption goods. This enables a breakdown of the value of exports of a specific industry from country A into the part generated domestically and the part embodied in imported intermediates. This study focuses on the part generated domestically, which is composed of the value added created directly by the exporting industry, the value added embodied in inputs from other domestic industries and also the domestic value added embodied in the imported inputs as a result of "back-and-forth" trade in intermediates.[8]

The TiVA dataset covers 40 countries: 34 OECD economies and the BRIICS (Brazil, Russian Federation, India, Indonesia, People's Republic of China, South Africa) economies. It covers 18 industries in both the manufacturing and services sectors. While the currently published data only include estimates for 2005, 2008 and 2009, these are augmented here with estimates for 1995 and 2000, based on the OECD ICIO model.

Knowledge-based capital

Recently, Corrado et al. (2012) produced "harmonised" estimates of business investment in KBC for the EU27 countries and the United States. The stock values of KBC, however, are only available for 14 EU economies and the United States (and are

used in this analysis). This database also includes estimates of KBC disaggregated by the classification described above. Its largest drawback is that it does not contain estimates for many important players in GVCs, including China, Japan and Korea.

The KBC stock is divided by the total hours worked by persons engaged, converted to US dollars. Table 5.5 lists these hourly values for the economies in the sample. For 2009, the United States boasts the largest endowment of KBC per hours of labour input. Among European economies, the stock of KBC is largest in Denmark and smallest in Czech Republic. However, the Czech Republic is among the economies in which the KBC stock increased the most between 1995 and 2009.

Table 5.5. KBC stock per hour worked by person engaged (14 European economies + United States)

Unit: USD per hour worked

	1995	2000	2005	2009	Change 1995-2009
United States	15.2	19.7	25.9	31.7	109%
Denmark	13.6	12.1	21.3	27.7	103%
Sweden	13.7	15.0	23.9	27.4	101%
Belgium	15.4	13.6	21.9	27.0	76%
France	12.4	11.2	18.5	24.3	96%
Finland	9.1	8.5	15.8	22.7	148%
Netherlands	12.5	10.9	17.5	22.2	77%
Germany	12.8	10.4	16.3	20.0	56%
Ireland	6.9	5.9	10.6	17.7	155%
United Kingdom	9.5	11.8	16.9	16.9	79%
Austria	7.1	6.8	11.7	15.9	126%
Italy	5.6	5.3	7.4	9.0	63%
Spain	4.6	3.6	5.8	8.8	92%
Slovenia	5.7	4.2	6.2	8.0	39%
Czech Republic	1.8	1.5	3.4	5.1	188%

Note: The figures for the KBC stock are chain-linked volumes, reference year 2005.

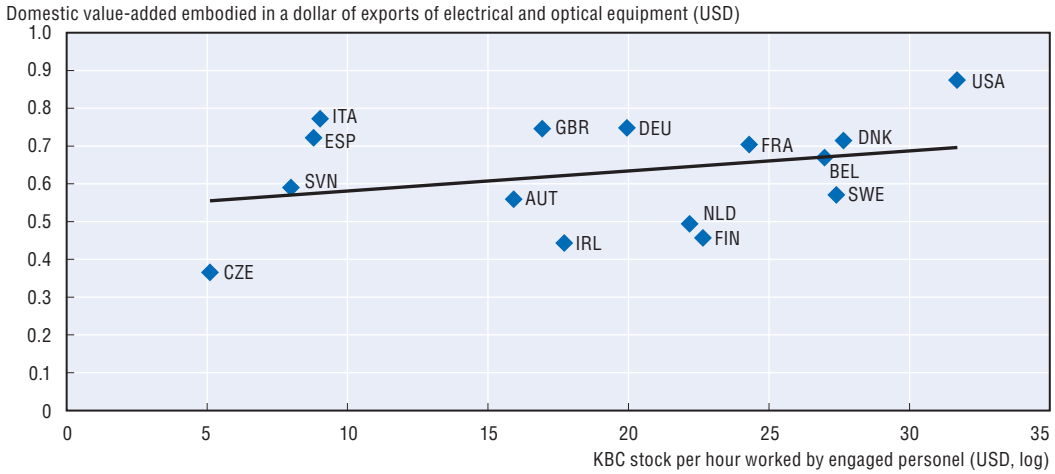
Source: Corrado, C., J. Haskel, C. Jona-Lasinio and M. Iommi (2012), "Intangible Capital and Growth in Advanced Economies: Measurement Methods and Comparative Results", Working Paper, June, www.intan-invest.net.

A simple correlation

The ratio of value added in exports to actual exports (VAX) is used as the measure of value created through GVC activities. It is the value added an economy earns from a dollar of its exports. VAX is expected to be greater for economies that create high value added or use fewer imported inputs in their exports. Therefore, while economies that specialise in knowledge-intensive activities that yield high value added in GVCs have a high VAX, economies with limited integration in GVCs or with a high share of mineral exports, which essentially do not require inputs, may also have a high VAX.

Figure 5.10 plots economies' VAX in electrical and optical machinery against their KBC stock, normalised by business sector value added. Among the countries covered, those with a larger stock of KBC tend to have higher VAX, which suggests that they are mostly specialised in segments associated with higher value added. However, while suggestive, such cross-economy correlation does not constitute evidence of causality. The positive relationship between VAX and KBC endowment may be due to common economy-level factors such as a well-developed financial system.

Figure 5.10. Knowledge-based capital and domestic value added embodied in electronics exports (14 European economies and the United States, year 2009)



Source: Value added in trade is obtained from the OECD-WTO TiVA Database. The knowledge-based capital stock is obtained from Corrado et al. (2012), "Intangible Capital and Growth in Advanced Economies: Measurement Methods and Comparative Results", Working Paper, www.intan-invest.net.

Empirical estimation of industry-economy difference in value creation

A difference-in-difference (DID) empirical technique is used to test the hypothesis that a larger stock of KBC helps create larger value-added in exports. This approach has been widely used to infer the relevance for growth of many other economy-level conditions such as financial development (Rajan and Zingales, 1998), contract enforcement (Nunn, 2007), service market regulation (Barone and Cingano, 2011), human capital endowment (Romalis, 2004), and entrepreneurship-friendly policies and institutions. The empirical framework is described in Annex 5.A1. The analysis is conducted for total KBC and separately for the three subsets: computerised information, innovative property and economic competencies as well as for the R&D stock alone. Table 5.6 summarises the estimation results.

Column 1 of Table 5.6 displays a positive and significant estimate of the coefficient. The size of this coefficient implies that KBC makes a non-negligible contribution to an economy's ability to capture higher value added from its exports. For instance, if economies with a smaller stock of KBC per labour input (such as the Czech Republic) increase their KBC stock to the median level of the 14 European economies, this would be associated with an increase of up to 35% in the value added obtained from a dollar of electronics exports.[9] However, further examination is needed before interpreting this estimated coefficient as a causal relationship.

Columns 2, 3 and 5 display the estimation results when the KBC stock is replaced by one of its three sub-groups. Column 4 corresponds to the case in which KBC is replaced by the R&D stock. Striking differences in the size and significance of estimated coefficients are observed among computerised information, innovative property and economic competencies. Economic competencies have the largest and most significant coefficient, whereas the coefficient on computerised information is markedly smaller and is not significant. This order is in line with the earlier discussion on how the difficulty of replicating key forms of KBC determines the value created by an upgrading.[10] Furthermore, the coefficient for the R&D stock is smaller than that for innovative property. This confirms the important role of many non-R&D based innovation efforts, such as design, in value creation.

Column 6 incorporates the potential role of financial sector development, an important framework condition that supports a firm's upgrading of its GVC activity (Manova and Yu, 2012). The coefficient of KBC remains positive and significant, and is in fact even larger than in the baseline model. On the other hand, the coefficient on the measure of financial development is not significant.[11]

Table 5.6. Estimated coefficients of the interaction of industry-level knowledge intensity with KBC stock

	(1)	(2)	(3)	(4)	(5)	(6)
h×KBC per hour worked	0.5378*** (0.1889)					0.7219*** (0.1972)
h×Computerised information		0.1679 (0.2344)				
h×Innovative Property			0.5131** (0.2121)			
h×R&D				0.4619* (0.2428)		
h×Economic Competencies					0.9113*** (0.2515)	
f×Financial Development						-1.0067 (0.7579)
Physical capital stock per hour worked	0.4091*** (0.0490)	0.4494*** (0.0593)	0.4213*** (0.0513)	0.4317*** (0.0535)	0.4006*** (0.0491)	0.4261*** (0.0521)
Number of observations	861	861	861	861	861	843
R-squared	0.994	0.994	0.994	0.994	0.994	0.994

Note: The table summarises estimated coefficients of the interaction terms between industry-level knowledge intensity with KBC and its subsets. "h" refers to each industry's knowledge intensity, proxied by the labour compensation share of personnel with tertiary education. "f" refers to each industry's financial dependence. All specifications include economy-industry fixed effects and economy-time fixed effects. Numbers in parentheses are standard errors. ***,**and * corresponds to 1%,5% and 10% confidence level.

Source: Estimation based on OECD-WTO TiVA database and estimates of KBC stock by Corrado et al. (2012), "Intangible Capital and Growth in Advanced Economies: Measurement Methods and Comparative Results", Working Paper, www.intan-invest.net.

Policy considerations

The significant role of KBC in value creation in GVCs has implications for policy makers seeking to increase the gains from global engagement. Recognition that a wide array of non-technological forms of KBC – such as data, design, brand and organisational structures – play a large role in capturing value in GVCs potentially opens the way to a reorientation of industrial policy. Policies that foster knowledge creation and investments in KBC appear crucial. While KBC has significant implications for strategies to move up the value chain, GVCs do not necessarily alter policies to encourage the accumulation of KBC. Participation in GVCs may enable firms to build upon spillovers from KBC held by foreign lead firms, but this does not mean that an R&D tax credit, for example, should differentiate between GVC participants and non-participants. The importance of policy support for KBC is reinforced in an era when global competition increasingly takes place in segments of GVCs rather than in industries, because KBC is the resource on which firms build their competitiveness in knowledge-intensive activities.

Strengthening knowledge linkages to support upgrading

Although participation in GVCs enables economies to access world markets, the value that countries derive from GVCs is determined by firms' ability to upgrade their GVC activities to those with higher value added. Since sustainable competitive advantage in such activities rests on sophisticated and hard-to-replicate KBC, an important policy goal is to accumulate such KBC faster than others and to prevent it from depreciating. This is a challenging task, especially for emerging economies, because it requires continuing investment over a long period of time.

Because investments in KBC are associated with greater uncertainty than investments in physical capital, firms may underinvest in KBC, especially when under significant resource constraints. This is the rationale for a pro-active policy that encourages the accumulation of KBC by firms. Such a policy should aim to enhance the "competitive parity" (Barney, 1991) of the economy by increasing the overall stock of KBC that can be shared among firms. Although this does not necessarily support the competitive advantage of specific firms, it enhances the capabilities of a wide range of firms to capture larger spillovers from foreign KBC through participation in GVCs and more efficient accumulation of KBC.

Policy can encourage the formation of industrial clusters in order to enable participants in GVCs to enhance their learning ability and accumulate KBC faster. Knowledge acquired through participation in GVCs can then be shared and used by local suppliers through collaboration and competition. Industrial clusters typically emerge organically, without the aid of policies specifically aimed at their creation. Nevertheless, policy can facilitate the sorts of knowledge interchange that can occur within clusters. This can be done, for example, through government-sponsored consortia aimed at developing new technology. Improved overall technological capabilities within a cluster provide an attractive environment for high value-added GVC activities, inducing MNEs to delegate wider range of functions to local firms.

Policy to encourage stronger links between firms and research institutions, educational and training institutions, and knowledge-intensive-business-services (KIBS) can also support the upgrading of GVC activities based on KBC. These links can lead to new technology, skills and organisational capital by facilitating firms' accumulation of the KBC that enables upgrading of GVC activities to new functions or chains that offer greater value added. Chinese IT firms in the Beijing area that are engaged in OEM have benefited from their collaboration with local universities and research institutions to achieve high-level R&D capabilities. They have been able to learn about the latest developments in the global IT industry through GVCs and to translate these to their own brand products for China's domestic market. Such product upgrading rewarded Chinese IT giants like Lenovo and Aigo with rapid growth (Breznitz and Murphree, 2011).

Entrepreneurship and access to finance are also areas that require policy attention. New firms with new KBC need finance in order to supply novel products or services to GVCs. For example, Chinese SMEs and spin-offs in the Beijing area were often forced to engage in non-core businesses to obtain enough cash flow to finance R&D and other creative activities (Breznitz and Murphree, 2011). Moreover, the most credit-constrained Chinese exporters tend to engage in pure assembly, with limited value added, whereas firms that are less constrained operate as "full-package" manufacturers and ordinary exporters (Manova and Yu, 2012). Access to finance is essential for firms seeking to upgrade their GVC activities through the deployment of KBC.

Policies to foster effective platforms for KBC-based upgrading should have a clear view of the type of GVC activities that can be developed. However, because policy makers may be less well placed to choose these than firms participating in GVC activities, policy should encourage the private sector's efforts to develop diverse types of new competencies in GVCs.

Other policies to create a favourable environment for KBC investments and upgrading include:

- Investment in broad and relevant forms of education and the development of skills that complement formal education. As firms engage in more complex activities in GVCs, workers will require new skills, and curricula and pedagogy need seek to equip students with the capacity to learn and apply new skills throughout their lives.
- Investment in public R&D and support for private R&D. Both will continue to play an integral role in KBC-led upgrading. Some support may also be directed to non-R&D investments such as design or organisational change.
- Support for platforms and infrastructure that facilitate more knowledge-intensive GVC activities. Good communication infrastructure, such as high-speed broadband, is a pre-requisite for global collaboration on new product development requiring significant data transfer.
- A well-designed and effective system of intellectual property rights that encourages firms to invest in innovation.

Providing the right incentives for KBC investments

While an effective innovation system is an important advantage for firms seeking KBC-led upgrading, firms' investments in KBC are fundamentally motivated by the desire for higher profits. For an economy to achieve a competitive advantage based on KBC, firms must have strong incentives to invest in KBC despite the high uncertainty and time involved. These incentives are strongest when competitive and market conditions provide opportunities for higher profit through upgrading and press firms to upgrade in order to sustain their margins. Market regulations and other policies that hamper competition may therefore reduce incentives to upgrade and may discourage firms from investing in KBC.

An economy's competitiveness in GVCs will also be determined by whether or not KBC is efficiently allocated to the most competitive firms. As described elsewhere in this volume, the ability to channel resources to high-productivity firms has an important impact on an economy's growth performance. For instance, Hsieh and Klenow (2009) estimate that if China and India aligned the efficiency of their resource allocation with that of the United States, total factor productivity in manufacturing could rise by 30-50% in China and by 40-60% in India. Pro-competition policies that facilitate the flow of resources to their most productive use can improve the ability of economies to capitalise on growth opportunities due to the rising importance of KBC (OECD, 2012b).

Such a perspective confirms the importance of free trade and investment policies to promote GVC upgrading based on KBC. For instance, import competition stimulates firms' efforts to enhance productivity (Pavcnik, 2002), improve quality (Amiti and Khandelwal, 2009) and invest in forms of KBC such as ICT and R&D (Bloom et al., 2011). Import competition is also associated with superior management practices (Bloom and van Reenen, 2007). While the evidence is mixed, competition with foreign invested enterprises often raises the productivity of domestic firms in the same sector (Haskel et al., 2007; Blalock and Gertler, 2009).

Dynamic domestic markets and free trade and investment are crucial for economies seeking to upgrade their GVC activity through deployment of KBC. Anti-competitive and protectionist policies obstruct the accumulation of KBC and constrain an economy's capabilities to upgrade into more knowledge-intensive segments of GVCs. Protectionism is a "beggar thyself" policy not only because of economic dependency on foreign inputs, but also because of the long-run consequence of protectionism in depressing an economy's accumulation of KBC and limiting its ability to derive value from GVCs.

More generally, policy must ensure good framework conditions. Firms' investment choices have become much more "footloose", in the sense that they respond swiftly and frequently to changes in relative business environments between home and other countries. Shrinking domestic markets, high business costs, the lack of new opportunities due to stringent regulations, poor quality institutions (IPR, contract enforcement) all decrease the attractiveness of the home country as a destination for KBC investments. Policies that strengthen the business environment for such investments are essentially important.

The future of manufacturing in advanced economies

OECD economies have witnessed a decline in manufacturing employment as firms have shifted their GVC activities from production to upstream (and far downstream) segments associated with more intensive use of KBC. At the same time, maintaining and reviving manufacturing activity has been high on the agenda of economic policy makers in OECD countries. Owing to the fierce competition within GVCs, however, only two kinds of manufacturing can sustain value added in the long run in advanced economies: the kind that can significantly outperform emerging economies in term of process, products or functions, and the kind that does not compete with emerging economies. The superior capabilities of OECD economies in some areas of manufacturing are sustained by sophisticated, hard-to-replicate forms of KBC. This suggests that the competitiveness of manufacturing in advanced economies depends on investments in innovative processes and network management, product development and management practices that are deeply integrated with new technology. Such competitiveness is closely linked to KBC-based upgrading. For instance, as customers in advanced economies increasingly demand timely delivery of highly specified products in small lots, some firms have found it sensible to return a part of offshored production to advanced economies, where knowledge workers that are able to process such complex orders are more abundant (McKinsey, 2010c).

The new wave of advanced manufacturing is in fact closely linked to KBCs, through the complex integration of computerised information with innovative property and economic competencies. For example, new trends in product development involve sophisticated modelling and simulation exploiting large volumes of data. Such methods employ design-related competencies to ensure manufacturing efficiency and reduce the need for expensive testing and prototyping. Shipp et al. (2012) have stressed the following five trends in manufacturing: the ubiquity of information technology; reliance on modelling and simulation in manufacturing; acceleration of innovation in supply chain management; more rapid response to customers' needs and external threats; support of environmentally sustainable manufacturing.

The essential role for policy aimed at promoting manufacturing is therefore to encourage the accumulation of these advanced, hard-to-replicate forms of KBC rather than specific GVC activities such as factory production or R&D.

Annex 5.A1.

Industry-Economy Difference-in-Difference Estimation

If KBC plays a significant role in determining the domestic value added created by exports, economies with a larger stock of KBC should have a larger difference in VAX between knowledge-intensive industries and less knowledge-intensive industries. This is tested by estimating the following model:

$$VAX_{ijt} = \beta\left(h_{ij} \times KBC_{jt}\right) + \gamma X_{ijt} + \alpha_{ij} + \alpha_{it} + \epsilon_{ijt}$$

The left-hand side is the *VAX* computed from the OECD-WTO TiVA Database for industry i in economy j at time t. Since it is a ratio the value of which is constrained between 0 and 1, it is transformed to *VAX/(1-VAX)* and uses a log value that better fits the OLS regression. The first term on the right-hand-side is the interaction of industry i's knowledge-intensity and the stock of KBC of economy j at time t. The KBC stock per hour worked by engaged personnel is expressed in log values. If the coefficient β is positive and statistically significant, it means that VAX is indeed higher in more knowledge-intensive industries and that the inter-industries difference is larger for economies possessing a larger stock of KBC. The second term is a vector of control variables that may influence both VAX and KBC. In the standard regression, only the economy-industry level physical capital per hour worked is included.[12] The third and fourth terms represent economy-industry fixed effects and economy-time fixed effects. The former fixed effects control for unobserved heterogeneity specific to each industry in each economy. They control not only for the structural difference among industries in terms of level of value-added embodied in exports, but also for the unique historical or geographical conditions that enable an economy to create larger value in specific industries. The latter fixed effects control for economy-specific shocks such as movements in the domestic business cycle and also for each economy's degree of integration into GVCs. As previously mentioned, an industry can have high VAX when its engagement in GVCs is low, because its use of imported contents in its exports is very small. Although VAX declined in many economies after 1990, with the rise of GVCs, the extent of this decline differed substantially across economies. Economies with fast income growth experienced the largest decline (Johnson and Noguera, 2012). Economy-specific time fixed effects, therefore, control for such heterogeneous trends in VAX. The last term is an error term assumed to be independent and identically distributed across economies and industries but potentially correlated across times. Heteroscedasticity-consistent standard errors are used to correct for the potential effect of serial correlation.

An important issue is the definition of industry-level knowledge intensity h_{ij}. Because industry-level estimates of KBC could not be obtained for the sample economies, they are proxied by the share of labour compensation of employees with tertiary education obtained from the EU-KLEMS database. This choice seems sensible given that advanced educational attainment is usually required for the creation and management of sophisticated knowledge. However, the knowledge intensity of an industry is likely to be influenced by the economy-wide availability of KBC. This may bias the estimated coefficient of the interaction term. Therefore, following Rajan and Zingales (1998), each economy's industrial knowledge intensity is replaced by that of the

United States as the benchmark economy. The time-averaged value of US knowledge intensity between 1995 and 2005 is used as the knowledge intensity of each industry. Each h_{ij} is thus replaced by the time-invariant $\bar{h}_{US,i}$. This approach requires excluding the United States from the sample for a final sample of 14 European countries. Table 5.A1.1 lists the measure of knowledge intensity for the 18 industries in the TiVA database. Knowledge intensity is relatively higher in manufacturing industries such as electrical and optical equipment and in service industries such as financial intermediation and business services.

Table 5.A1.1. Knowledge intensity of 18 industries ($\bar{h}_{US,i}$)

Share of labour compensation of personnel with tertiary education

01t05	Agriculture, hunting, forestry and fishing	0.21
10t14	Mining and quarrying	0.34
15t16	Food products, beverages and tobacco	0.29
17t19	Textiles, textile products, leather and footwear	0.26
20t22	Wood, paper, paper products, printing and publishing	0.38
23t26	Chemicals and non-metallic mineral products	0.42
27t28	Basic metals and fabricated metal products	0.22
29	Machinery and equipment, nec	0.31
30t33	Electrical and optical equipment	0.53
34t35	Transport equipment	0.36
36t37	Manufacturing nec; recycling	0.29
40t41	Electricity, gas and water supply	0.34
45	Construction	0.17
50t55	Wholesale and retail trade; Hotels and restaurants	0.26
60t64	Transport and storage, post and telecommunication	0.28
65t67	Financial intermediation	0.62
70t74	Business services	0.62
75t95	Other services	0.37

Note: The share of workers with tertiary education is a time-average value for the United States for 1995-2005.

Source: Computed from EU-KLEM database.

As an extension of the base model, the model is estimated by incorporating the potential role of financial development. Efficient financial intermediation can facilitate risky and long-term investments in KBC and enable economies to achieve comparative advantage in high value-added GVC activities. An interaction term between each industry's financial dependency and each economy's financial development is included. As the measure of financial dependency, each industry's input coefficients of financial intermediation obtained from the WIOD database are used. The input coefficients are those of the United States, averaged over 1995-2009. The measure of an economy's financial development is the amount of credit by banks and other financial intermediaries to the private sector as a share of GDP, used by Manova (2012).[13]

Notes

1. This implies that "barriers to entry" is a relative concept, in that it takes time and effort on the part of rivals to replicate the capabilities acquired by a firm.

2. The expression, "moving up the value chain" is vaguely associated with functional and chain upgrading. It is however not a rigorous expression, as high value-added activities are not only located in the upstream parts of GVCs, but also in downstream areas.

3. The figure focuses on KBC and ignores physical assets, such as structures and equipment.

4. Romalis (2004) provided evidence that supports this theory by showing that economies that have abundant skills and capital stock capture a larger share of US imports of commodities that use those factors intensively.

5. This is supported by empirical evidence (OECD, forthcoming) showing that larger endowments of KBC enhance a country's revealed comparative advantage in skill-intensive industries, and that the effect is stronger in industries with higher intensity of imported intermediate goods.

6. Unfortunately, economic theory on specialisation in global value chains is in its infancy and does not clearly predict how the endowment of KBC determines specialisation in GVCs. In one of the first theoretical models, Costinot et al. (2012) describe trade in terms of sequential production. In this framework, a final good is produced via a continuum of intermediate stages allocated to economies with different degrees of ability to process complex tasks. The model predicts that an economy with strong processing ability will specialise in the later stages of sequential production where the potential cost of failure is largest. Fally (2012) proposed a measure of the length of production stages in a context of backward linkages in an input-output table. However, the concept of "upstream" and "downstream" in these studies is not consistent.

7. Khandelwal (2010) estimates the quality of a product by using information on the imported product's quantity and unit import value (based on US data). Higher quality is assigned to products with large market shares conditional on their higher unit value. This approach is more plausible than studies such as Schott (2004) which assumed the quality of a product to be represented solely by its unit value.

8. For a detailed description of TiVA data, see the OECD-WTO note at www.oecd.org/sti/industryandglobalisation/49894138.pdf.

9. This figure is computed for the Czech Republic as follow: in 2009, its KBC stock per hour worked is USD 5.1. If the Czech Republic rises to the median level of the 14 European economies (USD 18.8), while other conditions such as physical capital stock remain unchanged, the change in the Czech Republic's logarithm of VAX/(1-VAX) in electrical and optical machinery is calculated by multiplying the estimated coefficient in column 1 (.54) by the knowledge intensity of the electronics industry (.54) by the increase in KBC (USD 13.7). Converting this to VAX yields an increase of 0.13, a 35% increase from its 2009 value. Similarly, Slovenia and Ireland both attain increases of 9% in VAX by raising their KBC per hour worked to the median level.

10. However, economic competencies are difficult to measure. For instance, Squicciarini and Le Mouel (2012) showed that in the United States, organisational capital – an important subset of economic competencies –is 90% larger than the estimate of Corrado et al. (2005), if estimated on the basis of detailed information on the task content of occupations.

11. While this result confirms the essential role of KBC, it does not necessarily invalidate the importance of financial development in upgrading GVC activities. It should be kept in mind that the sample consists of European economies with relatively advanced financial institutions. Financial development might have had a more significant contribution if emerging economies had been included in the sample.

12. The data on physical capital is taken from the EU-KLEM Database. As data on industry-level capital stock for later than 2007 are not available for many European countries, the OECD STAN Database was used to complement the observations in 2008 and 2009.

13. Data from the World Bank's Global Financial Development Database: http://data.worldbank.org/data-catalog/global-financial-development.

References

Amiti, M. and A.K. Khandelwal (2009), "Import Competition and Quality Upgrading", *NBER Working Papers* 15503, National Bureau of Economic Research, Inc.

Amiti, M. and C. Freund (2010), "The Anatomy of China's Export Growth", Chapter 1 in R.C. Feenstra and S.J. Wei (eds.), *China's Growing Role in World Trade*, The University of Chicago Press, Chicago, IL.

Barney, J. (1991) "Firm Resources and Sustained Competitive Advantage" *Journal of Management*, Vol 17(1), pp99-120

Barone, G. and F. Cingano (2011), "Service regulation and growth: Evidence from OECD countries", *The Economic Journal*, Vol. 121, pp. 931-957.

Bernard, A.B. J.B. Jensen and P.K. Schott (2006), "Survival of the best fit: Exposure to low-wage countries and the (uneven) growth of U.S. manufacturing plants", *Journal of International Economics*, Vol. 68(1), pp. 219-237,

Bernard, A.B., J.B. Jensen, S.J. Redding and P.K. Schott (2007), "Firms in International Trade", *Journal of Economic Perspectives*, Vol. 21(3), pp. 105-130.

Blalock, G. and P.J. Gertler (2009), "How firm capabilities affect who benefits from foreign technology" *Journal of Development Economics*, 90, pp.192-199

Bloom, N. and J. Van Reenen (2007), "Measuring and Explaining management Practices Across Firms and Nations", *Quarterly Journal of Economics*, Vol. 122:), pp.1351-1408.

Bloom, N., M. Draca and J. Van Reenen (2011), "Trade Induced Technical Change? The Impact of Chinese Imports on Innovation, IT and Productivity", *NBER Working Papers* No. 16717.

Bower, J. and J. Sulej (2005), "The Indian challenge: the evolution of a successful new global strategy in the pharmaceutical industry", *Innogen Working Paper* 21.

Brandt, L. and E. Thun (2010), "The Fight for the Middle: Upgrading, Competition, and Industrial Development in China", *World Development*, Vol. 38, (11), pp. 1555–1574.

Breznitz, D. and M. Murphree (2011), *Run of the Red Queen*, Yale University Press, New Haven, CT.

Brynjolfsson, E., L. Hitt and S. Yang (2002), "Intangible Assets: Computers and Organisational Capital", *Brookings Papers on Economic Activity*, No.1. pp. 137-198.

Cereda, M., G. Crespi, C. Criscuolo and J. Haskel (2005), "Design and Company Performance: Evidence from the Community Innovation Survey", *DTI Report*.

Cohen, W.M. and D.A. Levinthal (1989), "Innovation and Learning: The two faces of R&D", *The Economic Journal*, Vol. 99, pp. 569-596.

Corrado, C.A., C.R. Hulten and D.E. Sichel (2005), "Measuring Capital and Technology: An Expanded Framework in Corrado, C., J. Haltiwanger and D. Sichel (eds.), *Measuring Capital in the New Economy*, pp. 11-45, The University of Chicago Press, Chicago, IL.

Corrado, C., J. Haskel, C. Jona-Lasinio and M. Iommi (2012), "Intangible Capital and Growth in Advanced Economies: Measurement Methods and Comparative Results", Working Paper, www.intan-invest.net.

Corrado, C. and C.R. Hulten (2010), "How do you measure a 'Technology Revolution'?", *American Economic Review: Paper and Proceedings*, Vol. 100, pp. 99-104.

Costinot, A., J. Vogel and S. Wang (2012), "An Elementary Theory of Global Supply Chains", *Review of Economic Studies*, forthcoming.

Czarnitzki, D. and S. Thorwarth (2009), "The Design Paradox: The Contribution of In-house and External Design Activities to Product Market Performance", *ZEW Discussion Papers*, No. 09-068.

Dedrick, J., K.L. Kramer and G. Linden (2010), "Who Profits from Innovation in Global Value Chain?; A Study of the iPod and Notebook PCs", *Industry and Corporate Change*, Vol. 19(1), pp. 81-116.

Dierickx, I. and K. Cool (1989) "Asset Stock Accumulation and Sustainability of Competitive Advantage" *Management Science*, Vol 35 (12), pp1504-1511

Eberhardt, M., C. Helmers and Z. Yu (2011), "Is the Dragon Learning to Fly? An Analysis of the Chinese Patent Explosion", *University of Oxford, CSAE Working Paper* 2011/15.

Fally, T. (2012), "Production Staging: Measurement and Facts", manuscript, University of Colorado.

Gemser, G., M. Candi and J. van den Ende (2011), "How Design Can Improve Firm Performance", *Design Management Review*, Vol. 22 (2), pp. 72–77.

Gereffi, G. (1999), "International Trade and Industrial Upgrading in the Apparel Commodity Chain", *Journal of International Economics*, Vol. 48, pp. 37–70.

Gereffi, G., J. Humphrey and T. Sturgeon (2005) "The governance of global value chains" *Review of International Political Economy,* Vol. 12(1), pp 78–104

Haanes, K., and O. Fjeldstad (2000), "Linking intangible resource and competition", *European Management Journal*, Vol. 18(1), pp. 52-62.

Hall, R. (1993), "A Framework Linking Intangible Resources and Capabilities to Sustainable Competitive Advantage", *Strategic Management Journal*, Vol. 14, pp. 607-618.

Haskel, J.E., S. C. Pereira, and M. J. Slaughter (2007), "Does Inward Foreign Direct Investment Boost the Productivity of Domestic Firms?", *Review of Economics and Statistics*, Vol. 89(3): pp.482–496

Hertenstein, J.H., M.B. Platt and R.W. Veryzer (2005), "The Impact of Industrial Design Effectiveness on Corporate Financial Performance", *Journal of Product Innovation Management*, Vol. 22, pp. 3-21.

Hoops, D.G. and T.L. Madsen (2008), "A capability-based view of competitive heterogeneity", *Industrial and Corporate Change*, Vol. 17(3), pp. 393-426.

Humphrey, J. (2004), "Upgrading in global value chain", World Commission on the Social Dimension of Globalization, *ILO Working Paper* No. 28.

Hsieh, C-T. and P.J. Klenow (2009), "Misallocation and Manufacturing TFP in China and India", *The Quarterly Journal of Economics*, Vol. 124(4), pp. 1403-1448.

Ito, B., N. Yashiro, Z. Xu, S. Chen and R. Wakasugi (2011), "How do Chinese Industries Benefit from FDI Spillovers?", *China Economic Review*, Vol. 23(2), pp. 342-356.

Jacobides, M.G., T. Knudsen and M. Augier (2006), "Benefiting from Innovation: Value Creation, Value Appropriation and the Role of Industry Architectures", *Research Policy*, Vol. 35 (8), pp. 1200-1221.

Javorcik, B.S. (2004), "Does Foreign Direct Investment Increase the Productivity of Domestic Firms? In Search of Spillovers Through Backward Linkages", *American Economic Review*, Vol. 94(3), pp. 605-627.

Johnson, R.C. and G. Noguera (2012), "Fragmentation and Trade in Value addedover Four Decades", *NBER Working Paper* No. 18186.

Kaplinsky, R. and M. Morris (2002), "A Handbook for Value Chain Research", retrieved from Institute of Development Studies, www.ids.ac.uk/ids/global/pdfs/VchNov01.pdf.

Kawakami, M. (2012), "Innovating global value chains: creation of the netbook market by Taiwanese firms", *IDE-JETRO Discussion Papers* No. 325,

Khandelwal, A.K. (2010), "The Long and Short (of) Quality Ladders", *Review of Economic Studies*, Vol. 77(4), pp. 1450-1476.

Koopman, R., Z. Wang and S-J. Wei (2008), "How Much of Chinese Exports is Really Made In China? Assessing Domestic Value-Added When Processing Trade is Pervasive", *NBER Working Paper* No. 14109

Kotler, P. and G.A. Rath (1984), "Design: a powerful but neglected strategic tool", *Journal of Business Strategy,* Vol. 5(2), pp. 16-21.

Kraemer, K.L., G. Linden and J. Dedrick (2011), "Who captures value in the Apple iPad and iPhone?", Personal Computing Industry Center (PCIC), University of California, Irvine.

Lev, B. (2001), *Intangibles: Management, Measurement and Reporting*, Brookings Institution Press, Washington, DC.

Manova, K. (2012) "Credit Constraints, Heterogeneous Firms, and International Trade" *Review of Economic Studies*, forthcoming

Manova, K. and Z. Yu (2012), "Firms and Credit Constraints along the Value-Added Chain: Processing Trade in China", *NBER Working Paper* No. 18561.

Marsili, O. and A. Salter (2006), "The Dark Matter of Innovation: Design and Innovative Performance in Dutch Manufacturing", *Technology Analysis & Strategic Management*, Vol. 18 (5), pp. 515-534.

McKinsey (2010a), "Global Grid" *McKinsey Quarterly,* June.

McKinsey (2010b), "Clouds, big data, and smart assets: Ten tech-enabled business trends to watch", *McKinsey Quarterly*, August.

McKinsey (2010c) "Building the supply chain of future" *McKinsey Quarterly* January 2010.

Navas-Aleman, L. (2011), "The Impact of Operating in Multiple Value Chains for Upgrading: The Case of the Brazilian Furniture and Footwear Industries", *World Development*, Vol. 39(8), pp. 1386–1397.

Noble, C. and M. Kumar (2008), "Using Product Design Strategically to Create Deeper Consumer Connections," *Business Horizons*, Vol.51 (5), pp. 441-450.

Nunn, N. (2007), "Relationship-Specificity, Incomplete Contracts and the Pattern of Trade", *Quarterly Journal of Economics*, Vol. 122(2), pp. 569-600.

OECD (2011a), "OECD Export Competition: Price or Quality", Internal working document, OECD, Paris.

OECD (2011b), *OECD Science, Technology and Industry Scoreboard 2011*, OECD Publishing.
doi: http://dx.doi.org/10.1787/sti_scoreboard-2011-en

OECD(2012a), *China in Focus: Lessons and Challenges*, OECD, Paris. www.oecd.org/china, www.oecdchina.org

OECD (2012b), "Intangible Assets, Resource Allocation and Growth: A Framework for Analysis", *OECD Economics Department Working Papers*, No. 989, OECD Publishing.
doi: http://dx.doi.org/10.1787/5k92s63w14wb-en

OECD (2013a), *Interconnected Economies: Benefiting from Global Value Chains*, OECD Publishing.
doi: http://dx.doi.org/10.1787/9789264189560-en

OECD/WTO (2013b), OECD-WTO: Statistics on Trade in Value Added, (database).
doi: http://dx.doi.org/10.1787/data-00648-en.

Pavcnik, N. (2002), "Trade Liberalization, Exit, and Productivity Improvement: Evidence from Chilean Plants", *Review of Economic Studies*, Vol. 69(1), pp. 245-276.

Pietrobelli, C. and R. Rabellotti (2011), "Global Value Chains Meet Innovation Systems: Are There Learning Opportunities for Developing Countries?", *World Development*, Vol. 39(7), pp. 1261-1269.

Rajan, R.G. and L. Zingales (1998), "Financial Dependence and Growth", *American Economic Review*, Vol. 88(3), pp. 559-586.

Reed, R. and R.J. Difillipi (1990), "Causal Ambiguity, Barrier to Imitation, and Sustainable Competitive Advantage" *The Academy of Management Review*, Vol.15(1), pp.88-102

Romalis, J. (2004), "Factor Proportions and the Structure of Commodity Trade", *American Economic Review*, Vol. 94(1), pp. 67-97.

Schott, P. (2004), "Across-Product versus Within-Product Specialization in International Trade", *Quarterly Journal of Economics*, Vol. 119, pp. 647-678.

Shapiro, C. and H. Varian (1999), *Information Rules*, Harvard Business School Press, Boston, MA.

Shipp, S.S., N. Gupta, B. Lal, J.A. Schott, C.L. Weber, M.S. Finnin, M. Blake, S. Newsome and S. Thomas (2012), "Emerging global trends in advanced manufacturing", *Institute for Defense Analyses Paper* P-4603.

Siemens (2011) "Designing and Optimizing Efficiency in Consumer Packaged Goods Manufacturing", *Siemens Technomatix,* www.plm.automation.siemens.com/CaseStudyWeb/dispatch/viewResource.html?resourceId=17502.

Simon, H. (2009), *Hidden Champions of the 21st Century*, Springer Publishing.

Squicciarini, M. and M. Le Mouel (2012), "Defining and Measuring Organisational Capital: Task-based Approach", *OECD STI Working Paper* 2012/5.

Sturgeon, T.J. and M. Kawakami (2010), "Global value chains in the electronics industry: was the crisis a window of opportunity for developing countries?", *World Bank Policy Research Working Paper Series* No. 5417.

Teece, D.J. (1986), "Profiting from technological innovation", *Research Policy*, Vol. 15 (6), pp. 285-305.

Teece, D.J., G. Pisano and A. Shuen (1997), "Dynamic Capability and Strategic Management", *Strategic Management Journal*, Vol. 18 (7), pp. 509-533.

Teece, D.J. (2010), "Technological innovation and the theory of the firm: The role of enterprise-level knowledge, complementarities, and (Dynamic) Capabilities", in B.H. Hall and N. Rosenberg (eds.), *Handbook of Economics of Innovation*, North-Holland.

The Economist (2009), "Nestlé –The unrepentant chocolatier", 29 October.

The Economist (2011a), "Samsung –Next big bet", 1 October.

The Economist (2011b), "Slicing an Apple", 10 August.

Thoenig, M. and T. Verdier (2003), "A Theory of Defensive Skill-Biased Innovation and Globalization", *The American Economic Review*, Vol. 93(3), pp. 709-728.

Vervaeke, M. andB. Lefevre (2002), "Design Trade and Inter-firms Relationship in the Nord-Pas de Calais Textile Industry", *Regional Studies*, Vol. 33(6), pp. 661-673.

Wernerfelt, B. (1984), "A Resource-Based View of Firms", *Strategic Management Journal*, Vol. 5(2), pp. 171-180.

World Bank and the Development Research Centre of the State Council of People's Republic of China (2012), "China 2030: Building a Modern, Harmonious, and Creative High-Income Society", www.worldbank.org/en/news/2012/02/27/china-2030-executive-summary.

Xu, B. and J. Lu (2009), "Foreign direct investment, processing trade, and the sophistication of China's exports", *China Economic Review*, Vol. 20(3), pp. 425-439.

Zhang, C., D.Z. Zeng, W.P. Mako and J. Seward (2009), *Promoting Enterprise-Led Innovation in China*, The World Bank, Washington, DC.

Chapter 6.

Knowledge networks and markets

Rising investment in knowledge-based capital and the unprecedented accumulation of information and intellectual property rights have driven a widespread search for mechanisms to help individuals, businesses and organisations navigate increasingly complex innovation systems. Knowledge networks and markets (KNMs) are the set of systems, institutions, social relations, networks and infrastructures that enable the exchange of knowledge and associated intellectual property rights. KNMs provide services to actors in the innovation system ranging from facilitation of the search for, and matching to, relevant counterparties, to evaluating, executing and enforcing agreements. This chapter reviews the different types of KNM – including aspects of the market for skilled workers – their rationale, modus operandi, and what is known about best policy practice. Emphasis is placed on the complexity of policy analysis and evaluation. The challenges of measuring relevant knowledge flows are also examined.

The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

The achievement of a strong, integrated system of innovation has been linked to the ability of its key actors to engage in collaboration and exchanges of productive knowledge. Over many years, successful innovation systems have developed a complex and evolving layer of institutions, networks and markets that underpin specialisation in innovation efforts, the financing of research and commercialisation, knowledge infrastructure, the development of a skilled workforce and the entry of new companies alongside or in competition with incumbents. Over the last two decades there has been a major surge in the amount of information, knowledge and associated intellectual property (IP) rights generated globally in all domains of innovation and economic activity. As many of the chapters in this volume demonstrate, investment in various forms of knowledge-based capital has seen a sustained increase. New digital technologies have brought about large reductions in the cost of copying, storing and distributing data and information. In this environment, the knowledge that is relevant for companies' innovation activities is now less likely to reside within their internal boundaries (Chesbrough, 2003; Dahlander and Gann, 2010). IP rights have also become more important as a way to allow knowledge creators to exclude third parties from using an idea, or the expression of an idea, to extract value from knowledge-based assets.

The unprecedented availability of information and the rising volume of overlapping rights have led to a continued search for – and increase in the number of – mechanisms that help individuals, business and organisations navigate this complex ecosystem, identifying relevant sources or providers of knowledge beyond their immediate network of contacts, enabling them to clear IP rights and transact upon these rights at minimal cost. These mechanisms deal with a wide variety of knowledge-based products, from know-how and data arising from R&D activities in firms, universities or public sector labs, through to the recording of supermarket purchases in loyalty cards or the browsing histories of individual Internet users (see Chapter 8). All of these forms of knowledge have the potential to become economically relevant assets and to be exchanged and shared to meet the needs of their owners and society at large.

This chapter[1] views markets and networks for knowledge-based assets as the range of mechanisms and institutions that facilitate the creation, exchange, dissemination and utilisation of knowledge and associated rights in the innovation system. This perspective is based on a concept previously introduced by the OECD in its *Innovation Strategy* (OECD, 2010a), which defined knowledge networks and markets (KNMs) as "arrangements which govern the transfer of various types of knowledge, such as intellectual property, know-how, software code or databases, between independent parties". As such, this chapter examines a range of innovation-specific institutions and policy settings that are relevant to the accumulation and use of knowledge-based capital (KBC), the development of which is complementary to broader framework conditions addressed, for instance, in Chapters 2 (tax) and 3 (competition).

Efficient knowledge markets make it possible to separate various components of the production and use of knowledge across firms, thus encouraging specialisation through the division of innovative labour (Arora and Gambardella, 2010). (This chapter thus adds to the discussion of the importance of efficient resource allocation in Chapter 1.) Within knowledge markets and under some conditions, enforceable IP rights help address the threat of misappropriation in downstream markets, which could lead firms to adopt less efficient internal development strategies. Knowledge markets can therefore encourage the exploration of avenues of knowledge development that might otherwise go unexploited. Markets for disembodied knowledge can also enable companies to generate value from their knowledge-based capital. The existence of markets for rights to intellectual assets

can be used to secure funding and enable investors to manage their risk exposure if IP can be sold and bought in liquid markets where prices reflect underlying asset values. While the financing of innovation – from invention through to commercialisation – requires long-term capital commitments, the economic and financial crisis has accentuated the difficulties firms encounter for financing their innovation activities. More generally, the crisis has reduced confidence in the ability of markets for complex products to address information asymmetries and align risks and rewards.

There are several challenges to the emergence and sustainability of markets and networks for knowledge assets. Knowledge is no ordinary commodity and its markets are likely to be absent, owing to the lack of standard valuation approaches, issues of context dependency, the stickiness of information and the opportunistic behaviour of actors (Arora et al., 2001a). For similar reasons, when markets for knowledge exist, their net contribution to innovation and social well-being can be ambiguous, depending on whether their design and the constraints under which they operate provide incentives for rent seeking, as opposed to socially efficient behaviour. The recent evolution of knowledge markets raises a number of questions about the nature of knowledge markets, their impact and the appropriate role for policy. For instance:

- Has there been a genuine increase in business use of open innovation strategies? What is the role of IP rights in driving trends in this area?
- Which are the key defining and novel dimensions of knowledge networks and markets? What are the business models being adopted by new knowledge markets and networks and are they sustainable responses to the challenges that drove their emergence?
- What is the appropriate role of government in this rapidly changing landscape and can its different roles be reconciled?

This chapter attempts to shed light on these questions and to lay out a possible research agenda. It examines new evidence on the knowledge sourcing strategies of firms, investigating their role in innovation strategies and their link to business characteristics and performance. The concept of "knowledge networks and markets" is introduced, and a conceptual framework is proposed for understanding the purposes they serve in relation to knowledge flows and the transfer of IP rights. A number of new examples of KNMs are considered. The chapter also describes some developments in the market for IP rights, looking in the first instance at evidence on the size of the market and the role of intermediaries. The various features of the market for IP rights are considered, as well as the implications of a number of strategies in this highly complex marketplace. A final section extends the analysis of knowledge markets to the market for knowledge embodied in highly skilled employees. The ambiguous impact of mobility on innovation is discussed, particularly in relation to the use of agreements to restrict the movement of human capital and the potential implications of the enforcement of such agreements.

Knowledge flows and open innovation strategies

Previous OECD work has highlighted the importance of knowledge flows for the efficiency of national innovation systems. More recent OECD analysis has demonstrated the existence and importance of stylised open modes of innovation for business innovation strategies (OECD, 2009; Frenz and Lambert, 2012). Data from innovation surveys show that sourcing knowledge, collaborating with external knowledge sources and investing in external knowledge matter not only for R&D-performing companies in

so-called high-technology sectors but also matter for most other types of companies trying to introduce new products, including services, and to improve the efficiency of their processes. Preliminary results suggest that innovative companies in different sectors and countries tend to favour specific sources of external knowledge.

Mapping knowledge and innovation flows is a complex and demanding task, which does not permit reliance on a single source of evidence. It also requires a comprehensive data infrastructure composed of elements that allow for forming linkages between actors, outputs and outcomes. Systems approaches to innovation have shifted the focus of the innovation policy debate towards an emphasis on the interplay of institutions and the interactive processes at work in the creation of knowledge and in its diffusion and application. For example, the term "national innovation system" was coined to represent this set of institutions and these knowledge flows (OECD, 1997). This theoretical perspective influences the choice of indicators and data sources to develop within various measurement frameworks (such as R&D and innovation surveys), and the need, for example, to aim for extensive coverage of linkages and knowledge sources.

The concept of open innovation describes the "use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation". This includes proprietary-based business models that make active use of licensing, collaborations or joint ventures, for example. In this context, "open" does not mean freely available. The literature abounds with examples of a shifting culture and acceptance of more open innovation strategies that cut across organisational boundaries. Companies such as IBM, Intel, and Procter & Gamble all exemplify organisations that have adopted an open innovation model (Chesbrough et al., 2006a).

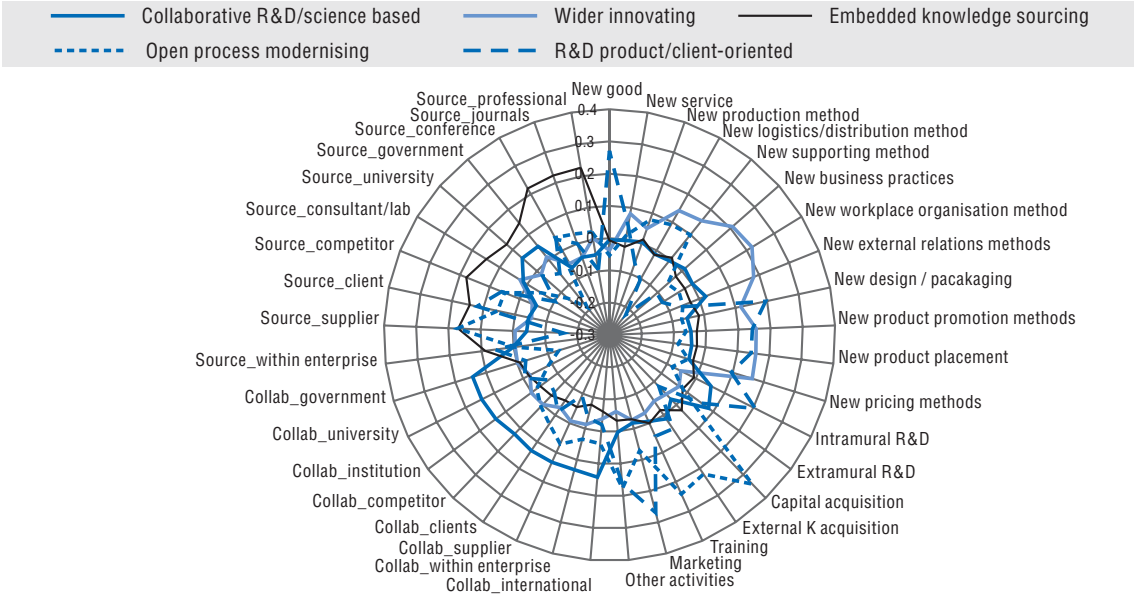
Despite the frequent use of the term "open innovation" and abundant anecdotal evidence, the size and nature of this phenomenon are relatively little understood in terms of official statistics. It has long been recognised that organisations – and firms in particular – do not rely exclusively on their in-house research or development resources to generate inventions and develop them into new final goods and services (OECD, 2008). Knowledge sourcing strategies in businesses can be very complex and have significant complementarities (Cassiman and Veugelers, 2006). It can therefore be useful to analyse a reduced set of synthetic measures that encapsulate various modes of sourcing knowledge among firms that are actively pursuing innovation. In this connection, the study by Frenz and Lambert (2012), carried out in the framework of the OECD Innovation Microdata Project, uses exploratory data analysis techniques to develop typologies of innovation modes or strategies for groups of firms based on innovation survey data for 2006, collected under the guidelines contained in the OECD/Eurostat *Oslo Manual*. This work has recently been extended to examine in more detail the different patterns of openness in business innovation strategies, by looking at the full breadth of information available on the sources of knowledge identified by companies as important to their innovation efforts, the partners engaged in collaborative innovation efforts and the use of company resources in innovation activities (including R&D). These possible approaches for sourcing innovation knowledge are combined with indicators of different types of innovation outcomes reported by firms, thus providing a complete characterisation of modes of innovation used by firms and their degree of openness.

Innovation survey data covering 2006-08 were subjected to factor analysis, a statistical process that can be used to identify complex relationships among variables in a data set, by grouping the variables under unified concepts termed "factors". On this basis, Figure 6.1 reveals the existence of five main modes of knowledge sourcing and

innovation in a sample of innovating firms from a number of European countries.[2] The five modes have been labelled as follows to represent groups of innovative firms:

- *R&D product/client-oriented* (companies that carry out intramural R&D while introducing new product and marketing innovations).
- *Collaborative R&D/science-based* (companies that are R&D-active, particularly in procuring extramural R&D while collaborating with, and sourcing knowledge from, organisations in the higher education and government sectors).
- *Embedded knowledge sourcing* **(**companies whose approach to innovation involves the sourcing of external know-how embedded in capital and software purchases).
- *Open process modernising* (companies introducing new processes in response to collaboration with market partners, including suppliers and customers).
- *Wider innovating* **(**companies that appear to use only consultants and professional/industry associations as main external sources of knowledge).[3]

Figure 6.1. Modes of innovation and knowledge sourcing for European innovation-active firms, 2008



Note: Rotated factor loadings for five main factors and business responses to official innovation survey questions on sources of information for innovation (e.g. internal, clients, suppliers, institutions), collaboration (likewise), innovation activities (from intramural and extramural R&D through to IP acquisition and marketing, training and other expenditures including design) and types of innovation (varieties of product, process, organisational and marketing innovation). Factors have been interpreted and named on the basis of their loading scores.

Source: OECD calculations based on CIS 2008 microdata (Eurostat), 2012.

The key features of these five modes are summarised in Table 6.1. The descriptive validity of these "implied" modes can be further assessed by studying how business characteristics correlate with the factors describing the innovation modes. The standardised factors have therefore been compared with business characteristics dummies, including sector, firm size and country. The results show that firms in the "pharmaceutical", "other transport equipment" (comprising aerospace) and "scientific and technical activities" sectors, followed by "motor vehicles" are most likely to display the

"collaborative R&D/science-based" mode. Within pharmaceuticals, as one might expect, firms also tend to score relatively high on the "R&D product/client-oriented" mode. The information and communication technology (ICT) manufacturing and services sectors are among those scoring highest on this particularly mode. Firms in "finance and insurance" and "wholesale and retail trade" tend to score high on the "wider innovating" mode. The "open process modernising" mode is particularly salient among transport services and some of the less R&D-intensive manufacturing sectors. Differences are less marked across sectors in terms of the "embedded knowledge sourcing" mode of innovation and knowledge sourcing. But this mode appears to be particularly present among firms in the pharmaceutical and scientific and technical services sectors.

Table 6.1. Modes of knowledge sourcing and innovation

Summary of factor analysis

Modes	Variance	R&D	Knowledge Sources	Collaboration	Innovation activities / investment	Innovation outcomes
R&D product/client-oriented	7 %	Yes	High on clients and competitors	Low, mainly clients and customers	Intramural R&D, other activities including design	Goods, marketing, partly services
Collaborative R&D/science-based	21%	Yes	High on labs, universities, government	High on all, including institutional	Intramural and extramural R&D	New products (goods and services)
Embedded knowledge sourcing	11 %	No	High, most sources	Low	Capital acquisition	Low, only production process
Open process modernising	7 %	No	Market sources, principally suppliers	Market sources, principally suppliers	Training and capital and knowledge acquisition	Process
Wider innovating	13%	No	Low, consultants	Low	No systematic activity	Services, marketing, organisation

Note: % variance denotes the proportion of the overall variation in the data accounted for by the relevant factor.

Results not reported here also confirm that firm size is positively associated with all types of innovation. Size appears to be a particularly discriminating factor for the collaborative R&D science-based mode. This may reflect the need for scale to develop the internal capabilities to engage in such relationships. The regression results can also be used to study whether the different innovation modes are more prevalent in some countries than in others.[4] Within the sample, the results indicate that Germany displays the highest scores across all but two of the innovation modes. Only Finland exhibits a higher score than Germany on the "collaborative, science-based" mode. Germany's performance on the "wider innovating" mode is below average. Scores for this mode are particularly significant in Portugal, followed by Italy, Spain, the Czech Republic, France and Luxembourg.

Table 6.2. The relationship between modes of innovation and business performance, European firms, 2006-08

OLS regression estimates and standard errors

Dependent variable / Independent variable (Standardised score)	Innovation novelty			External engagement				Business performance		
	Share of turnover from new products	Whether product new to market	Whether process new to market	Whether co-dev'd new product	Whether product mainly dev'd by others	Whether co-dev'd new process	Whether process mainly dev'd by others	Growth in turnover	Growth in employment	Productivity level
Collaborative, scientific R&D-based	0.040***	0.114***	0.034***	**0.079*** **	-0.021***	**0.076*** **	-0.041***	**0.029*** **	**0.024*** **	0.037***
	(0.003)	(0.005)	(0.007)	(0.006)	(0.003)	(0.006)	(0.004)	(0.005)	(0.003)	(0.008)
Wider innovating	0.044***	0.083***	**0.122*** **	-0.004	-0.018***	-0.006	-0.045***	**0.028*** **	**0.029*** **	0.019
	(0.003)	(0.005)	(0.007)	(0.006)	(0.004)	(0.007)	(0.004)	(0.004)	(0.003)	(0.011)
Embedded process sourcing	0.024***	0.056***	0.020**	**0.017** **	-0.009*	0.018**	-0.016***	0.015***	**0.015*** **	0.040***
	(0.003)	(0.005)	(0.007)	(0.007)	(0.004)	(0.006)	(0.004)	(0.004)	(0.003)	(0.009)
Open process modernising	0.014***	0.043***	**0.062*** **	0.018**	0.000	**0.050*** **	0.002	0.012*	**0.009** **	0.007
	(0.003)	(0.005)	(0.007)	(0.006)	(0.003)	(0.007)	(0.004)	(0.005)	(0.003)	(0.01)
Product / client-oriented R&D	**0.095*** **	**0.215*** **	0.004	-0.053***	-0.034***	-0.070***	-0.053***	0.007	**0.010*** **	0.017
	(0.003)	(0.004)	(0.007)	(0.007)	(0.004)	(0.006)	(0.004)	(0.004)	(0.003)	(0.009)
Number of observations	35102	36051	16953	23991	23991	26620	26620	33497	33599	36031
Sample	Innovation-active firms	Innovation active firms	Innovation-active firms*	Product innovators	Product innovators	Process innovators	Process innovators	Innovation - active	Innovation active	Innovation-active

* Variable not available for all countries.

How to read: One standard deviation increase in the "collaborative science-based" mode score raises the proportion of turnover from new products by 4 percentage points.

Note: Regression controls for firm size, country and sector affiliation. Three asterisks denote statistical significance at 1%.

Source: OECD estimates based on CIS 2008 microdata (Eurostat), 2012.

The analysis of innovation modes also shows the extent to which knowledge sourcing and innovation modes can predict specific features of innovation as well as economic outcomes within the firm. The results in Table 6.2 provide some further insights on the specific role of companies in developing innovations. R&D product/client-oriented innovators are the most likely to report higher shares of new-to-market products and turnover accounted for by new products, although all four other modes are positively correlated with this measure of innovativeness. Wider innovators and open process modernising firms are the most likely to report new-to-the-market processes. R&D product/client-oriented firms that introduced new products or processes are significantly less likely to report having co-developed these with other parties in any form, which reveals a strong degree of internal control over the development process, notwithstanding external engagement with customers. Collaborative R&D/science-based firms are more likely to have co-developed products or processes, but less likely to have let another party take responsibility for their development. Open process innovating firms are more likely to have co-developed their process innovations. Conditional on having introduced a new process, wider innovators are less likely to report that another firm mainly developed the innovation. All five modes are positively correlated with growth in turnover and employment over the 2006-08 period. While this is not necessarily evidence of a causal effect, the relationship is robust to controlling for other firm characteristics including sector and firm size.

One limitation of existing innovation surveys is the lack of information on the outbound dimension of knowledge exchanges and interactions with the knowledge sourcing strategies described above. Most official innovation and R&D surveys focus on the "outside-in" perspective of open innovation. The academic literature has highlighted the importance of considering interaction at the firm level between inbound and outbound approaches to innovation. *Outbound diffusion* is recognised in the OECD/Eurostat *Oslo Manual* as being "relevant both for identifying the economic effects of innovation and for establishing the shape of an enterprise's network", although no guidelines or recommendations are made in this respect. *Ad hoc* surveys carried out mainly by academics have identified three broad categories of open innovation typically used by companies.

Official innovation surveys capture companies' use of *"outside-in"* strategies, whereby they assimilate ideas that originate externally, often with customers or suppliers, into their own innovative processes. This type of activity may be slightly under-reported, as some companies may not necessarily describe the implementation of innovations developed elsewhere as their innovation. The *"inside-out"* approach normally refers to the commercialisation or licensing of companies' existing technologies and the finding of new applications for these technologies in completely different markets (Chesbrough et al., 2010). In this case, new knowledge becomes the "product innovation" of firms that bring ideas to market, sell IP, and multiply technology by transferring ideas to the outside environment. Based on a sample of 1 095 firms in the United Kingdom, Cosh and Zhang (2011) estimated that 29% engaged in transfer of technology and knowledge to external parties. This study also found that confidentiality agreements were the most widely used and most highly regarded way to protect firms' innovations (although other legal methods were less frequently used, they were considered very important by firms that had used them). The authors point out that this may reflect not only the effectiveness of the IP regime, but also the availability of certain means of legal protection for products and services. Companies that *combine the "inside out"* and *"outside in"* approaches have been described as *"ambidextrous"* (Cosh and Zhang, 2011). Such companies engage in

coupled or joint processes, typically performed with entities from outside the industry, which involve the search for new sources of knowledge and the recombination of knowledge from inside and outside the company.

Inbound and outbound innovation processes differ in their practices and capability requirements. Business willingness to engage in different types of open innovation strategies depends on the potential costs arising from transactions and the reduced control over their knowledge assets, which a closed approach to innovation protects, and the benefits of specialisation offered by open approaches. Gassmann et al. (2011) report on a study of 107 companies and show that risks such as loss of knowledge (48%), higher co-ordination costs (48%), and loss of control and greater complexity (both 41%) are mentioned as frequent risks connected to open innovation activities. Other significant internal barriers pointed out in this study include the difficulty of finding the right partner (43%), the imbalance between open innovation activities and daily business (36%), and the lack of sufficient resources for open innovation activities.

Estimates of flows of funds for R&D across sectors are among the most long-standing indicators of innovation-related, transactional flows.[5] Data on business extramural R&D expenditures can be used in some cases to gauge the importance that companies attach to procuring R&D services from outside their organisation, within or outside their institutional sector. While data on intra-sectoral R&D flows do not yet feature in the OECD's standard international reports, evidence from selected countries suggests an increasing propensity to outsource R&D; it is implied by the growing ratio of extramural to intramural R&D expenditures incurred by businesses. For some countries, there is some initial evidence of a slowdown or even reversal in this trend that coincided with the onset of the global financial crisis. On the one hand, financial stress may accelerate a shift towards external approaches for sourcing and producing knowledge that transfer risk to third parties. On the other hand, companies may prefer to reduce external R&D expenditures rather than internal activities if the latter correspond to core business competencies and there is an expectation that the research capability embodied in their personnel will eventually be re-utilised. Thus, it may be easier to sever external ties rather than write off internal investments in building research capability. A promising area for further research could be to identify comparable data across OECD countries and test how the economic downturn has affected the open innovation paradigm.

The role of knowledge networks and markets

As previously noted, the OECD introduced the concept of knowledge networks and markets in its 2010 *Innovation Strategy*. The term has grown in popularity and been applied to a diverse set of agreements, institutions, organisations and intermediaries in the innovation system.

The definition of "knowledge network" proposed by Phelps et al. (2012) can be used to describe the range of knowledge interactions in KNMs. It is "a set of nodes – which can represent knowledge elements, repositories and/or agents that search for, transmit and create knowledge – that are interconnected by relationships that enable and constrain the acquisition, transfer and creation of knowledge". There are two main types of nodes: knowledge objects and network subjects or actors. These correspond to "What is exchanged?" and "Who exchanges?" Alongside knowledge objects, actors exchange others types of goods and services, as well as financial compensation and risk. Identifying and categorising the subjects, parties or actors participating in the exchange can be particularly important for understanding motivations and potential constraints.

The object of the exchange may include databases, information, coded software routines, codified inventions, scientific results and know-how, to cite some examples. A classification system for knowledge objects should take account of a range of dimensions: i) the extent to which knowledge is explicit or implicit and therefore the ease with which it can be transferred to other parties (von Hippel, 1994, Polanyi, 1958); ii) the degree to which it is possible to exclude other parties from using the knowledge and non-rivalry in the use of many forms of information and knowledge; iii) the distinction between knowledge as such and legal rights to knowledge (for instance, a transfer of control of IP rights does not necessarily entail a flow of knowledge from the seller to the buyer of the rights); iv) the extent to which the knowledge object already exists or is prospective, in the sense that knowledge is to be procured *ex novo* or jointly produced. Joint production of *prospective knowledge* is invariably preceded by some pledge or exchange of *existing knowledge*.

Knowledge exchange subjects are the organisations, agents or individuals involved in knowledge flows. They can be classified according to:

- *Sectoral affiliation*. It is customary in the measurement and policy analysis of science, technology and innovation (STI) to classify actors, individuals or organisations by allocating them to a given institutional sector and sector of activity. Institutional affiliation reflects a combination of attributes that summarises information relating to ownership, independence and control, predominant sources of funding and general purpose of activities.
- *Supply/demand/intermediary roles*. Actors can also be characterised on the basis of their position with respect to the knowledge object in the exchange, alongside the usual supply/demand distinctions. It is common to refer to knowledge providers and knowledge seekers. There are various contexts in which the same actor may adopt multiple roles as supplier and user of knowledge.
- *Size, experience, expertise and other capability-related attributes*. These help predict the "absorptive" (both outside-in and inside-out) capacity of individuals and organisations to engage in knowledge exchange with other parties (Cohen and Levinthal, 1990).
- The "relatedness" between parties, such as ownership ties, geographic distance and common network membership. The use of criteria based on the existence of formal ties or commonalities between actors is often required to identify the relevant measure of "distance" for predicting the likelihood that an exchange of knowledge will take place.

The literature suggests that it is particularly important to distinguish between the *ex ante* and *ex post* dimension of knowledge exchange agreements. As pointed out by Arora and Gambardella (2010), contracts for existing knowledge are somewhat more straightforward than contracts for knowledge "futures", as "ex-ante deals create greater potential contracting problems arising from the moral hazard". *Ex ante* deals are necessarily more complex because they not only entail agreements on the use of existing knowledge by the parties, but also require an explicit or implicit agreement on the production and distribution of future knowledge. Based on the *ex ante/ex post* distinction, Table 6.3 provides a tentative classification of knowledge exchange agreements. Within the class of transactions involving existing knowledge, a distinction is made between those focused on disembodied, IP rights-based mechanisms, and those in which knowledge flows are embedded in separate transactions. Among the latter, one may consider the embedded transfer of knowledge

through the transfer of company ownership, capital equipment or materials. Within the broad class of agreements involving the creation of prospective knowledge, a distinction is made between agreements to provide custom knowledge-based solutions, and agreements between parties to contribute in kind to the joint development of a knowledge product. It is easy to appreciate the choices a company can face at any given time, for example between contracting with an R&D provider, expanding the internal R&D unit to address the same problem, or crowd-sourcing the solution through a prize mechanism. The choice will ultimately depend on the relative efficiency of the various knowledge markets in delivering a solution and the firm's own capacity to implement a solution that mitigates their specific limitations and risks.

Table 6.3. Different types of knowledge exchange agreements and examples

Existing knowledge	Prospective knowledge
Disembodied, IP rights-based mechanisms	***Sourcing solutions***
• Confidentiality and non-disclosure agreements • IP licensing (exclusive, non-exclusive) • IP rights pooling agreement (may also involve commitments about future rights) • Sale or assignment of IP rights • Franchise agreements • Know-how contracts (transfer in tangible form through technical data)	• Service and consultancy purchase agreement • Consultancy services • Research services • Crowd-source prize commitment
Embedded knowledge transactions	***Co-development***
• Transfer of rights to IP and other knowledge-based capital through mergers and acquisitions of holding companies • Acquisition of equipment; turn-key project agreements (delivery of facility with incorporated technology ready to use) • Material / data transfer agreements	• Co-development programmes • Research joint ventures • Research / commercialisation alliances • Private-public partnerships • Secondments / release agreements • Hiring of R&D personnel (co-development between employee and hiring firm) • Network membership agreements (depending on the nature of exchanges within the network)

As a result, very subtle and context-dependent factors may drive organisations to opt for a particular form of agreement for sourcing or deploying knowledge outside their own boundaries. This is particularly important for any attempt to identify the relevant knowledge network or market, given what is *a priori* a potentially high degree of substitutability among possible options.

Types of knowledge networks and markets

While many KNMs are the outcome of policy decisions, a wide range of independent mechanisms, institutions, platforms and intermediaries also emerge from private initiatives. The common feature of these various – public and private – mechanisms, institutions, platforms and intermediaries is an attempt to provide a number of critical services to market participants at various stages of the knowledge exchange process. Maass (2008) describes a sequence: i) search and evaluation of knowledge partners and offerings, such as knowledge object and/or partner search tools, information storage/repository platform, clearing of IP rights, rating, consulting, legal; ii) determination of terms, such as platform for price determination and due diligence; and iii) execution, e.g. delivery/transmission of the knowledge object; recording of the transaction; IP rights and payments clearing; rules enforcement and conflict resolution.

KNM enablers can specialise in: providing specific services or bundles thereof, e.g. matching knowledge providers and seekers, providing quality assurance, enforcing agreements, etc.; facilitating access to or providing exchanges for specific types of knowledge objects, such as databases, patents or knowledge embodied in individuals; or serving the needs of specific types of actors (e.g. technology transfer offices that specialise in supporting the needs of higher education institutions).[6] To be effective, KNMs must convey relevant information to market and network participants while ensuring participation and encouraging parties to contribute the high-quality knowledge objects/applications without which the market cannot be sustained. When dealing with agreements on the co-creation of future knowledge, KNMs must also deal with the additional challenge of encouraging and verifying the efforts of the participating parties. A tentative functional classification of KNMs is proposed in Table 6.4, which draws on the literature and in particular on some elements of the taxonomy proposed by Dahlander et al. (2012).

Table 6.4. A proposed typology of knowledge networks and markets

Defining feature	*Knowledge object*	*Core/salient types of KNMs*
Sourcing / providing knowledge	Existing knowledge	(1) Searchable registers and data repositories
	Create and co-create new knowledge	(2) Platforms for sourcing solutions
Sourcing / providing rights to knowledge	Existing knowledge	(3) IP-based marketplaces and intermediaries (e.g. patent market intermediaries, digital rights collecting societies)
Making knowledge transferable	Create and co-create new knowledge	(4) Standard setting bodies and consortia, accreditation bodies, etc.
	All	(5) Infrastructures and intermediaries in the market for embodied knowledge

Source: OECD (2012a), *Knowledge Networks and Markets in the Life Sciences*, OECD Publishing, doi: http://dx.doi.org/10.1787/9789264168596-en.

Broad categories of KNMs can be defined on the basis of whether their focus is on facilitating the transfer of disembodied knowledge, as in the case of searchable registers and repositories of existing data and information (1) and platforms for sourcing solutions to *ad hoc* problems and challenges (2), which includes platforms for implementing inducement prize incentives or identifying consultants to assist with new R&D projects. Both seek to transfer knowledge between firms or other parties, including individuals.

To continue the categorisation, KNMs can also directly focus on resolving ownership and the transfer of rights to disembodied knowledge (3). IP brokers, pools and funds primarily deal with the allocation of IP rights – not necessarily driven by a wish to transfer knowledge – and the origination and management of financial assets and liabilities attached to these rights. As a further category, it is worth emphasising the role of institutions and actors that specialise in facilitating the transfer of knowledge embodied in goods or people by transforming the nature of the knowledge. For example, standard-setting organisations (4) codify existing know-how and best practices embodied in a community of practice into more widely replicable guidelines. Many of the services provided by the OECD to its members fit under this category. Intermediaries that support the transfer of knowledge embodied in people (5) may also be included in this category.

Objectives and challenges faced by KNMs: Some examples

A recent OECD study of KNMs in the life sciences described a number of theoretical advantages that would also apply to wider knowledge domains (OECD, 2012a). If properly designed, KNMs can help shift the traditional trade-off between the specialisation benefits, the transaction costs and the risks arising from increased openness. In principle, this is achieved when KNMs achieve economies of scale and scope, provide effective new tools for managing complexity and risk sharing, promote specialisation and division of labour, facilitate collaboration, lead to learning and development of organisational capabilities, and facilitate the emergence of market-based signals. Potential downsides may arise from the higher likelihood of agency risk, conflicts of interest not appropriately dealt with, barriers to entry, lock-in effects and other anti-competitive behaviours. Government funding of KNMs is fairly common. In general, market failures seem more prominent in the early stages of network formation and operation (search, set-up, trust formation, etc.). In the later stages network participants can deal with market failures themselves. Therefore, policy should not continue to support networks once they are established and their benefits are clear to participants. At this stage, all participants should have found and put in place mechanisms for contributing fairly to the costs while sharing the benefits. The government's role should shift to addressing problems that may be due to established networks, such as detrimental effects on competition in product markets (OECD, 2001).

In the absence of government funding, or voluntary contributions from participants, the sustainability of KNMs depends on their ability to finance their operations in return for services. They may charge prices, membership fees, or bundle free services with proprietary ones, as in the case of advertising. Exploiting economies of scope and scale in providing services for knowledge exchange can be particularly difficult in some narrowly defined knowledge domains and those in which information about knowledge, such as estimating the value of knowledge assets, can be difficult to standardise and communicate.

Online knowledge marketplaces

Online knowledge marketplaces (OKMs) manage platforms (websites from a user perspective) that accommodate communicating, matching and transacting innovative knowledge (Dushnitsky and Klueter, 2010). In general, these are independent entities, unaffiliated with either knowledge owners or seekers, in order to avoid potential conflicts of interest. Many are for-profit companies, but some are not-for-profit ventures that rely to different degrees on member subscriptions, fees or external support, possibly from governments. OKMs share many similarities with more ubiquitous online marketplaces for goods and services, including their ambition to exploit economies of scale and scope.

While OKMs may attract owners of high-quality inventions, their anonymity and speed may result in domination by ideas of low quality, and, in a variation of Gresham's law on money, in "bad knowledge driving out good knowledge". This risk can deter serious knowledge seekers from using the platforms and thus affect their long-term sustainability. By bringing together strangers, unbound by pre-established trust, the model marks a sharp departure from practices in which transactions tend to occur within an organisation's immediate (geographical or social) circle. Anonymity reduces disclosure risk and prevents competitors from gaining valuable information about a company's strategic interests, but also helps to dilute the reputational ties that bind parties together and prevent them from deviating from the established social norms that contribute to building trust.

In order to be efficient, OKMs typically require standardised models to collect and convey information about the knowledge being procured and the knowledge being offered. Otherwise, they would not deliver services at a significantly lower cost than the sum of individual, un-coordinated search efforts. OKMs typically use proprietary technologies and databases to provide value added services that are not openly available. The use of semantic technologies can be particularly important for organising and communicating information about knowledge. They help process content from unstructured text and extract the names, dates, organisations, and events from a text. They can tease out trends and correlations in large sets of data, answer complex questions automatically through machine-learning algorithms, and use heuristics and rules to tag data with categories to help with search and analysis. They also allow users to locate information by concept instead of by keyword or key phrase. Semantic Web technologies enable users to create data stores on the web, build vocabularies, and write rules for handling data.[7]

OKMs use a number of strategies to address the challenges of misappropriation and asymmetric information problems that challenge their existence. For example, they have mechanisms that relate payments to the quality of the posted knowledge in order to attract knowledge seekers (Leland and Pyle, 1977). Non-disclosure agreements may not always be effective in reducing the likelihood that knowledge seekers will exploit disclosed information and imitate knowledge owners. Social norms in the network and reputational measures can sometimes be used to manage that risk. A marketplace may enforce disclosure requirements on knowledge owners to enable knowledge seekers to evaluate the knowledge accurately, but this may discourage some knowledge providers from participating. Dushnitsky and Klueter (2010) studied 30 prominent websites that act as marketplaces in which owners of knowledge (e.g. a patent owner or an entrepreneur with an innovative business idea) interact with knowledge seekers (e.g. potential licensees or prospective investors). They find that IP-related OKMs[8] systematically require entrepreneurs and inventors to disclose their inventions and/or make upfront fees a prerequisite for participation. Both mechanisms appear to alleviate adverse selection and thus attract prospective investors and licensees, but their effectiveness as an inducement to widespread market participation may be limited.

Box 6.1. New online knowledge marketplaces: The case of platforms for inducement prize contests

Online platforms for inducement prize contests represent an interesting example of KNMs. Contests have driven many innovations throughout history, from the construction of the Duomo in Florence in 1418 to the invention of an accurate ship-board clock to win the Longitude Prize of 1714. They have recently experienced a significant revival, as inducement prize contests and other crowd-sourcing tools have been enabled by a new wave of Internet-based platforms. Inducement prize contests are increasingly used by firms and governments worldwide to make prizes and challenges a complementary, and sometimes alternative, means to promote innovation, by having one party (a "seeker") challenge a third party or parties (a "solver") to identify a solution to a particular problem or reward contestants for accomplishing a particular goal. Challenges can range from fairly simple proofs of concept, to designs, to finished products that solve grand societal challenges. Competitions such as the Ansari X Prize in 1996 and Netflix's 2006 contest to improve its film recommendation engine received considerable publicity.

In recent years, the number of websites making and facilitating open calls for solutions to tasks such as logo design, software development, and image labelling has grown tremendously. Examples include Amazon Mechanical Turk, Ninesigma, Taskcn, Topcoder, 99designs, Innocentive, CrowdCloud, and CrowdFlower, to name a few. A number of governments have been using challenges and competitions as a means of stimulating innovation. In the United States, for example, the Challenge.gov website is a centralised clearinghouse for information about such competitions, including the National Library of Medicine's "Show Off Your Apps: Innovative Uses of NLM Information Challenge", which was intended to develop innovative software applications – using the NLM's collection of biomedical data, including downloadable data sets, application programming interfaces, and/or software tools – to further NLM's mission of aiding the dissemination and exchange of scientific information pertinent to medicine and public health.

…/…

Box 6.1. New online knowledge marketplaces: The case of platforms for inducement prize contests *(continued)*

As many types of competitions are used in different contexts, it is difficult to generalise. Evidence from the literature on contests implemented in the "TopCoder" and "Innocentive" platforms suggests that contests appear to be particularly useful for tackling high-uncertainty problems that can be defined in an abstract, standardised format and addressed by a relatively wide range of experts endowed with the fundamental tools to solve them. These platforms have been found to deliver solutions of a quality about an order of magnitude larger than state-of-the-art solutions, at a fraction of the cost (Jeppesen and Lakhani, 2010, Lakhani et al., 2013). These platforms and the award mechanisms they support can disrupt certain labour markets and existing models of innovation, as they transfer much of the risk and cost to the knowledge supplier. The literature also suggests the importance of considering participation incentives in detail (Boudreau et al., 2011).

Standards-setting organisations: Networks for codifying knowledge

A standard is a published document that contains technical specifications or other precise criteria designed to be used consistently as a rule, guideline or definition. Standards are created by bringing together the experience and expertise of all interested parties, such as the producers, sellers, buyers, users and regulators of a particular material, product, process or service. The collaborative process of standard setting, in which standards setting organisations (SSOs) play a major role, requires a significant co-ordination effort by interested parties. The broad class of SSOs comprise both "traditional" standards development organisations and the consortia, alliances, special interest groups and other organisations that have emerged in recent years. SSOs differ in their geographic membership and technology and sectoral focus.

Examples of SSOs include the International Organisation for Standardization (ISO), the International Electrotechnical Commission (IEC), the International Telecommunication Union (ITU), the IEEE (originally the Institute of Electrical and Electronics Engineers), the European Telecommunications Standards Institute (ETSI) and national organisations such as the American National Standards Institute (ANSI), the British Standards Institute, the "Association Française de Normalisation" (AFNOR) and Germany's Deutsches Institut für Normung (DIN). These are typically private non-profit organisations with varying degree of public-sector engagement. In addition to standards development, some organisations focus on activities to support and promote the development of standards, including provision of information, certification, accreditation and training services.

SSOs are network-based collaborative mechanisms that underpin the process of knowledge co-creation, which allows the dispersed and often tacit knowledge of a limited number of experts to be easily communicated and codified for wider usage and adoption. By developing a common language and definitions, the use of standards facilitates the exchange of information and knowledge. Given the wide range of standards available, it is not possible to estimate the contribution of SSOs to knowledge flows. However, many firms hold that standards are a source of information that facilitates their innovation activities (Swan, 2010).

SSOs are both affected by the development of markets for IP rights and further shape their development. A recent study by Bekkers and Updegrove (2012) provides a comprehensive assessment of the challenges arising from the interaction between standards and IP rights and the role played by SSOs. IP rights policies are a major aspect of SSO practices because the implementation of a standard may require the use of products or processes that draw on protected IP rights. This is the case of standards-essential patents (SEPs), which grant the owner the ability to control the use of an invention required to practise a given industry standard.

SSOs must strike a fine balance between securing participation by owners of relevant technology ("the supply side") and encouraging adoption of the standard ("the demand side"). While SSOs may require SEPs to be made freely available to standard users, the usual response of SSOs to the "hold-up" problem – i.e. the demand for excessive royalty payments once the standard has been adopted and investments have been made by producers – is to require IP holders in advance to make their essential technology available on "fair, reasonable and non-discriminatory" (FRAND) terms in return for having the technology selected as a standard.

FRAND pledges have recently become a focus of contention in technology markets – particularly for ICT standards – because FRAND terms can be ambiguously specified, leaving considerable room for disagreement between parties regarding the transferability of those pledges and the determination of an appropriate royalty rate in thicketed markets (Box 6.2). The recourse to injunctions by SEP holders has been evaluated by courts and authorities, which are concerned about the potential implications for competition and innovation. There is an on-going debate as to whether SSOs should determine more precisely IP terms at the standard-setting phase, but many observers see this as a potentially unwelcome distraction from their core remit.

Box 6.2. Patent thickets and patent pools

The last two decades have witnessed an unprecedented growth in the number of patent applications filed and granted in all major intellectual property offices. The scope of patentable subject matter has widened in a broad number of jurisdictions. The possibility of granting software and business method patents has led to difficulties in assessing the patentability (in particular the non-obviousness) of new inventions. Although the general increase in numbers is a potential source of inefficiency in the system, many observers have found that it is not the numbers but the structure and complexity of relationships among patents that may be more problematic. The existence of "patent thickets", which can be defined as dense webs of overlapping patent rights (Shapiro, 2001), has become a growing problem for inventors who seek to commercialise their inventions. This is particularly the case in "complex product" industries, such as electronics and semiconductors, which are characterised by cumulative processes of innovation (Ziedonis, 2004). The high search and transaction costs that must be incurred to hack through patent thickets may discourage market entry, depress competition and negatively affect future innovation (Hargreaves, 2011). The problem is even more severe when the ownership of patent rights is fragmented among multiple entities, a situation that tends to considerably raise bargaining costs in licensing negotiations. A recent study by von Graevenitz et al. (2011) shows that the market for complex technological products (e.g. electronics and semiconductors) has become increasingly thicketed, while that of discrete technological products (e.g. pharmaceuticals) has only experienced a mild increase in thickets.

Highly thicketed markets tend to exacerbate two intertwined problems: patent holdup and royalty stacking. As explained in Lemley and Shapiro (2007), patent holdup refers to the threat by a patent holder to obtain an injunction that will force the downstream producer to pull its product from the market. Injunction threats often involve a strong element of holdup when the target firm has already invested heavily in the design, manufacture, marketing and sale of the product with the allegedly infringing feature. In these cases, the threat of injunction enables the patent holder to negotiate royalties far in excess of their invention's true economic contribution. These excessive royalties may act as a tax on new products incorporating the patented technology, thereby impeding, rather than promoting, innovation. Royalty stacking occurs when a single product is protected by multiple patents. Under many plausible circumstances, the threat of litigation and holdup can result in royalty values that exceed the intrinsic value of the invention. The growth in complex, highly interlinked technology domains such as ICT has resulted in patent pools being used to circumvent the patent thicket problem by allowing firms to combine their patents, sharing them with other patent holders and, in some cases, licensing them to other firms as a package. Examples include those devoted to the rights associated with standards for telephone or video compression. The resurgence of patent pools has been subjected to close scrutiny by competition authorities to ensure that they do not impede access to the market by hindering competition, a socially undesirable outcome that is more likely when IP rights are close substitutes, rather than complements.

Knowledge markets and emerging technologies: The case of synthetic biology

Emerging technology domains with potential "general purpose" features present challenging test cases for KNMs. It is important for policy makers to consider how the knowledge market supports the growth of promising new general purpose technologies, drawing lessons from past experience in other technology domains.[9] For example, the emerging field of synthetic biology relies heavily on engineering and computer science.[10] As noted by Torrance and Kahl (2012), among others, disciplinary influences on synthetic biotechnology have led to more consideration of standards setting, interoperability and interchangeability than is usual in other areas of biology. Rai and Kupmar (2007) have noted that, by operating at the intersection of biotechnology and information technology, synthetic biotechnology has the potential to be affected by the intellectual property problems that exist in both fields. They found, in a preliminary patent landscape, problematic foundational patents that could, if licensed and enforced inappropriately, impede the technology's potential and result in a proliferation of patents on basic synthetic biology "parts" that could create patent thickets. Both foundational patents and patent thickets are likely to be particularly problematic to the extent they read on standards that synthetic biologists would like to establish. Synthetic biologists have argued that strings of DNA bases are comparable to source code and that DNA strings could therefore be covered by copyright. However, Rai and Boyle (2007) have questioned the appropriateness of invoking copyright protection in this domain, owing for example to the wide scope for expressive choice when constructing DNA sequences with base pairs that do not exist in nature.

Many institutions that have features of knowledge markets, networks and collaborative mechanisms have been created with standards setting in synthetic biology as an important goal. Probably the best known is the BioBricks Foundation (BBF), which has created a registry and repository of standard biological parts that are the building blocks of synthetic biology, effectively promoting the creation of a "commons" solution. A BioBrick™ standard biological part is a "nucleic acid-encoded molecular biological function […] along with the associated information defining and describing the part". Scientists can browse the BioBricks catalogue and contribute new parts that conform to the Foundation's specification. The BBF also provides a model contract "that allows individuals, companies, and institutions to make their standardised biological parts free for others to use". BioBricks has created a technical standard, an open technology platform, and a repository open to anyone interested in building new biological parts. An example of a patent-based commons is the one created by the group Biological Innovation for an Open Society (BIOS).

Among the standards-setting groups that have formed in the synthetic biology community, most have expressed a preference for standards that remain open and accessible to the community as a whole. In this early development stage, academics play an important role and the public ethos is quite visible. This preference, however, has not yet been incorporated into formal policies requiring the disclosure and licensing of IP rights covering technical standards, which frequently draw on outputs of publicly funded research. Whether such policies could be made mandatory or would ultimately be beneficial to the field of synthetic biology remain open questions. Synthetic biology also illustrates a potentially symbiotic relationship between open and proprietary innovation models. For example, the dissemination of synthetic biology "parts" on a free and open basis would likely increase demand for various proprietary DNA-synthesis platforms. A 2009 OECD symposium on the opportunities and challenges of synthetic biology highlighted the intellectual property challenges, including the relevance of various forms

of IP protection for the bundle of rights covering patents, material transfer agreements, databases, trademark- and copyright-protectable material (OECD, 2010c). The symposium noted that the synthetic biology community was built around trust, because output volume was still relatively small, but raised questions about the transition to the more contractual basis that may develop in the event of rapid growth. The symposium stressed the importance of user-driven, collaborative and community-driven approaches for progress in this field.

Markets for intellectual property rights

Intellectual property rights

The creation and assignment of IP rights convey a right to exclude third parties from the economic exploitation of an idea (in the case of patent rights) or of a particular expression of an idea (in the case of copyright) that has been disclosed. This right is provided for a defined period, applies in a given territory, and is theoretically underpinned by a social contract that provides legal protection against misappropriation in return for disclosure of the idea or its expression.

In most jurisdictions, IP rights include patents, copyrights, trademarks and designs. Innovation surveys have been and are being used to collect information on firms' use of IP strategies to protect their innovations. Frenz and Lambert (2012) identify a strong association between modes of innovation and IP protection strategies, based on 2006 data, the latest year in which the Community Innovation Survey (CIS) reference questionnaire included questions on IP rights. OECD analysis of CIS data indicates that trademarks are the most frequently and widely used form of IP protection, with more than 10% of companies reporting their use. Use of trademarks is more likely in knowledge-intensive services. A more recent wave of official survey results reporting statistics on the use of IP in firms has become available. For example, a recent survey by Statistics Canada shows that among the 5% of Canadian companies that held or used patents in selected industries, most have been applied for by the firm or originated with founders or predecessors. Non-disclosure agreements are the most often cited type of IP used by Canadian firms and are used by nearly 26%, followed by trademarks (20%), copyrights (18%), IP accessed through open sources (12%) and trade secrets (7%).[11] In the United States, trademarks and trade secrets are identified by the largest number of businesses as important forms of IP protection, followed by copyrights and then patents (Jankowski, 2012).

Statistical evidence on business IP strategies can also be gauged from the linking of registered IP data to business registers that contain information on companies, such as the public repositories in which companies file their accounts as part of their corporate reporting activities. Initial results from OECD work linking patent and company databases provide a picture consistent with previously available evidence, but highlight the challenges for describing patenting behaviour when business register data are incomplete and coverage is limited to certain types of firms. This type of exercise should be replicated on a country-by-country and confidential basis with more reliable, national statistical registers. These could be further linked to national innovation and R&D surveys in order to gain a more complete picture of the relationship between patenting behaviour, innovation activities and business performance.

The ability of IP rights to exclude third parties allows the organisation of markets for knowledge.[12] In turn, the availability of IP markets creates economic incentives to generate new protectable ideas and to find new applications for old ones. If IP markets succeed in allocating these rights to those who are prepared to pay the most for them, they

can serve a socially useful purpose by preventing ideas from remaining the exclusive and possibly secret possession of creators, discoverers and inventors, who can in turn be rewarded for their efforts and achievements.

In order to understand the very specific features of IP rights as instruments in the market for knowledge and technology, it is equally important to understand what potentially limits their use as currency-like instruments for specialisation and knowledge exchange. Because the validity of an IP right can often be questioned and challenged, its value is somewhat uncertain. The distribution of patent value is in fact highly skewed: a few patents are very valuable while a majority have very limited value on their own (InnoS&T, 2011). The knowledge contained in a disclosed invention may also be insufficient to enable its practical use. Further agreements are often required to access the know-how and additional information may be required to put an invention to use. IP rights are negative rights in the sense that they only confer on the holder the right to preclude third parties from using the protected knowledge. The owner only has the right to use provided the use does not infringe on other IP rights held by third parties. This is difficult to establish as there need not necessarily be a simple correspondence between an idea (e.g. a patented invention) and a particular innovation, which may draw on several rights of different forms. Finally, IP rights are not uniformly enforced and infringement can be inadvertent.

For these reasons, the IP market is not necessarily driven by the transfer of technological knowledge. It can also serve as a mechanism for procuring rights to sue potential infringers and for settling the outcome of litigation (through the payment of royalties, in addition to any damages awarded). Depending on the perspective adopted, the ability to trade IP rights provides buyers with a range of assertive and defensive[13] strategies that leverage the broad range of remedies offered by courts, such as injunctions, damages and royalties. Independently of these potential uses, which underpin the value of a patent to a potential acquirer (technology transfer, offensive and defensive uses), IP rights can be also used as security in financing deals. According to the strategy pursued by an organisation, patent portfolios can be leveraged externally in many ways.

In the post-war period, when the innovation landscape was characterised by the dominance of large industrial corporations, relatively small sums were exchanged in the market for patent rights, as companies typically developed their inventions in house and implemented cross-licensing agreements to attain freedom to operate in their markets. In the last couple of years, unprecedented sums of money have been paid in auctions for patents and for the acquisition of patent-rich companies. These deals have brought the market for patents to the attention of the wider public. For example, the Nortel patent portfolio reached USD 4.5 billion in auction while IP-rich Motorola was sold to Google for more than USD 12 billion. Kodak has been selling its digital imaging patents to a consortium of technology companies led by two well-known companies in the patent fund marketplace (RPX and Intellectual Ventures) as part of on-going bankruptcy proceedings. Using data from various sources, the IP market intermediaries IPOfferings LLC analysed 35 transactions made in 2012 and found a unit value per patent close to USD 373 000, and a median value just above USD 220 000.[14]

The size of the market for IP rights

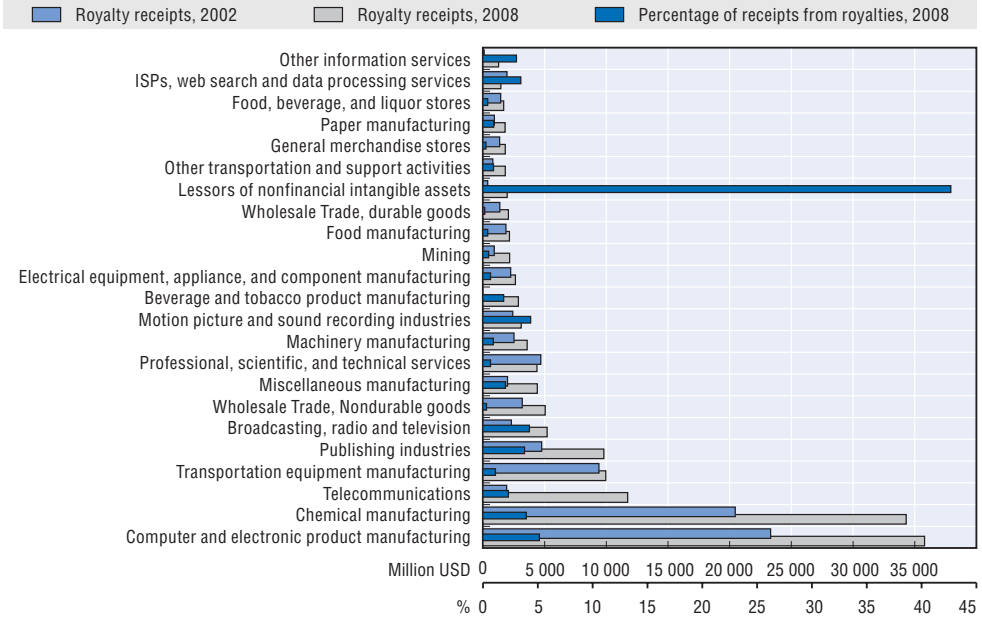
Available statistics, while providing only a partial picture, appear to confirm a trend towards increasing trading levels for patents and other IP rights, although these apply only to a minority of companies and patents. Managers are realising that even after a company loses its overall competitiveness in its product market, its legacy IP can be a valuable asset to be

used in a number of ways. IP markets have therefore provided investors with an avenue for value realisation that is independent of the commercial success of their venture. Robust estimates of the size of the IP marketplace are difficult to produce because most transactions are based on confidential agreements and key elements go unreported in open sources. Furthermore, statistical agencies have had few incentives to collect related information on a confidential basis because a majority of IP rights were not considered as produced assets, but as the outcome of administrative decisions, and therefore did not count – for national accounting purposes – as the formation of new capital by firms, organisations or individuals. By implication, most IP-related transactions did not appear in the estimation of key economic aggregates such as investment or GDP unless they involved cross-country transactions.

Evidence from trade-related statistics suggests an upward trend in transactions. Disembodied technology royalty payments and receipts across countries increased at an average annual rate of 8.5% during 2000-10, well above growth of world GDP, and reached a total value of approximately USD 180 billion in 2009 (Athreye and Yang, 2011). These figures include transactions between affiliated parties, which have been estimated to account for approximately two-thirds of the overall value of transactions. Similar results are obtained from more recent data in the OECD's Technology Balance of Payments Database (OECD, 2012b).

Specific information on royalty and licensing income for the entire economy, including both domestic and international transactions, is difficult to come by for the aforementioned reasons. According to the United States Statistics of Income, based on the "gross royalties" income line of the US Corporation Income Tax Return Form 1120, the returns of active corporations reported gross royalty receipts increasing from USD 115.8 billion in 2002 to USD 171 billion in 2008, for nearly 1% of total business revenue.[15] Figure 6.2 shows that in 2008 over 5% (i.e. more than USD 35 billion) of income in US computer manufacturing industries derived from royalties and licence fees. This figure is likely to have increased since, judging by recent news coverage and reports such as those mentioned above.

Figure 6.2. US internal revenue service royalties by industry and royalty revenue shares, 2002-08



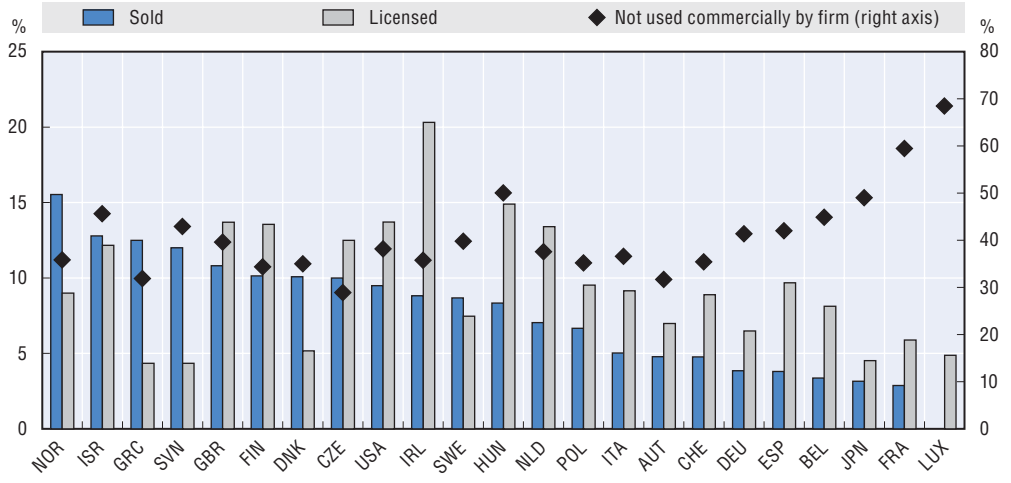
Source: OECD, based on SOI Tax Stats - Table 16 - Returns of Active Corporations, Form 1120. www.irs.gov/uac/SOI-Tax-Stats---Table-16---Returns-of-Active-Corporations,-Form-1120 Accessed on September 2012.

IP transaction strategies

A number of business surveys, such as the re-designed US Business R&D and Innovation Survey (BRDIS), provide detailed, although not internationally comparable, evidence on the use of various forms of IP transaction strategies. Preliminary results suggest that, for 2009, in the full population of companies, use of open source and freely available sources were the most common form of IP-related exchange (1.3% of all firms). In second place, slightly fewer than 1% of companies indicated having received IP from unrelated parties through assistance or "know-how" agreements, and a slightly smaller proportion reported the counterpart outward flow of know-how. Other forms of transaction, such as cross-licensing, spin-off or spin-out activity, and IP-motivated merger and acquisition activity are much rarer in the general population of firms, although it may be qualitatively and quantitatively significant among the subset of R&D-intensive companies, indicators that are not currently available. In Canada, detailed information on sources of patent use reveal that 0.7% of all companies license patents, while the fraction of companies acquiring rights to patents stands at 0.4%. In contrast, the acquisition of patents via mergers and acquisitions stands at a slightly higher 0.5%. It is important to bear in mind that these are not exclusive categories. In addition, 0.2% of firms engage in cross-licensing agreements while only 0.1% report accessing patents through patent pools.

Figure 6.3. Patents sold, licensed and not used commercially

As a percentage of patents, by country



Source: InnoS&T (2011), based on inventors identified from patent applications to the European Patent Office with priority dates between 2003 and 2005. Data available from www.innost.unibocconi.it

In contrast to representative sample surveys of the entire business population, public patent data repositories enable the retrieval of inventor and patent ownership information, which can facilitate analysis of patent-inventor or patent-owner pairs. The InnoS&T survey of inventors who filed patents at the European Patent Office (EPO) (InnoS&T, 2011) shows significant variations in the likelihood that patents are used either in transactions or internally by firms. Figure 6.3 shows that in most countries patents are more likely to be licensed than sold. This may reflect the need to mitigate informational asymmetry problems that impinge on the economic valuation of intangible assets. The most likely use for patents is often within the firm, although a large proportion of patents

are not used in either way. Their implicit value arises from the option to use the knowledge and associated rights (internally, licensing to third parties, or litigation) in the future. This finding has been used to motivate a discussion on policies to ensure the economic exploitation (valorisation) of patents.

The proportion of patenting companies that license their technologies to non-affiliated companies was estimated by Zúñiga and Guellec (2008) at 13% in Europe and 24% in Japan, based on a sample of 600 European and 1 600 Japanese patent filing firms. A previous, smaller-scale study of 105, mostly large, firms in Europe, North America and Asia-Pacific revealed that almost 60% of the firms interviewed reported increased inward and outward licensing during the 1990s (Sheehan et al., 2004). Moreover, North American and Japanese firms reported this more frequently than European firms.

Box 6.3. Data on patent re-assignments and knowledge markets

Under some conditions, it is possible to identify trade in patents through changes in patent ownership records. Patent ownership data is "noisy", as not all transactions are necessarily recorded at all or in a timely fashion, as recording in most jurisdictions is only required to protect rights owners against third parties acting in good faith. Alternatively, confidential agreements and warrants can be used by parties to protect their rights against other trades that impinge on the value of the patent, particularly if there are strategic reasons for not publicising the existence of a deal. Furthermore, patent documents cannot provide up-to-date, detailed information on the ultimate ownership of patents, which requires parties willing to trade to conduct complex due diligence exercises. In many cases, reassignments are only belatedly registered with no particular strategic motivation. The administrative cost (direct and legal fees) can add up substantially if the transaction requires recordation for several patents and in many different jurisdictions. Notwithstanding these limitations, the analysis of ownership changes could be a promising avenue for future research and indicators, if differences in legal regimes and enforcement can be accounted for.

In the United States, Serrano (2011) found a re-assignment rate of 10% for total granted patents by the USPTO (including reassignments owing to mergers and acquisitions). Traded patents were more likely to have a higher number of citations and come from private inventors and small firms than their non-traded counterparts. Ménière et al. (2012) have also investigated ownership registration changes for French patents, distinguishing between those applied for at the national and European patent offices from 1997 to 2009. They find that approximately 2.7% of patent applications were reassigned (5% of granted patents), of which nearly three-quarters correspond to transactions within the same group. This indicates a relatively low proportion of patents being sold as arm's-length transactions. This marked difference with the United States is consistent with the results of the InnoS&T/Patval studies. Results for Japan indicate comparable results (Chesbrough, 2006b). The overall reassignment rate stood at around 3% in 2005, depending on the method of calculation, with only 30% of reassignments being accounted for by actual transfers (compared with 20% in 1997). The bulk of reassignment activity corresponds to name changes (nearly 50% of the total plus a further 18% for mergers). One pattern that is common to reassignment data across many countries is that it mainly occurs across affiliated enterprises within larger organisations. It provides more evidence of dynamism and restructuring within companies than of activity in the market for technology.

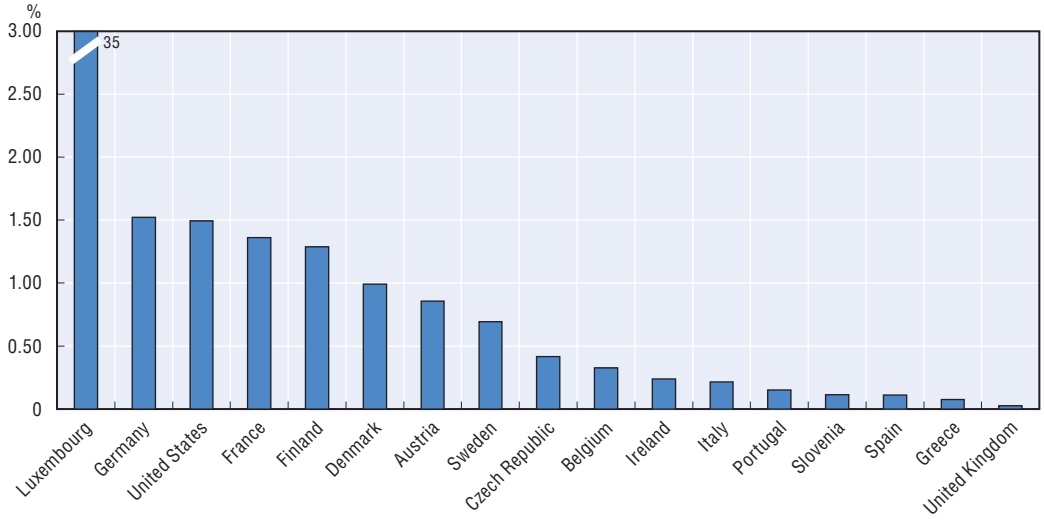
Intermediaries

The increasing importance of markets for technology and other intellectual property has given rise to the appearance of companies whose main activity is the monetisation of IP, principally through licensing. A possible indicator of the relative importance of IP intermediaries in the innovation system can now be derived from detailed service sector statistics corresponding to a recently identified sector in the standard international classification of economic activities ISIC774 ("Leasing of intellectual property and similar products, except copyrighted works") and its counterpart in the North American Industrial

Classification (NAICS) category "Lessors of Nonfinancial Intangible Assets (except Copyrighted Works)", subsector NAICS533. This includes establishments that are primarily engaged in assigning rights to assets, such as patents, trademarks, brand names and/or franchise agreements for which a royalty payment or licensing fee is paid to the asset holder. Firms in this subsector own the patents, trademarks and/or franchise agreements that allow others to use or reproduce the IP for a fee and they may or may not have created those assets. The revenue for companies in this industry sector comprises not only royalties and licence fees, but potentially also litigation compensation, fees for ancillary IP management and advisory services. Figure 6.4 presents the revenues of this industry (scaled by the business sector's overall investment in the categories of knowledge-based capital dealt with by this industry). Leaving aside the outlier case of Luxembourg, this proxy indicator of IP specialist trade intensity is dominated by Germany and the United States, followed by France and Finland. In the United States, data available from the Census Bureau indicate total revenues of USD 20 billion in 2010, a significant increase (4% nominal) with respect to 2009 at a time of widespread economic contraction. Comparing US and EU totals for 2009, the last year for which a full EU figure is available, estimates suggest that US licensing industry revenues (at around EUR 13 billion) were nearly 90% larger than in the EU (EUR 6.7 billion), a possible indication of a higher degree of specialisation in the market for IP rights. More up-to-date figures for individual EU countries indicate particularly high growth rates. For example, in Germany, revenues increased by nearly 25% in 2010. In the United Kingdom, turnover for this sector was estimated to be seven times as large in 2011 as in 2009 (although starting from an admittedly low value). As official statistics begin to emerge for this sector on a wider international basis, it will become more important to understand what types of companies are effectively included in and excluded from this category.

Figure 6.4. Revenues of specialist licensing firms, 2009

As a percentage of business investment in R&D, other innovative property and economic competences



Notes: Turnover estimates of NACE Rev2 sector ("Leasing of intellectual property and similar products, except copyrighted works") and NAICS Sector "Lessors of nonfinancial intangible assets (excluding copyrights)", divided by Intaninvest estimates of business sector investment in intangible assets currently not included in the pre-SNA 2008 National Accounts asset boundary (R&D, Design, New Financial Products, Advertising, Market Research, Training and Organisational Capital).

Source: OECD analysis, based on Eurostat (2013), Annual detailed enterprise statistics for services; United Census Bureau 2010 Annual Services Report Data, and Intaninvest cross-country intangible investment data, www.intan-invest.net (Corrado et al, 2012).

Patent assertion entities

Unlike companies that license their IP for new products, a category that includes many universities and R&D specialist companies, patent assertion entities (PAEs) assert patents on existing products as a business model (Chien, 2012b). PAEs – sometimes pejoratively described as patent trolls – share a number of unusual features: they have relatively low assertion costs as they cannot be countersued or disrupted in their activities; because they do not operate in the market they cannot infringe on other parties' IP. Furthermore, they often use contingent fee lawyers and assert the same patents in the same venues to capture economies of scale (by reducing the marginal cost of bringing forward an additional case). While courts are now less willing to grant injunctions to such companies and thereby reduce their scope for demanding high licence payments and damages, the cost of litigation for the alleged infringer is such that it can be economical for the defendant to settle, regardless of the merits.

PAEs have been described by experts in the field as a "path-breaking, legal and disruptive technology for monetising patents that eliminates traditional obstacles to enforcement" (Chien, 2012a). From the perspective of inventors, the model provides the opportunity to sell their IP at more favourable prices, because PAEs are likely to outbid an un-coordinated set of operating companies. This can create incentives for invention, as the exit value increases. From the perspective of market operators, PAEs can be particularly damaging and inhibit the commercialisation of promising inventions. Recent US evidence suggests that the majority of new patent infringement suits are brought forward by PAEs. However, public cases may be only a small fraction of all relevant disputes since private demands – as well as public cases – are often resolved under non-disclosure agreements. This implies that very little is known about the overall impact of PAEs. It is not clear either whether the phenomenon is as prevalent in jurisdictions outside the United States or whether any major changes can be expected in the near future.

A potential on-going development is that PAEs may be used by companies seeking to shield themselves from the retaliatory and reputational costs arising from attempts to assert patents. In this scenario, companies could retain a licence on the IP but sell the ownership rights, thus transferring to the new buyer the ability to sue potential infringers. An escalation scenario may distort the already fragile balance of "mutually assured destruction" strategies that has led many companies to build up large IP portfolios. The implications for the credibility of the IP marketplace and the future conduct of innovation in some technology domains could be particularly damaging. Public authorities may need to consider whether increased transparency in the market for patents could help mitigate this risk as well as the point at which the public interest might take precedence over the legitimate right of companies to maintain a basic degree of confidentiality in their innovation strategies.

The market for IP rights for financing purposes

Markets for disembodied knowledge can also allow companies to leverage their knowledge-based assets to raise finance. To the extent that they can be transferred independently and provide their owners with economic value that does not automatically dissipate, rights to intellectual assets can be used, at least in principle, to secure funding for business activities. This can enable investors to manage their risk exposure by selling and buying IP in liquid markets where prices reflect the underlying value of the assets. The economic and financial crisis has accentuated firms' difficulties for financing their innovation activities, which require long-term capital commitments to move from invention through to commercialisation. The crisis has also reduced confidence in the ability of markets for complex products to address information asymmetries and align risks and rewards.

New valuation methods and products are increasingly used to demonstrate the independent (direct or indirect) cash-flow-generating capacity of knowledge assets, but progress has been limited so far owing to the lack of widely applicable standards and methods across very idiosyncratic intellectual assets. Furthermore, although knowledge assets and other intangibles account for a large proportion of the market value of companies, not all are suitable for use as collateral and for being traded independently. The existence of a well-functioning market for IP rights depends critically on the ability to identify and transfer the rights to these flows. This could provide in some cases a much needed source of collateral, particularly for firms with a limited track record and with few tangible assets to pledge against finance. Existing and new players are developing various strategies and business models to use knowledge-based capital as a mechanism for raising finance. Yanagisawa and Guellec (2009) discuss different types of companies that provide IP-based financial instruments. These have also been examined by Ellis (2009) and Nikolic (2009).

IP equity funds invest money raised from the capital market in promising inventions. They acquire rights to a number of inventions from sources with cutting-edge technologies, such as universities, research institutes, individual inventors and small start-ups. Large investment banks and boutique private equity (PE) firms alike have been involved in activities that target intellectual property and other intangible assets. Investors in the fund may not have specific strategic interests as regards the use of the IP rights, but it is in their interest for these to be fully utilised so as to maximise revenues for the fund. Patent trading funds collect investments from private equity, institutional investors, high net worth individuals, or other investors.

IP-backed debt financing. Intellectual property owners seeking debt financing may find that their trademarks, copyrights or patents are their most valuable property for use as collateral. In fact, a bank that provides capital or credit to an IP owner will most likely require pledging the latter's intellectual property as collateral. For example, Alcatel-Lucent recently secured a EUR 1.6 billion loan by using its extensive patent portfolio as collateral. Some firms specialising in lending structures based on intellectual assets provide additional services as a credit enhancement agent to the larger bank or firm that ultimately lends the funds, for example by agreeing to buy the intangibles of a firm undergoing bankruptcy proceedings at a given price. This helps the lender reduce its exposure to the vagaries of distress sales, i.e. auctions in bankruptcy proceedings.[16]

IP-related revenue stream securitisation is a variant of IP-backed lending, which allows a seller to use future cash flows from an asset or group of assets to receive upfront payments from investors in exchange for an interest in the revenue associated with the underlying asset. The basis for the work of royalty monetisation companies is existing licensing agreements between the original patent owner (licensor) and another company (licensee) that generate the somewhat predictable cash flows that enable investors to accept the exchange. Leading firms in this field include the likes of Capital Royalty LP, Cowen Healthcare Royalty Partners, DRI Capital Inc., Paul Capital Healthcare, and Royalty Pharma. Music copyright owners (e.g. the well-known "Bowie bonds") and companies in the pharmaceutical sector are known to have used such instruments. The underlying intellectual assets are used as security in order to reduce the risk borne by investors and increase their willingness to anticipate future proceeds. In a royalty purchase transaction, the capital-seeking company receives an upfront payment and assigns all or a portion of its future royalty inflows to the royalty monetisation company. The upfront payment is typically structured through a royalty bond issuance, whereby royalty interests are bundled, securitised and sold to the capital market. As security, the royalty monetisation company acquires the IP and concomitant licences through a special purpose vehicle (SPV) in a true sale transaction.

The policy landscape and its impact on the market for intellectual property rights

Providing quality assurance through the application and granting process and communicating information about the ownership of IP rights such as patents rank among the key services provided by public authorities in the market for knowledge. This is just one example of the roles that governments and public-sector organisations play in facilitating, shaping and regulating KNMs. Regimes that grant and enforce high-quality, distinctive rights help reduce the threat of misappropriation and indirectly encourage the transfer of knowledge through IP rights. Strict IP award decisions contribute to higher quality and help reduce uncertainty about the validity of the granted IP rights. A systematic requirement to pay renewal fees is thought to encourage the search for potential licensors if the company does not intend to develop the technology itself, as it increases the opportunity cost of holding patents without using them. Rules regarding responsibility for litigation costs linked to the final outcome can affect litigation costs and potentially deter assertion-based IP market models.[17]

Patent rights that are limited in time and scope in return for disclosure of information on inventions is a common feature of the social contract of modern economies (Graham and Vishnubhakat, 2013). An IP marketplace potentially enhances but also potentially disrupts the balance of the IP system, while changes to the IP system can affect the performance of the IP marketplace. The US Patent and Trademark Office (USPTO) and the EPO have recently overhauled their fee structures and rules in order to discourage excessive patent filing. Both institutions have also expressed the need for better screening of patent applications in order to increase patent quality.[18] Transparency in the patent market as regards information on IP rights ownership has also become an area of increasing policy interest. Lack of knowledge about patent ownership may undermine risk management and decision making about patents, creating arbitrage and hold-up opportunities, and is a major component of patent notice failure (Federal Trade Commission, 2011). Clarity regarding patent ownership is a critical component of patent notice. If patents provide the right to exclude, the public is entitled to know the source of the decision to exclude. While there are significant legal and economic benefits to accurate recordation of IP ownership (legally, when asserting IP against *bona fide* acquirers, and economically, when demonstrating the value of IP assets such as inventions to potential investors), there are many reasons why records do not accurately represent the real owner.

Chien (2012a) notes different factors that may account for poor patent ownership record keeping. These include: cost (attorney time and fees), especially for a privately owned start-up or small company, company dissolution or bankruptcy, or tax reasons. It may also occur if the patent is subject to a "whole company" transfer and no individual assignment is necessary, or if ownership issues are not straightforward. Too often, companies refer to themselves inconsistently in their interactions with the relevant IP office. Companies can also deliberately withhold patent ownership information in order to gain strategic advantage, for example to avoid indicating to competitors their intention to enter a given market.

The USPTO has been considering changes designed to encourage a more complete record of patent assignments. Late in 2011, the USPTO invited the public to provide comments on methods the USPTO can use to collect more timely and accurate patent assignment information both during prosecution and after issuance. In contrast, Japan's patent law has recently been amended to remove the requirement to register licensing agreements as a condition for allowing licensees to assert their rights against third parties,

as this was considered a too onerous reporting requirement. In Europe, a recent 2012 EC working document (European Commission, 2012) noted that information about valid patents is highly fragmented. While applications can be filed centrally to the EPO, patent maintenance is managed by national offices. The availability of data on the maintenance, ownership or licensing of European patents in the EPO Patent Register is at the discretion of national patent offices' reporting and transmission to the EPO. The implementation of the Unitary Patent system will affect the recordation system.

The provision of information on ownership and rights is important not only for assertion and defence purposes, but also for enabling a financial market for IP. Investors need reliable sources of information on the IP offered as security. For a lender to obtain priority over other parties that might have an interest in the IP owner's trademarks, copyrights and patents, lenders across OECD jurisdictions must "perfect" (complete a series of legal steps) their interest in the intellectual property. This means that they have priority over other creditors for the collateral if the debtor cannot repay its debts. In the United States, for example, lenders with a security interest are required to file financing documents identifying the security in compliance with either Article 9 of the Uniform Commercial Code (UCC) or an appropriate federal government entity as required by statute. For example, the USPTO allows the recordation of security interests on patents. In France, notarisation is not required but a pledge of IP rights needs to be registered with the national register for intellectual property rights (INPI). A recent WIPO questionnaire indicated that recordation in IP registers was the prevalent requirement for effective security interest in IP against third parties (in Chile, China, Colombia, Estonia, Greece, Israel, Japan, Korea, Luxembourg, the Netherlands, the Russian Federation, Slovakia, Sweden, Switzerland and the United States, and, except for copyright, in Austria, Brazil, Estonia and Mexico). In Australia, Austria, Brazil, the Czech Republic, Germany, New Zealand, Slovenia and the United Kingdom, an interest becomes effective upon creation. Other registers can be used in Denmark, Israel, South Africa and Spain.[19] Information from these registers could be a potentially useful source of information for policy analysis.

Many companies subject to litigation threats are increasingly discovering the power of crowd-based information markets to carry out tasks that previously required expensive efforts by in-house legal specialists. These firms are turning to crowd-sourcing patent research sites including Article One, Patexia, and Ask Patents to help combat infringement claims, check for existing patents on products they want to develop, and scrutinise rivals' patents before licensing them. For example, when Philips Electronics faced a potential legal challenge on its LED lighting products, it turned to one of these services for evidence. On the policy side, a number of patent offices increasingly use crowd-sourcing methods to identify prior art. The EPO has launched a Third Party Observation service and the USPTO and Australia, among others, have developed peer-to-peer patent systems (www.peertopatent.org/ and www.peertopatent.org.au/, respectively). In the United States, the 2011 Leahy-Smith America Invents Act, designed to reduce litigation and streamline the patent filing process, attempts to improve patent quality by allowing researchers and patent attorneys to file evidence related to pending applications at the USPTO electronically.

Tax policies can have profound impacts on IP marketplace dynamics. International and domestic IP trade may be partly explained by the relative advantages of setting up separate companies and vehicles for managing revenues arising from the use of IP. Recent research has for example demonstrated that differences in capital gains taxes that apply to patent sales can drive incentives for individual inventors to sell their patents

(Galasso et al., 2011). This allows researchers to infer that in otherwise comparable circumstances, the reallocation of patent rights reduces litigation risk because buyers will deal more effectively with litigation challenges.

Many governments have become increasingly concerned about the ability of domestic firms and organisations, in particular the liquidity-constrained, such as small and medium-sized enterprises, universities and public research organisations, to access and operate effectively in a growing and complex IP marketplace. Policy makers have also been concerned about the way in which the move to a digital economy has rendered obsolete many of the traditional arrangements and infrastructures for clearing rights to art, music and other copyrightable items. This is also perceived as a factor potentially stifling the development of new businesses and ideas that draw upon such material. For example, the UK government has been considering the creation of a Digital Copyright Exchange to offer a more efficient marketplace for owners and purchasers of rights and to open up markets to creators who may not have previously been able to access them (Hargreaves, 2011). Other examples of government and public-sector organisation engagement in knowledge markets perceived to be deficient include: Denmark's web-based portal IP-Handelsportal, which aims to facilitate co-operation and trade in IP; the World Intellectual Property Organisation's WIPO Green, a hub aimed at enabling environmental technology owners to make IP and know-how available to users through a searchable public database of available intellectual property assets and resources; and Re:Search, a similar WIPO-led consortium in the domain of research on treatments for neglected tropical diseases.

Government intervention in the IP marketplace: Public patent fund initiatives

A number of governments and organisations are sponsoring the creation of patent funds as a policy instrument to promote the economic use of patented IP rights. The business models of government-sponsored patent funds share some features with those of private-sector funds. Patent funds can be defined as entities that invest in the acquisition of titles to patents from third parties, with a view to achieving a return by monetising these patents through sale, use of security interest, licensing or litigation. Some governments have recently contributed financially to the creation of private-public entities and consortia, either directly or through state-owned banks, which fund the acquisition of rights to patented inventions, among other possible activities. Examples include Korea (Intellectual Discovery and IP Cube Partners funds), France (France Brevets) and Japan (Life Sciences IP Platform Fund).

Many of these interventions are based on the perception that IP aggregation and defensive services are undersupplied in the marketplace and so require some degree of public co-ordination and support. This perception appears to be stronger outside the United States, where most private funds operate and where IP markets appear to be most developed. Advocates of public support for patent funds argue that publicly controlled funds are less likely to resort to aggressive patent assertion behaviour than their privately owned counterparts.

A number of objections have been raised against publicly backed funds. Constraints on the funds' IP assertion strategies may be difficult to define and implement, especially if a fund is operated at arm's length from public authorities. The acquisition strategies of funds may raise prices in the short term, without necessarily increasing the level of inventive activity, especially if actors consider the intervention to be transitory. The likely competition effects of public patent funds are also difficult to predict, as they will depend on how the fund is implemented and on the relations among the components of the patent rights portfolio. For example, bundles of unrelated IP assets contribute to a more diversified portfolio and financial exploitation, while complementary assets are better

suited to providing protective services around a set of technologies as a pool. The problems of adverse selection in buying – and moral hazard in managing – portfolios are common to private and public patent funds, but in the latter case the acquisition criteria need to be much clearer for accountability purposes. If they focus on specific technology domains, government-backed patent funds may unintentionally trigger technology lock-in if conducted at a sufficiently large scale. From an international perspective, government-backed patent funds bring about the risk that they may become instruments of support for national champions. Co-ordination of various national funds could be costly and challenging, especially if the funds' strategies give some form of preferential treatment to domestic companies. The inappropriate use of these funds could potentially result in escalating "patent wars" and "patent arms races" at the level of sovereign states.

Underlying the debate on the case for publicly sponsored patent funds is a recurring reference to countries' perceptions of weaknesses in national innovation systems in the face of fierce international competition, rapidly changing global value chains and patent-related initiatives adopted elsewhere. There is a risk that the stated objective of achieving a level playing field may unwittingly result in using patent funds to give preferential treatment to national champions. To counter this risk, a basic set of rules may be necessary at the international level, for example, to differentiate between defensive and aggressive behaviour and to recognise the eligibility of patent owners who genuinely invest locally in the patent's exploitation, including engineering, R&D or licensing. Policy makers should not lose sight of the need for coherent strategies for reducing the number of overlapping patent rights in complex product industries.

The implementation of policy experiments such as patent funds needs to be matched by a conscious investment in gathering evidence on their impact. Given the relatively limited public funds devoted so far to these policies, it is important to improve the evidence base before significant policy scale-up. Furthermore, without strong supporting evidence, these efforts are likely to be discontinued, whatever their actual merits.

Recent proposals for government-backed patent funds clearly recognise the importance of complementary measures to improve the functioning of the IP ecosystem. For instance, it is understood that the absence of operators and intermediaries in key market segments could hinder certain functions essential to promoting growth in the knowledge-based and inventive economy (database services, a rating system, portfolio management, etc.).

There is not enough evidence to make any firm recommendations on the design features that can be considered best practice, as the very rationale for public patent funds is still subject to question.

Knowledge flows through mobile knowledge workers: Potential barriers

Knowledge flows and job mobility

There is widespread consensus about the importance of knowledge diffusion as an enabler of innovation and about the key role played by networked and mobile highly skilled employees in facilitating such flows. Employee mobility is widely held to be important not only for enhancing labour market efficiency and productivity, by allowing human resources to flow to the jobs that value them most, but also as a major conduit for knowledge flows across firms and organisations. Human capital plays an essential role in facilitating knowledge flows, as knowledge cannot always be commoditised and transferred without the know-how and knowledge embedded in people that facilitate its absorption and use. For example, in their influential study of flows of technological

knowledge, Levin et al. (1987) highlighted the role of the movement of personnel – specifically, the hiring of R&D employees away from innovating firms – as a key element in a wider range of potential channels of information flows, such as licensing, patent disclosures and reverse engineering. This contribution also noted the very close link between the movement of skilled personnel and other forms of information flows involving interpersonal communication (technical meetings, informal conversations, etc.). Hyde (2011) went on to argue that "mobile employees are the best source for spreading lawful, public domain information". In particular, Hyde argues that, rather than trying to learn from scientific and trade journals, conferences and the like, it is easier for firms to hire someone with the relevant expertise. The labour market for the services of highly skilled individuals and knowledge workers can thus be described as one of the most, if not the most, important markets for knowledge.

While business innovation surveys carried out worldwide consistently find that the main source of information for innovation is typically found within the business itself or an affiliated company with shared ownership links, this may hide the fact that resources that are internal to the company at the time of reporting may have been obtained externally. Unfortunately, OECD countries have little information on the extent to which internal sources of innovation are linked to the hiring of new staff. One exception is the Australian Innovation Survey which asks businesses how they "sourced labour for the development or introduction of new goods, services, process or methods". Internal sources prevail, with 81% of firms referring to persons already in the company, while 22% of firms reported hiring new employees. Consultants and persons employed by the business's collaboration partners are mentioned in 18% and 11% of cases, respectively. The New Zealand innovation survey shows that the three most important sources of information for innovating businesses were "existing staff" (70%), customers (56%) and new staff (48%). Existing and new staff are internal sources of knowledge that businesses can draw upon to support their innovation efforts. New employees bring their previous education and talent to their job; they own these skills, and are free to decide if and when and where they will contribute this capital to the firm. However, the human capital embodied in employees contains a great deal more than what the employee brought from previous experience. It includes newly acquired knowledge through training or qualifications sponsored by the employer that may be applicable, to a greater or lesser extent, in other companies in the same or different sectors. Only by maintaining a continuing employment relationship with employees can firms secure exclusive access to and use of the organisation's stock of human capital and the knowledge assets embodied in its staff.

The empirical literature has found some evidence of positive knowledge spillover effects arising from mobility (e.g. Almeida and Kogut, 1999). However, the causal direction and the net impact of mobility are not known. A high degree of employee mobility implies the obsolescence of investments made by firms in knowledge that is embodied in employees, as well as a potential loss of competitiveness *vis-à-vis* competitors that may recruit former employees. Free riding on other individuals' and firms' investments in training is a well-known and important economic problem that is addressed through a number of contractual arrangements and practices.

Non-compete agreements

Over time, employers have developed strategies to protect business interests challenged by the risk of employee turnover. One of these strategies is to place contractual restrictions on employees, requiring them to agree not to compete with the employer upon departure from the firm. These covenants are typically described as non-

compete agreements (NCAs) and their use is widespread although not universally enforced. NCAs have been described as among the most sophisticated contractual instruments used in employment law today. By accepting NCAs, which can either be included in the employment contract or agreed upon separately, the employee promises not to carry out a set of pre-defined activities for competing firms if a number of conditions are met. Employees may thus be prevented from working for a competitor or starting up a business in a related area, within geographic and time limits after the termination of the employment relationship with the current employer. NCAs can also include specific provisions regarding protection of confidential information, such as solicitation of former clients and colleagues. In some cases, the NCA may include provisions that oblige the employer to compensate the employee for such restrictions.

The existence of rules preventing the enforcement of NCAs has been linked anecdotally to the entrepreneurial success of some states and industries. For example, in the early days of California's Silicon Valley, key inventors were allowed to set up their companies after leaving large incumbent firms. Saxenian (1994) examined key differences between Silicon Valley and Boston's Route 128 as part of an investigation into the role of decentralised industrial and innovation systems with comparable technological capabilities. She famously concluded that Silicon Valley's success at various stages had been related to the tendency of skilled employees to move from company to company and to apply the knowledge they developed along the way more easily. Gilson (1999) went further by arguing that jurisprudential differences between the state of California, which has banned non-competition agreements by statute since 1872, and Massachusetts, which permits them, could have had the probably unintended consequence of making it relatively easier to move jobs ("job-hopping") in California and thus to promote an entrepreneurial community of technology-based start-ups. While most observers are willing to agree with the general statement that knowledge spillovers provide economic benefits, it is also argued (Wood, 2000) that venture financing and start-up success have also been prevalent in regions where non-competition clauses are legal. The suggestion is that regions that enforce these agreements may have developed alternative means of ensuring labour mobility and the associated knowledge spillovers.

The potential impact of NCAs was noted in the OECD's *Innovation Strategy* (OECD, 2010a) alongside other labour market policies that may affect how the mobility of highly skilled personnel contributes to research and innovation activities. There are significant differences in general job mobility rates and average tenure across OECD countries. With few exceptions, job mobility is by and large lower in most European countries than in non-EU OECD countries, owing to differences in labour market regulations but also in general institutions and practices. The use of NCAs appears to be more prevalent than commonly thought, judging by evidence from *ad hoc* surveys and litigation statistics from the United States. Litigation on NCAs appears to be increasingly associated with disputes regarding trade secrets.

International comparisons of legislation on NCAs in employment contracts and its impact have been limited. Most of the policy debate and available empirical evidence have so far been largely US-centred, likely owing to the combined effect of significantly higher employee mobility than in many other OECD countries and the possibility for researchers to study variations across states, a source of greater analytical insight than comparisons across countries with very different labour regulations and systems. An initial investigation of legal sources was therefore carried out to identify how countries' regulations and judicial practices differ in their enforcement of NCAs and to examine a range of factors that affect whether and how the authorities consider NCAs to be

"reasonable". Among the parameters considered (Table 6.5) are the breadth of employers' protectable interest (e.g. whether it goes beyond trade secrets), the use of time and regional limitations, the special treatment of certain "knowledge workers", the required compensation for employees prevented from competing, the ability of courts to modify NCAs, and the possibility of awarding injunctions.

Table 6.5. Countries in which NCAs are lightly or not enforced

Country	General comments and key features
Australia	Common law declares restraint of trade clauses as prima facie void because considered against public policy. Restraint clauses must be proved reasonable. No formal requirement on compensation. New South Wales allows contracts to be modified.
Chile	Non-compete clauses made after termination of the employment contract are only accepted to a limited extent as they are deemed to be in conflict with the constitutional rights established in Article 19, Nos. 16 and 21, of the Constitution, namely freedom to contract in labour matters and the right to develop any economic activity. The Dirección del Trabajo has rejected non-compete clauses having effect after termination of the employment contract by Ruling 4 392/187 dated 6 August 1992 and Ruling 5 620/300 dated 22 September 1997.
Czech Republic	The employer is obliged to compensate the employee with his or her full average salary during the effective period of non-competition. The maximum period is 12 months.
Slovak Republic (until September 2011)	Non-compete clauses that apply after termination of employment were not permitted under Slovak law prior to 2011. Work Inspectorates were able to impose a fine of up to EUR 100 000 if the employer had concluded a non-compete clause with an employee. However, from September 2011, an amendment to Act 311/2001 Coll. Labour Code introduces the possibility of using NCAs that apply after the conclusion of the employment relationship.
Israel	Recent case law (see main text) has led some authors to conclude that Israel's National Labour Court's interpretation of the Basic Law of Freedom of Occupation effectively coincides with the California approach to NCAs.
India	Agreements in restraint of trade are governed by Section 27 of the Indian Contract Act 1872. Generally speaking, the validity and enforceability of a non-compete clause usually depends on whether or not such a clause constitutes or amounts to restraint of trade, which, with a few exceptions, is barred by law. All restrictions that operate after the term of the contract are void except in cases of the sale of goodwill, where protection may be given to the buyer. An employer would only be entitled to protect his proprietary interest, namely his trade secrets, confidential information, intellectual property, etc., and can in no way restrict an employee from working with anyone after termination of the contract.
Luxembourg	It is not possible to prevent an employee from working in competition with the former employer if this is done through a new employer, as the Luxembourg labour code only serves to prevent former employees from running their own businesses and does not stop employees from working for competitors within the framework of new employment contracts. Annual gross salary of the employee concerned must be at least EUR 47 875.60. It cannot be extended outside the Grand-Duchy of Luxembourg. A non-compete clause must also to be restricted to a specific professional sector as well as to professional activities that are similar to those performed by the employer, limited to a maximum 12 month period.
Mexico	Under Mexico's Constitution (Article 5), no one can be prohibited from participating in the profession, industry, business activity or type of work she/he chooses. In the context of an employment agreement, provisions can only deviate from labour law principles if the deviation is more favourable to the employee and the employee's Constitutional guarantees are not violated. An employer may not specifically enforce a covenant not to compete, but any breach of such covenant may give rise to an action for damages.
Russian Federation	Russian law does not allow for an employee to be restricted from working for another employer (a competitor of the company) during employment or for some time after its termination. If a non-compete clause is included in an employment contract, it cannot be legally applied and will not be enforceable in the Russian courts. In practice, many employers (especially companies with foreign management) often include non-compete provisions in their employment contracts and other labour-related documents as a "moral" obligation on the employee. The provisions of Russian law on the protection of information comprising commercial secrets (including production secrets) of the company are reported to be quite strict.
United Kingdom	Covenants not to compete after the end of employment are unenforceable unless the employer can show that they are reasonable. Courts are favourable to preventing restraints on trade. Less than one year in practice. Trade secrets and confidential information are automatically protected.
United States (California)	Under California law, covenants not to compete are generally void and unenforceable: "Except as provided in this chapter, every contract by which anyone is restrained from engaging in a lawful profession, trade, or business of any kind is to that extent void." Cal. Bus. & Prof. Code § 16000.

The interim results from an initial examination of legal sources indicates that, in addition to the better-known examples of US states such as California, India, Israel, Mexico, Luxembourg and the Russian Federation rarely enforce NCAs (Table 6.5). Chile and a number of "common law" countries such as the United Kingdom, Australia and

New Zealand have regimes in which the enforcement of NCAs is permitted but only under restricted circumstances. In contrast, most European continental countries and a majority of US states have a more permissive approach towards NCAs, although their statutes often require payment of compensation to affected employees, which in some cases can be particularly large. The enforcement of NCAs is evolving through legislative reform and case law arising from decisions by courts. For instance, the Slovak Republic allowed the use of NCAs in 2011 as part of a broader reform of labour market laws.

Policy and court decisions on NCAs have broad ramifications. A reduced level of enforcement may increase litigation around trade secrets or encourage firms to adopt other anti-competitive practices to limit the flow of employees across firms. For example, US authorities have been looking at the alleged use of agreements between major information technology companies not to poach each other's employees. In small countries, NCAs may have little independent impact because of the limited scope for employee mobility, particularly in highly specialised jobs. There is evidence that companies often use NCAs strategically, for purposes other than preserving trade secrets and other valuable knowledge. For example, NCAs are often presented to employees after they have signed their contracts or on their first day at work, when their bargaining power is limited (Marx, 2011). The available evidence suggests that NCAs often lead employees to take career detours away from their field of expertise, which may be socially wasteful and discourage specialisation and moves from academia (where NCAs do not apply) into industry (Marx and Fleming, 2012). Research shows that NCA enforcement does reduce skilled labour mobility across firms in the relevant jurisdiction (Marx et al., 2009), while encouraging key knowledge workers such as inventors to take jobs in areas where NCAs are not enforced (Marx et al., 2010).

However, the evidence on the impact on entrepreneurship and innovation is ambiguous. While employees might be more willing to leave an incumbent to join a start-up, the absence of NCAs may also allow incumbents to poach key staff from young innovating competitors. The impact on R&D efforts and patenting can be also uncertain. Initial OECD analysis of data by Bishara (2011) on changes in the enforceability of NCAs across US states for the 1991-2009 period looked at the statistical relationship between enforcement and two innovation proxies, R&D expenditures and patents granted. Initial results suggest a possible relationship between a reduction in the relative enforcement of NCAs and innovation. This preliminary result is imprecise and too broad to be interpreted as evidence of any particular mechanism through which NCA enforcement affects innovation in a given region or state. In contrast, Younge and Marx (2012) found that enforceable non-compete agreements boosted companies' Tobin's q – an indicator of company value in excess of asset values – by 26-30%, suggesting that the market places an extra value on companies whose human assets are more strongly protected by NCAs.[20]

The study of NCAs and their economic impact highlights the importance of assessing the systemic nature of the innovation system. While investment in innovation by any given firm may be encouraged through the strict enforcement of NCAs, this may not necessarily be optimal from the perspective of the system as a whole if the circumstances are such that the benefits arising from higher human resource mobility and knowledge flows outweigh the impact on the specific incumbent. The regulation and enforcement of NCAs lie at the complex intersection of employment, IP, contract and competition law. These various strands of law need to be considered as an interlinked set of rules that shape the relationships within the innovation system and the investment decisions of firms and individuals.

Policy makers can focus their future monitoring of existing practices by identifying how trade secret legislation and NCA rules intersect, and exploring how they can best address the strategic use of NCAs for purposes other than protecting legitimate business interests. For example, the US state of Oregon recently passed legislation requiring firms to make clear in offer letters whether employees will be expected to sign non-compete agreements, thus precluding the abuse of dominant position to impose NCAs after the terms of employment have been discussed. An improved evidence base would be an essential step in identifying the features of the labour market for inventors and other key knowledge workers that prevent flows from academia into research occupations in the business sectors.

Concluding remarks and measurement implications

Knowledge networks and markets play a central role in the functioning of the innovation system. KNMs should be recognised as being context-specific and should therefore be regarded as part of a wider toolkit. The promotion of specific knowledge markets should not be considered as a policy objective in its own right, but rather as a set of potential instruments for achieving a wide range of policy objectives. Policy makers should be mindful of the potential distortions that markets and the intermediaries that operate within them might bring for incentives to invest in innovation.

Interest in KNM is based on the notion that ideas and knowledge need to be put to work. While more knowledge can now be disembodied and separately traded, and potentially result in reduced transaction costs, it is still true that information, as expressed in textbooks or patents, usually must be invested in and interpreted by experienced people, or teams of people, with rich supplies of tacit knowledge and relevant implementation skills. Such tacit knowledge may in fact become the scarcest and most valuable factor of production. It is possible to understand observed patterns of location and co-location in knowledge-intensive industries from this perspective. This helps redefine KNMs more clearly, as a proxy for the kind of people-centred knowledge sharing that leads to innovation and economic growth.

Resources for innovation and growth in small and large companies are increasingly driven by access to knowledge markets and networks through a combination of closed and open, proprietary and free approaches. The coexistence of and potential synergies between these approaches is exemplified by practices being adopted in some emerging technology domains that the OECD has been examining in recent years. Trust, commitment, reciprocity and openness are all essential to effective markets and networks in which knowledge flows efficiently. For example, industries under pressure to deliver "winner-takes-all" blockbuster discoveries may fail to deliver sustained innovation because of overemphasis on confidentiality and insufficient collaboration. This problem can be resolved in part through precompetitive knowledge networks, which enable closed industries to experiment with greater openness. The use of trusted intermediaries to aggregate confidential knowledge, draw conclusions from it, and then pass the conclusions back to consortium members may also be valuable. Precompetitive information sharing and research collaboration can expand the knowledge commons, delaying the point at which companies feel they must start protecting their competitive differentiation.

Markets for IP rights are particularly complex for measurement (see Box 6.4) and policy analysis purposes and, on the evidence available, it is not possible to conclude that larger markets are necessarily a sensible policy objective. The absence of a healthy market for IP rights may be a symptom rather than a cause of weakness in an innovation system. Policy

makers should concentrate on identifying the ultimate causes and evaluating mechanisms for dealing with them appropriately. Among these, measures that improve the ability of markets to address the fundamental asymmetries that limit their effectiveness could feature quite prominently, but due care should be given to potential unintended impacts.

Box 6.4. Measurement implications

Mapping the innovation system and knowledge flows within it has been a long-standing ambition of the OECD as part of its development of conceptual, analytical and measurement frameworks that support policy decision making in its member countries. This requires a modern infrastructure that cannot be built overnight. Some countries have developed comprehensive strategies to trace some of the flows of knowledge and funds in ways relevant to their national systems. In a highly globalised world, the implementation of these approaches needs to be considered on a truly global scale. Through the OECD's work on KNM indicators, four broad areas for measuring knowledge flows have been identified:

- *Skills mobility and knowledge flows through people*. The specific knowledge embodied in people and the very different types of data required for tracing such flows warrant special measurement efforts, highlighting a number of indicators on the allocation and mobility (sectoral and international) of highly skilled individuals, from general graduates through to very specific populations such as doctorate holders or patent inventors.
- *Disclosing and accessing knowledge*. Analysing access to and use of knowledge sources found elsewhere in the innovation system, including repositories of disclosed information on science and technology, is of key importance. Citations of scholarly and patent publications provide a relevant source of information on knowledge connections, but are not the only ones. New approaches are emerging for tracing wider user communities and developing a more integrated measurement system that spans different, less traditional knowledge "communities".
- *Transacting on knowledge and knowledge rights*. Traditional and new evidence sources should be used to shed light on how different actors transact with other parties to procure knowledge. Current data on R&D funding flows and disembodied technology trade have significant limitations but also offer considerable potential. Transactions can relate to payments for accessing existing knowledge or benefiting from rights to it, but can also involve agreements to provide customised knowledge solutions.
- *Co-creating new knowledge*. Moving beyond transactions, several sources of evidence point to indicators of collaboration in the creation of knowledge. This includes the process of scientific creation, technological invention, and introduction of new products and process. In contrast to transactions, collaboration involves shared efforts, risks and, obviously, the upside from any resulting knowledge.

Because there is a risk that measurement will fail to keep up with the rapid changes in the innovation system, the policy debate may focus on fewer, easier-to-measure indicators that do not reflect the rich variety of mechanisms for exchanging and using knowledge. Building a measurement system that is able to capture differences between knowledge production and use (as in the case of R&D), cover partnerships and their financial dimension, monitor the combined outward and inward dimension of knowledge flows, and go beyond IP indicators as measures of the third-mission output of public research organisations, is a way to fill the most important evidence gaps at present.

Although knowledge is inherently connected, existing databases are not, and there are considerable technical and institutional difficulties for linking them (OECD, 2010b). For example, concerted efforts need to be made to disambiguate data on people and organisations engaged in knowledge creation. Raw data sources have to be transformed into standardised databases on which matching functions can be used to obtain derived and cross-linked information that can be mined for various purposes, such as research outcomes tracking and aggregating and analysing research, publications, patents and, finally, products. Measurement standards need to adapt to improve the interoperability of STI data sources across different domains, such as R&D, patents, other forms of registered IP, scientific publications, innovation survey data and administrative sources, and to develop solutions that address the impact of knowledge flows on the interpretation, relevance and international comparability of existing STI indicators.

Notes

1. The OECD's recent work on Knowledge Networks and Markets (KNMs), of which this chapter provides a synthesis, was partly funded by a voluntary contribution of the European Commission through its 7th Framework Programme, under the "Making the most of knowledge – KNOWINNO" project grant number 257078. The chapter draws on contributions from various OECD working parties. The project has benefited from the input of policy officials and experts and participants at three workshops in June 2011 (Paris), November 2011 (Alexandria, United States) and May 2012 (Paris), a final conference held in Paris on 26-27 November 2012, as well as OECD-mediated discussions with and among government officials. Further information on this project's events and outputs is available at: www.oecd.org/sti/knowledge.

2. This work is being extended to other countries, within and outside the EU, with similar data sources.

3. The European CIS only asks companies to report activities, sources of knowledge and collaboration occurring in relation to the pursuit of product or process innovations. Therefore, it may not be appropriate to describe this mode as fundamentally less open than then other four.

4. Because sector dummies were included alongside other controls, the analysis accounts for differences in sector composition.

5. See OECD R&D Statistics Database and *Main Science and Technology Indicators* (www.oecd.org/sti/msti). R&D flow data are currently being examined in detail by NESTI (the OECD Working Party of National Experts on S&T Indicators) as part of its on-going revision of the *Frascati Manual*.

6. In a presentation at the OECD in June 2011, Prof. Ellen Enkel highlighted the distinction between mechanisms aimed at securing knowledge from within the organisation ("the people we have"), within the communities of interest, e.g. key customers, investors, known experts ("the people we know") and within the broader crowd, both lay and expert ("the people we don't know"). See Enkel (2010).

7. See www.w3.org/standards/semanticweb/. The term "Semantic Web" refers to W3C's vision of the Web of linked data. Linked data are empowered by technologies such as RDF, SPARQL, OWL, and SKOS.

8. Examples included Yet2, Flintbox, Ideaconnection, SparkIP, Techtransferonline, Patentcafe (2XFR), Ideaconnection and Taeus, some of which are described in Yanagisawa and Guellec (2009).

9. For a number of reasons, patenting activity in emerging fields such as nanotechnology, green materials, bioinformatics and synthetic biology has not reached levels comparable to those found in ICT, and some of these domains are heavily influenced by an open science ethos which is associated with public funding. IP rights other than patents, such as copyrights and trademarks, have played a significant role.

10. Synthetic biology involves the synthesis of large DNA molecules of specified nucleotide sequence, which gives rise to an industry that synthesises made-to-order DNA molecules on a commercial scale, which is facilitated by the speed and cost improvements of DNA synthesis technology. Synthetic biology also involves the design and implementation of genetic circuits constructed from basic genetic components.

11. www.statcan.gc.ca/daily-quotidien/121218/dq121218b-eng.htm.

12. According to Gans et al. (2002), analysis of the determinants of firm choice to sell the technology or to operate in the downstream final market shows that weak IP discourages technology sales. A number of studies also provide evidence that weak IP protection discourages entry of technology specialists in the chemical engineering (Arora et al., 2001b), semiconductor (Hall and Ziedonis, 2001), and software industries (Cockburn et al., 2010).

13. In instances where complex, overlapping claims and rights apply to their products or processes, companies may be driven to acquire rights to patents to protect themselves against the risk of patent litigation. By stockpiling on rights that competitors may infringe upon, companies can retaliate against or neutralise threats of suits, secure better cross-licensing terms and ultimately secure freedom to operate. See Chien (2010).

14. www.ip-watch.org/weblog/wp-content/uploads/2013/02/Patient-Quotient.pdf.

15. Royalties account for approximately 40% of the gross income reported by the NAICS533 Lessors of Nonfinancial Intangible Assets (except Copyrighted Works) sector (which accounts for between 1% and 2% of the total).

16. While intangibles have always been included in a blanket lien on all assets, it is becoming more common for creditors to focus their analysis more directly on intangibles, either as a separate asset or as an integral part of overall company value. Most banks insist on obtaining a security interest in the IP owner's trademarks, copyrights and patents using a security agreement that greatly favours the bank and may severely restrict the IP owner's ability to alienate any of its intellectual property assets in the normal course of business. Under international banking regulations, however, banks cannot use intangibles as Tier 1 capital, which tends to reduce their attractiveness as an asset class.

17. In Europe, a "loser pays" principle applies and the use of contingency fees is also limited by law. These measures increase the expected cost of litigation and reduce the likelihood of settlements to avoid nuisance. Such settlements may have negative externalities on the system as a whole as they may encourage further rent seeking behaviour. In the United States, a 2012 legislative proposal entitled "Saving High-tech Innovators from Egregious Legal Disputes" (SHIELD) would require a non-practising entity to pay the legal costs of the company it sued if a court determines the lawsuit did not have a reasonable likelihood of succeeding. As proposed, the SHIELD Act would only apply to software and computer hardware patents.

18. See www.epo.org/news-issues/news/2012/20120124.html and www.uspto.gov/about/stratplan/ar/2011/mda_02_03.html.

19. WIPO Information Meeting on Intellectual Property (IP) Financing. WIPO/IP/FIN/GE/09/7 Geneva, 2009, at: www.wipo.int/meetings/en/2009/ip_fin_ge_09/.

20. Younge et al. (2011) show a significant increase in the likelihood that firms in Michigan will become an acquisition target following the strengthening of non-compete enforcement by legislative changes in 1985.

References

Almeida P. and B. Kogut (1999), "Localization of knowledge and the mobility of engineers in regional networks," *Management Science*, Vol. 45, pp. 905-917.

Arora, A., A. Fosfuri and A. Gambardella (2001a), *Markets for Technology: The Economics of Innovation and Corporate Strategy*. MIT Press, Cambridge, MA.

Arora, A., A. Fosfuri and A. Gambardella (2001b), "Specialized Technology Suppliers, International Spillovers and Investments: Evidence from the Chemical Industry", *Journal of Development Economics*, Vol. 65 (1), pp. 31-54.

Arora, A. and A. Gambardella (2010), "Ideas for Rent: An Overview of Markets for Technology", *Industrial and Corporate Change*, Vol. 19, No. 3, pp. 775–803.

Athreye, S. and Y. Yang (2011), "Disembodied Knowledge Flows in the Global Economy", WIPO Economic Research Working Paper No. 3, www.wipo.int/econ_stat/en/economics/pdf/WP3_Athreye_final.pdf.

Bekkers, R. and A. Updegrove (2012), "A study of IPR policies and practices of a representative group of Standards Setting Organizations worldwide", report commissioned by the US National Academies of Science, Board of Science, Technology, and Economic Policy (STEP), Project on Intellectual Property Management in Standard Setting Processes, http://sites.nationalacademies.org/xpedio/groups/pgasite/documents/webpage/pga_072197.pdf.

Bishara, N. (2011), "Fifty ways to leave your employer: Relative enforcement of covenants not to compete, trends, and implications for employee mobility policy", *University of Pennsylvania Journal of Business Law*, Vol. 13-3.

Boudreau, K., N. Lacetera and K. Lakhani (2011), "Incentives and Problem Uncertainty in Innovation Contests: An Empirical Analysis", *Management Science*, Vol. 57(5), pp. 843-863.

Cassiman B. and R. Veugelers (2006), "In Search of Complementarity in the Innovation Strategy: Internal R&D and External Knowledge Acquisition", *Management Science*, Vol. 52(1), pp. 68-82.

Chesbrough, H. (2003), *Open Innovation: The New Imperative for Creating and Profiting from Technology*, Harvard Business School Press, Boston, MA.

Chesbrough, H. (2006a), *Open Business Models: How to Thrive in the New Innovation Landscape*, Harvard Business School Press, Boston, MA.

Chesbrough, H. (2006b), "Emerging Secondary Markets for Intellectual Property: US and Japan Comparisons", National Center for Industrial Property Information and Training (INPIT), Tokyo.

Chesbrough, H., W. Vanhaverbeke and J. West (eds.), (2006), *Open Innovation: Researching a New Paradigm*, Oxford University Press, Oxford.

Chesbrough, H., E. Enkel and O. Gassmann (2010), "The future of open innovation", *R&D Management*, Vol. 40, Issue 3.

Chien, C. (2010), "From Arms Race to Marketplace: The New Complex Patent Ecosystem and Its Implications for the Patent System", *Hastings Law Journal*, Vol. 62, p. 297.

Chien, C. (2012a), "The Who Owns What Problem in Patent Law", Santa Clara Univ. Legal Studies Research Paper No. 03-12, http://ssrn.com/abstract=1995664.

Chien, C. (2012b), "Patent Assertion Entities", Presentation to the 10 December 2012 DOJ/FTC Hearing on PAEs, http://ssrn.com/abstract=2187314.

Cockburn, I., M. MacGarvie and E. Müller (2010), "Patent thickets, licensing and innovative performance", *Industrial and Corporate Change*, Vol. 19(3), pp. 899–925.

Cohen, W. and D. Levinthal (1990), "Absorptive Capacity: A New Perspective on Learning and Innovation", *Administrative Science Quarterly*, Vol. 35, pp. 128-152.

Corrado, C., J. Haskel, C. Jona-Lasinio and M. Iommi (2012), "Intangible Capital and Growth in Advanced Economies: Measurement Methods and Comparative Results" www.INTAN-Invest.net.

Cosh, A. and J.J. Zhang (2011), "Open innovation choices – What is British Enterprise doing?", UK Innovation Research Centre, University of Cambridge, June, www.cbr.cam.ac.uk/pdf/OI_Report.pdf.

Dahlander, L. and D. Gann (2010), "How Open is Innovation?" *Research Policy,* Vol. 39, pp. 699-709.

Dahlander, L, D. Gann, and G. George (2012), "Taxonomy-Analytical Study for the Project on Open Collaborative Projects and IP-based Models", WIPO Committee on Development and Intellectual Property, www.wipo.int/edocs/mdocs/mdocs/en/cdip_8/cdip_8_inf_7.doc.

Dushnitsky, G. and T. Klueter (2010), "Is there an eBay for Ideas? Insights from Online Knowledge Marketplaces," *European Management Review*, Vol. 8(1), pp. 17-32.

Ellis, I. (2009), "Maximizing Intellectual Property and Intangible Assets", *Athena Alliance Working Paper* #07.

Enkel, E. (2010), "Attributes required for profiting from open innovation in networks", *International Journal of Technology Management,* Vol. 52, No.3/4.

European Commission (2012), "Towards enhanced patent valorisation for growth and jobs", Commission Staff Working Document. SWD(2012)458 FINAL.

Federal Trade Commission (2011), "The Evolving IP Marketplace: Aligning Patent Notice and Remedies With Competition", March, www.ftc.gov/opa/2011/03/patentreport.shtm.

Frenz, M. and R. Lambert (2012), "Mixed Modes of Innovation: An Empiric Approach to Capturing Firms' Innovation Behaviour", *OECD Science, Technology and Industry Working Papers*, No. 2012/06, OECD Publishing, doi: http://dx.doi.org/10.1787/5k8x6l0bp3bp-en.

Galasso, A., M. Schankerman and C. Serrano (2011), "Trading and enforcing patent rights", *NBER Working Pape*r No. 17367, National Bureau of Economic Research, www.nber.org/papers/w17367.

Gans J., D. Hsu and S. Stern (2008), "The Impact of Uncertain Intellectual Property Rights on the Market for Ideas: Evidence from Patent Grant Delays", *Management Science*, Vol. 54 (5), pp. 982-997.

Gassmann, O., M. Daiber and E. Enkel (2011), "The role of intermediaries in cross-industry innovation processes", *R&D Management*, Vol. 41, pp. 457–469.

Gilson, R. (1999), "The Legal Infrastructure of High Technology Industrial Districts: Silicon Valley, Route 128, and Covenants Not to Compete", *New York University Law Review*, Vol. 74, pp. 575-629.

von Graevenitz, G., S. Wagner, and D. Harhoff (2011), "How to measure patent thickets – A novel approach", *Economics Letters*, Vol. 111, pp. 6-9.

Graham, S. and S. Vishnubhakat (2013), "Of Smart Phone Wars and Software Patents", *Journal of Economic Perspectives*, Vol. 27(1).

Hall, B. and R. Ziedonis (2001) "The Patent Paradox Revisited: An Empirical Study of Patenting in the US Semiconductor Industry 1979-1995", *RAND Journal of Economics*, Vol. 32 (1), pp. 101-128.

von Hippel, E. (1988), *The Sources of Innovation*, Oxford University Press, New York.

Hargreaves, I. (2011), "Digital Opportunity: A review of Intellectual Property and Growth", UK Intellectual Property Office, www.ipo.gov.uk/ipreview.htm.

Hyde, A. (2011), "Intellectual Property Justifications for Restricting Employee Mobility: A Critical Appraisal in Light of the Economic Evidence", in M. Wachter and C. Estlund (eds.), *Research Handbook on the Law and Economics of Labor and Employment Law,* Edward Elgar, Cheltenham.

InnoS&T code 217299, Innovative S&T indicators combining patent data and surveys: Empirical models and policy analyses (2011), Publishable Summary Report, Funding Scheme: SP1-Cooperation - SSH-CT-2008, 01/04/2008-31/03/2011, project co-ordinator, A. Gambardella, Bocconi University, Italy, www.innost.unibocconi.it.

Jankowski, J. (2012), "Business Use of Intellectual Property Protection Documented in NSF Survey", National Center for Science and Engineering, *Statistics Infobrief* 12-307, National Science Foundation, www.nsf.gov/statistics/infbrief/nsf12307/nsf12307.pdf.

Jeppesen, L. and K. Lakhani (2010), "Marginality and Problem-Solving Effectiveness in Broadcast Search", *Organization Science*, Vol. 21 (September – October), pp. 1016–1033.

Lakhani, K., K. Boudreau, L. Backstrom, C. Baldwin, P. Loh, E. Lonstein, M. Lydon, A. MacCormack, R. Arnaout and E. Guinan (2013), "Prize-based contests can provide solutions to computational biology problems", *Nature Biotechnology*, Vol. 31, pp. 108-111.

Leland, H. and D. Pyle (1977), Informational asymmetries, financial structure, and financial intermediation, *Journal of Finance*, Vol. 32(2), pp. 371-387.

Lemley, M.A. and C. Shapiro (2007), "Patent Holdup and Royalty Stacking" *Texas Law Review*, Vol. 85, pp. 1991-2007.

Levin, R., A. Klevorick, R. Nelson and S. Winter (1987), "Appropriating the Returns from Industrial Research and Development", *Brooking Papers on Economic Activity*, No. 3, pp. 783-831.

Maass, W. (2008), "A Knowledge Market Prototype: From Conception to Execution", OECD Expert Workshop on Knowledge Markets in Life Sciences, Washington, DC, 16-17 October.

Marx, M. (2011), "The Firm strikes back: Non-compete agreements and the mobility of technical professionals", *American Sociological Review*, Vol. 76, p. 695.

Marx, M. and L. Fleming (2012), "Non-compete Agreements: Barriers to Entry…and Exit?" in Josh Lerner and Scott Stern (eds) *Innovation Policy and the Economy*, Volume 12, pp. 39 – 64. The University of Chicago Press.

Marx, M., D. Strumsky and L. Fleming (2009), "Mobility, Skills, and the Michigan Non-compete Experiment", *Management Science*, Vol. 55, pp. 875-889.

Marx, M., J. Singh and L. Fleming (2010), "Regional Disadvantage? Non Compete Agreements and Brain Drain" (21 July), http://dx.doi.org/10.2139/ssrn.1654719.

Ménière, Y., A. Dechezleprêtre and H. Delcamp (2012), "Le marché des brevets français", www.inpi.fr/fileadmin/mediatheque/pdf/OPI/Rapport_Cerna_final.pdf.

Nikolic, A. (2009), "Securitization of patents and its continued viability in light of the current economic conditions", *Albany Law Journal of Science and Technology*, 19.

OECD (2001), *Innovative Networks: Co-operation in National Innovation Systems*, OECD Publishing, doi: http://dx.doi.org/10.1787/9789264195660-en.

OECD (2008), *Open Innovation in Global Networks*, OECD Publishing, doi: http://dx.doi.org/10.1787/9789264047693-en.

OECD (2009), *Innovation in Firms: A Microeconomic Perspective*, OECD Publishing, doi: http://dx.doi.org/10.1787/9789264056213-en.

OECD (2010a), *The OECD Innovation Strategy: Getting a Head Start on Tomorrow*, OECD Publishing, doi: http://dx.doi.org/10.1787/9789264083479-en.

OECD (2010b), *Measuring Innovation: A New Perspective*, OECD Publishing. doi: http://dx.doi.org/10.1787/9789264059474-en.

OECD (2010c), *Symposium on Opportunities and Challenges in the Emerging Field of Synthetic Biology: Synthesis Report*, OECD Publishing, doi: http://dx.doi.org/10.1787/9789264086265-en.

OECD (2012a), *Knowledge Networks and Markets in the Life Sciences*, OECD Publishing, doi: http://dx.doi.org/10.1787/9789264168596-en.

OECD (2012b), *OECD Science, Technology and Industry Outlook 2012*, OECD Publishing, doi: http://dx.doi.org/10.1787/sti_outlook-2012-en.

Phelps, C., R. Heidl and A. Wadhwa (2012), "Knowledge, Networks, and Knowledge Networks: A Review and Research Agenda", *Journal of Management*, Vol. 20, No. 10.

Polanyi, M. (1958, 1998), *Personal Knowledge. Towards a Post Critical Philosophy*, Routledge, London.

Rai A. and J. Boyle (2007), "Synthetic Biology: Caught between Property Rights, the Public Domain, and the Commons", PLoS Biol, Vol. 5(3), p. e58, doi:10.1371/journal.pbio.0050058 www.plosbiology.org/article/info:doi/10.1371/journal.pbio.0050058.

Rai, A. and S. Kumar (2007), "Synthetic Biology: The Intellectual Property Puzzle", *Texas Law Review,* pp. 1745-1768 (2007), http://scholarship.law.duke.edu/faculty_scholarship/1628.

Saxenian, A. (1994), *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*, Harvard University Press, Cambridge, MA.

Serrano, C. (2011), "Estimating the Gains from Trade in the Market for Innovation: Evidence from the Transfer of Patents," *NBER Working Papers* 17304, National Bureau of Economic Research, Inc.

Shapiro, C. (2001), "Navigating the Patent Thicket: Cross Licenses, Patent Pools, and Standard-Setting", in A.B. Jaffe et al. *Innovation Policy and the Economy*. Volume I. MIT Press, Cambridge, MA.

Sheehan, J., C. Martinez and D. Guellec (2004), "Understanding Business Patenting and Licensing: Results of a Survey", in *Patents, Innovation and Economic Performance*, OECD, Paris.

Swan, P. (2010), "The Economics of Standardization: An Update", Report for the Department for Business, Innovation and Skills, www.bis.gov.uk/feeds/~/media/ED32CDA672764D7C8AC2F4E323581010.ashx.

Torrance, S. and L. Kahl (2012), "Synthetic biology standards and intellectual property", the National Academies. Draft presented to the to the Symposium on Management of Intellectual Property in Standards-Setting Processes, www.synberc.org/content/articles/standards-and-intellectual-property.

Wood, J.S. (2000), "A comparison of the enforceability of covenants not to compete and recent economic histories of four high technology regions", *Virginia Journal of Law and Technology*, Vol. 5, p. 14, www.vjolt.net/vol5/issue3/v5i3a14-Wood.html.

Yanagisawa, T. and D. Guellec (2009), "The Emerging Patent Marketplace", *STI Working Paper* 2009/9, *Statistical Analysis of Science, Technology and Industry*, OECD, Paris.

Younge, K., T. Tong, and L. Fleming (2011), "How Anticipated Employee Mobility Affects Acquisition Likelihood: Evidence from a Natural Experiment", Working Paper, University of Colorado Boulder and Harvard Business School.

Younge, K. and M. Marx (2012), "The Market Value of Knowledge Protection: Evidence from a Natural Experiment", Preliminary Working Paper.

Ziedonis, R. (2004), "Don't Fence Me In. Fragmented markets for technology and the patent acquisition strategies of firms", *Management Science*, Vol. 50, pp. 804–820.

Zúñiga, M.P. and D. Guellec (2009), "Who Licenses out Patents and Why? Lessons from a Business Survey," *OECD Science, Technology and Industry Working Papers* 2009/5, OECD, Paris.

Chapter 7.

Corporate reporting and knowledge-based capital

Corporate reporting has been much debated in recent years, with diverging views on how to enhance its quality and usefulness. Enhancing reporting on intangible assets (or KBC) has been an important part of this debate. Corporate financial reports provide limited information on companies' investments in KBC. This may hinder access to corporate finance and quality of decision making. Prevailing accounting standards do not require disclosure of KBC in most cases. Frameworks to enhance KBC management and disclosure have proliferated in recent years. Most have been pioneered by private-sector organisations and some by governments in the form of voluntary guidelines. Nonetheless, a lack of standardisation in reporting is a challenge. Governments might consider: i) supporting better corporate disclosure by establishing voluntary recommendations and guidelines; ii) creating mechanisms to facilitate companies' reporting of investments in KBC; iii) introducing frameworks for auditors; iv) engaging in international co-ordination to improve international comparability of data and information supplied by companies; and v) promoting the establishment of asset classifications that would increase consistency in data collection and reporting.

Already in the early 1990s, the importance of intangible resources and the difficulty of accounting for them were recognised. Today, intangible assets (IA) such as employee skills, knowledge, trade secrets, software, copyrights and patents, and customer and supplier relationships are increasingly recognised as important corporate assets, which contribute significantly to a firm's competitiveness. Recent years have even seen the rise of a "conceptual company", characterised by the low relevance of physical assets in favour of intangible intensive activities.

Estimates of the value of intangibles, particularly in human capital-intensive, high-technology, innovative companies have increased, though they vary by country. For example, finance directors surveyed as part of one study believed that 50% or more of corporate value is attributable to intangible assets (APCA, 2010). At the same time, the ability to incorporate IA in current accounting frameworks appears limited; hence, the relevance of accounting information has deteriorated, especially in sectors characterised by significant intangible capital.

This observation raises serious questions about the continued relevance of financial reporting and places growing emphasis on non-financial reporting as a way to bridge the information gap. There is a growing consensus among practitioners and policy makers that intangibles need to be better covered in non-financial reporting in order to improve its relevance to users. Much academic research has focused on exploring this question, and in so doing, has tried to establish the value of improved IA reporting for company valuations or access to credit, an area which has proven difficult given concerns about causality.

Despite the active interest in promoting IA reporting, progress appears slow. Information about the adoption of IA disclosure frameworks by companies is not readily available. However, there are indications that they have not been widely adopted. This chapter attempts to explore this issue by examining the entire chain of management of IA information, from collection of data and asset management to reporting of information on intangibles by companies and its use by investors and analysts.

As a first step, this chapter first examines the incentives and challenges faced by executives, management and boards for collecting information and managing IA assets. While the motivation for executives to adopt relevant management tools should in principle be strong, this assumption needs to be examined in light of practical obstacles and organisational dynamics. The incentives for disclosure of information on intangibles are examined next in order to present a picture of current reporting practices and to establish how and why companies choose to communicate IA information.

The following section examines the use of IA reporting by analysts and investors seeking to establish whether it is valuable in terms of satisfying specific information gaps and improving narrative reporting more generally. Finally, the political economy of intangibles reporting is reviewed in the context of other initiatives to improve narrative reporting. Independently of the quality of IA reporting, the quality of narrative reporting has been and continues to be subject to frequent criticism, despite the fact that it has grown tremendously in volume to address compliance concerns and to communicate with stakeholders on a wider set of issues.

In responding to concerns about the relatively weak adoption of IA reporting, the chapter does not take for granted that better disclosure is always justified. It takes the pragmatic view that such reporting may not be feasible for some companies in view of its costs. That is, enhanced IA reporting, in so far as it remains voluntary, should be perceived by companies as having specific benefits, such as easier access to credit, improved stakeholder relations or enhanced analyst coverage. Policy measures that could encourage companies to provide better IA disclosure are presented at the end of the chapter; however, this is an area that merits further research and investigation.

Collection and management of IA information

Motivation and resources for data collection

While a great deal of research attempts to elucidate the benefits of better IA management and reporting, few surveys of executives have aimed to understand their information needs and management practices. Better understanding of whether executives perceive measurement and management of intangible assets as beneficial and for what purposes is crucial to a better grasp of how intangible assets are treated within the firm. It is important to differentiate the perceptions of executives and of lower-level management, which often better understands how intangibles fit in the value creation process.

Several key questions can be raised in this regard. First of all, how do firms select a suitable framework for management and reporting on their intangibles? How do they select the key performance indicators (KPIs) for which data can be collected? What organisational structures and processes are necessary to support this effort? While these questions may sound banal, answering them is difficult, as the structure of IA management systems is complex, particularly in large companies where the size and complexity of processes make even internal reporting difficult.

More often than not, companies wishing to set up IA management processes require dedicated human resources and expert support. Such support is offered by consulting companies, business and professional associations, and even boutique firms specialising in intangible asset management. Private equity or other professional investors may provide targeted support if they require their investee companies to establish IA management mechanisms and to report on specific performance indicators.

The ultimate motivation for companies to introduce IA data reporting and management tools varies, depending on the maturity of the company, the availability of resources to support this exercise and other factors. Corporate efforts to collect IA information are not exclusively driven by companies' desire to report externally. On the contrary, interviews with industry participants show that many companies, especially young ones, collect data or information on their IA strictly with a view to improving their management of such assets (InCas, 2011).

Generally speaking, the collection of information on intangibles is conditioned by whether information is seen as valuable for the overall strategy of the firm or for a particular decision. Research demonstrates that management may be interested in one or more specific components of IA and not the wider picture, because the component or components relate to the growth and development of the firm and are therefore critical for board monitoring. This observation is corroborated by prior research showing that some specific intangibles have greater impact on the performance of individual firms than others (Clarke, 2011).

There are several reasons for collecting information on intangibles for decision making. They include focusing attention on key assets, supporting risk management and innovation, creating resource-based strategies and monitoring the effects of certain strategies, translating business strategy into actionable measures and improving management of the enterprise as a whole (Andriessen, 2004). IA data collection can also be undertaken for reasons such as due diligence in the context of a merger or an acquisition. One of the main goals of IA reporting is, in fact, a better understanding of intangibles and of the learning process that companies go through to arrive at such an understanding (Sveiby, 2010).

An important question that arises with respect to internal management of IA relates to managers' incentives to establish systems to collect information on and manage the company's intangible capital and how they determine which assets, and therefore what metrics, are most appropriate. This question cannot be adequately answered without consideration of company dynamics and their complexity. Fundamentally, managers' views regarding the utility of collecting IA-related information depend on their view of the importance of intangibles for getting easier access to capital, higher company valuations or better analyst coverage.

A number of studies have found a positive association between better management and disclosure of intangibles and financial performance (measured as company valuation or profitability), although causality and the impact of other variables have not been fully addressed. A criticism often made of available studies is that because IA management processes are costly to introduce, only relatively successful enterprises can afford them. Therefore, it is difficult to say unequivocally whether IA management and reporting improves their performance.

Board members should have an incentive to inform themselves about the company's intangibles where relevant. The OECD Principles for Corporate Governance argue that board members should act on a fully informed basis and that they are responsible for reviewing and guiding corporate strategy and major plans of action. Whether boards can act on a fully informed basis in companies characterised by significant intangible assets is an important question. So far, there is little evidence that boards explicitly demand information about intangible capital. In KPMG's survey of non-executive directors (2003), more than 60% noted that they were not very knowledgeable about non-financial performance indicators as information provided by executives is mainly financial; this situation does not appear to have evolved significantly.

Available methodologies and instruments

There are a number of methodologies for measuring and reporting intangibles. The evolution of reporting frameworks to accommodate IA disclosure began in the 1990s and was primarily driven by private-sector interest and academic research. The OECD's report on *Intellectual Assets and Value Creation* (2006) presented a variety of approaches to measurement and reporting. Although these approaches have been refined and extended over the past five years, the major conceptual foundations of this work were laid down in this earlier period. Annex 7.A1 provides a summary of over 40 approaches documented by Sveiby in 2010; less than a quarter of these have been developed in the last five years.[1]

Most reporting frameworks developed to date favour a qualitative approach, with intangibles reported in a narrative format to complement financial reporting. Very few approaches have sought to develop a methodology for valuation of intangibles, given the difficulty of incorporating such figures in the financial reporting. On the national level, only one approach, developed by the French *Observatoire de l'Immateriel* and supported by the French Ministry of Finance, provides a methodology for the valuation of intangibles to complement existing financial reporting.

More generally, quantitative methods for valuation of intangibles take the form of: i) "direct valuation methods", which estimate the monetary value of intangible assets by identifying the various components and directly evaluating them, either individually or collectively; ii) "market capitalisation methods" which calculate the value of intangible assets as the difference between a company's market capitalisation and the value of stockholders' equity; or iii) "return on asset methods" which seek to calculate companies' annual earnings from intangibles (Sveiby, 2010).

An alternative approach is provided by the French Thésaurus-Bercy which identifies: i) "the cost approach" which seeks to estimate the cost of replacement of a particular asset; ii) "the comparability approach" which seeks to estimate the value of a particular asset with reference to other transactions in similar asset types; iii) "the cash flow approach" which seeks to gauge cash flows arising from a particular intangible asset; and finally iv) "the real options approach" which seeks to estimate the cost of a right, with no obligation, to purchase a given intangible asset at fixed price on a given day.

Few OECD member countries have introduced national recommendations or guidelines on reporting of intangible assets. Except in Denmark and Japan, most guidelines, even at the national level, were developed by private-sector initiatives to support better narrative reporting so as to result in better company valuations. The French guidelines are unique in trying to go beyond providing a disclosure framework to outline a methodology for quantifying intangibles. This does not imply that such estimates should be part of the financial accounts. Box 7.1 provides additional information about national reporting guidelines.

Box 7.1. National guidelines on IA management and reporting

France: In October 2011, the *Observatoire de l'Immatériel* released an instrument for the valuation of intangible capital, prepared by a group of experts at the request of the former Finance Minister Christine Lagarde. This instrument, called *Thésaurus Bercy*, proposes an extension of reporting under the International Accounting Standards (IAS) or the International Financial Reporting Standards (IFRS) that allows assigning a financial value to assets that cannot be recognised in the current accounting frameworks. This approach does not propose to extend the scope of traditional accounting, nor does it focus on narrative reporting, which has been the approach of most other jurisdictions. Instead, it proposes to value IA and disclose a valuation as an extension of financial reporting. This approach, initially developed five years ago, has been used by many French companies wishing to communicate their IA formally or to develop internal metrics for tracking IA.

Japan: The Ministry of Economy, Trade and Industry (METI) of Japan has been at the forefront of global efforts on intangibles reporting. It released an *Intellectual Property Policy Outline* in 2002, which was followed by a *Pilot Model for Disclosing Patent and Technical Information* in 2003. Finally, METI released the *Guidelines for Intellectual Property Information Disclosure* in 2004. This marked a turn towards a broader focus on IA than research and development, patents and other, narrower, asset classes. The Ministry has also issued some suggestions on how small and medium-sized enterprises (SMEs) can make more effective use of their intangible assets. It is estimated that close to 200 SMEs in Japan have so far published IC reports and 600 companies have publicly disclosed some information on their IC strategy and its implementation.

Denmark: the Ministry of Science, Technology and Industry released its first *Guidelines on Intellectual Capital Reporting* in 2000; revised guidelines were made available in 2002. These guidelines aim to support the development of Intellectual Capital Statements by Danish companies that include a description of the corporation's four knowledge resources: employees, customers, processes and technologies. The same initiative produced, in 2003, a framework, *Analysing Intellectual Capital Statements,* to offer analysts a systematic method for reading and interpreting them. Denmark is unique in that its Accounting Law requires companies with significant IA assets to report on them. Verification of such assets by external auditors is a common practice and is subject to existing recommendations.

Germany: In 2004, a consortium of several companies and institutions launched an initiative that developed the *ICS-Made in Germany* framework. The experience of this project inspired the emergence of German guidelines on reporting of IC, *Wissensbilanz-Made in Germany*, and later the launch of the *InCas guidelines* in 2010 to promote disclosure in Germany but also to identify common grounds for IA reporting in Europe. These guidelines target SMEs. The categories of intangibles included in the guidelines are human, social and relational capital. Currently, few listed companies in Germany have embraced IA reporting, but it is reported that its adoption among SMEs is much more widespread.

Sweden: Since 1986, Statistics Sweden has conducted a voluntary survey on intangible assets that covers all manufacturing companies with more than 500 employees. Although the government had debated introducing mandatory guidelines on IA disclosure for all companies with more than 100 employees, a proposal has never been submitted to the Parliament. However, in 1993 the Swedish Council for Service Industries recommended that its member companies use a number of indicators describing their human capital in annual reports. Furthermore, the Ministry of Industry, Employment and Communications has supported EU's MERITUM Project (discussed later in this chapter) and continues to support research in this area.

The motivations for introducing national IA reporting guidelines appear to have varied across jurisdictions and also among individual companies. For the most part, these initiatives were piloted by ministries of finance as part of a wider attempt to capture economic value added better or by ministries of economy or industry in connection with initiatives designed to support innovation, primarily in SMEs. Jurisdictions in which governments were involved in the development of IA reporting guidelines often considered their national value added and productivity undervalued by traditional accounting methods and hence by markets. In Japan for example, government interest in encouraging companies to report on intangible assets was driven by low company valuations and their vulnerability to takeovers, including by foreign competitors.

It is unclear whether these national guidelines have advanced disclosure much further than in jurisdictions with no guidelines. For instance, while the incidence of IA disclosure in listed German companies is extremely low, in Spain, all IBEX 35 companies provide intangible capital disclosures (Sanchez, 2011). However, IA reporting is said to be quite developed among German SMEs, while it appears lacking among Spanish SMEs. That said, because guidelines are voluntary[2] and because no central government entity is charged with monitoring IA reporting, the extent of adoption of these guidelines among listed or privately owned companies is largely unknown.

Irrespective of any guidelines, country characteristics play a role in determining the extent and format of IA disclosure. In OECD member countries, the incidence of IA disclosure appears to be highest in Norway, Sweden, Denmark and Japan, although statistics are not readily available. This may be due in part to the fact that some of these countries have a relatively large stock of intangibles. As noted earlier, some of these jurisdictions have introduced voluntary guidelines for reporting on intangibles.

Guidelines on IA disclosure developed as a result of international efforts are also voluntary in nature (Box 7.2). In principle, the adoption of these guidelines could result in some consistency in countries' reporting, as their creation took diverse inputs into account. So far, there have been few explicit efforts to make any of these guidelines an internationally recognised reference and there is currently no evidence of companies gravitating to one of these frameworks.

Box 7.2. International frameworks and guidelines

The World Intellectual Capital Initiative (WICI), established in 2007 with the OECD's assistance, is one of the main institutions driving the IA reporting agenda globally. WICI is a private-public collaboration established to develop a global framework for measuring and reporting overall corporate performance to shareholders and other stakeholders. WICI's basic premise is that companies need to make clear their value creation mechanism, the specific assets that are linked to value creation, and the company's perspective regarding future risks, opportunities and strategy. The emphasis on innovation and value creation through explicit links with KPIs is a unique aspect of the WICI framework.

A key output of WICI's work is the *Framework and Guidance for Integrated Business Report*, which encourages comprehensive reporting on the company's landscape, strategy, resources and processes, as well as value creation and its drivers. It is supported by XBRL (eXtensible Business Reporting Language). To supplement this framework, WICI has focused on the development of KPIs that reflect a range of market, industry and company-specific factors. Industry KPIs have been developed for the automotive, telecommunications, electronic devices and pharmaceuticals sectors; others are currently under preparation. Examples of sector-specific KPIs include: number of new models of eco-cars and sales performance for the automobile sector or number of test cases for the pharmaceutical industry.

…/…

Box 7.2. International frameworks and guidelines (*continued*)

The European Commission issued the MERITUM Guidelines in 2002. These guidelines provide a conceptual framework for reporting and management of intangibles, including the preparation of a report on intellectual capital. The MERITUM guidelines resulted from an EC-supported project that identified best practices in European firms and constituted a first attempt to create an international conceptual framework for intangibles management and reporting. The guidelines describe how to prepare an Intellectual Capital Report and outline its contents (i.e. vision of the firm, summary of intangible resources and activities and a system of indicators). They conclude with recommendations on how to collect the relevant information, who should prepare the information and frequency of reporting.

InCas is a reporting model designed to help SMEs manage and report on IA in the form of an intellectual capital statement certified by professionals from the Fraunhofer Institute for Production Systems and Design Technology in Berlin. InCas aims to provide a pan-European model for IA reporting for SMEs, although it has not been formally adopted by the EC. The originality of the model lies in the fact that it proposes the preparation of an internal version of the IA statement on which the external model is structured. InCas is currently looking to implement its reporting model in other countries in Europe and in Latin America, with the support of business associations in the respective countries. So far, it has not been implemented widely in Europe (it is going to be implemented in Spain) and is best described as a well-developed pilot project.

The European Federation of Financial Analysts Societies (EFFAS) has established a Commission on Intellectual Capital and issued in 2008 the *Principles for Effective Communication of Intellectual Capital*. These principles recommend that companies prepare a separate intellectual capital report and also include information on intellectual capital in Management Discussion and Analysis. The aims of the EFFAS in issuing these principles are: to promote the measurement and disclosure of IA, highlighting the needs of financial professionals; to promote standardisation of the disclosure format to keep costs to the minimum and facilitate benchmarking; and to foster the valuation of the information on intangibles by financial analysts.

Disclosure of information on intangibles

Reporting on IA is in principle motivated by the same considerations as any other type of voluntary disclosure – that is, the desire to increase market valuation, enhance access to credit and attract investors. Disclosure is principally aimed at investors, although it may also target partners in cases of mergers or acquisitions or even others, such as potential employees or lawyers and bankruptcy judges in the case of bankruptcy proceedings. Financial institutions providing credit may also be interested in better IA disclosure. In many cases, IA disclosure is intended for multiple audiences and is prepared so as to satisfy these specific categories of users.

This section of the chapter therefore focuses on the objectives of IA disclosure and its impact on shareholders, analysts and the wider market. It sheds light on why some companies decide to disclose information on their intangibles publicly by exploring factors leading to the disclosure, the benefits that accrue to companies that provide such disclosure, as well as the corporate governance variables that might affect company reporting practices.

Factors affecting external disclosure

The previous section has already explored the reasons for executives and lower-level management to collect and manage data and information on intangibles systematically and report them to the board. However, the incentives for reporting this information externally may differ. Perhaps the primary motivation for disclosing such information is to bridge the information gap created by the inability of current accounting frameworks to communicate the value of intangibles. While the overall rationale for disclosing additional information on intangibles to the market is clear, company-specific motives differ.

Industry differences, ownership and company size are often used in the literature to explain the scope and sometimes even the channels of disclosure. It is difficult to draw generalisations since most studies focus on a single jurisdiction and their conclusions may not be applicable to other jurisdictions. The additional difficulty faced by these studies is that "establishing relationships indirectly between disclosure and other firm characteristics involves both constructing a measure of disclosure (which is problematic) and using proxies to capture the unobservable disclosure incentives and disincentives, such as those related to information asymmetry and competition" (ICAS, 2010).

There is no conclusive evidence that company size dictates the extent of IA disclosure. Some studies have found that younger companies provide more IA disclosure because they are more likely to seek capital than mature listed firms with access to funds. Recent evidence confirms that IA reporting by younger, technology-intensive companies is beneficial. For instance, a project carried out in 2010 by experts from academia, government and companies in Spain showed that a reliable and comparable report on intangibles is highly beneficial for these companies (Sanchez, 2011). The OECD also found that financial markets especially reward SMEs for increased disclosure (OECD, 2006).

That said, young, developing companies face financial and human resource constraints when it comes to introducing IA management and disclosure frameworks. While they might stand to benefit the most from enhanced IA disclosure, their capacity to report may be limited by lack of resources and by lack of standardisation. Since the EC's RICARDIS report (2006), which encouraged policy initiatives to foster the standardisation of IA reporting practices for research-intensive SMEs, little progress has been made in this area. That does not, however, mean that smaller companies do not track their intangible capital; it may just be that their ability to report it formally is constrained.

It appears that better disclosure occurs in high-technology sectors in which IAs are significant and the gap between accounting and market values tends to be large. For instance, a recent study focusing on the Australian market found that although disclosure about intangibles was generally low, companies operating in high-technology or knowledge-intensive industries had more extensive disclosure (Whiting and Woodcock, 2011). Likewise, Vafaei et al. (2011) conclude that IA disclosure is noticeably higher in non-traditional industries in the United Kingdom and Australia, and minimal in traditional industries, even though they may have important skills and know-how. A study of IA disclosure of firms prior to initial public offering (IPO) on the Copenhagen Stock Exchange also found that industry classification and ownership were the variables that most influenced the extent of IA disclosure (Bukh et al., 2005).

Recent surveys show that incentives for IA disclosure related to capital markets are extremely important (ICAS, 2010); indeed some evidence confirms that IA disclosure has a positive impact on companies' market capitalisation (Abdolmohammadi, 2005; Lajili and Zéghal, 2005). However, the hypothesis that IA disclosure positively affects share price is not unambiguous. One study of disclosure of IA information in prospectuses of firms conducting an IPO on the Singapore Stock Exchange found a negative association between disclosure and post-issue stock performance (Singh and Van der Zahn, 2009).[3] That said, one of the primary motives for better disclosure by listed firms is to correct an undervalued share price and to reduce the cost of capital.

While most of this section has dealt with the benefits of external IA disclosure, the benefits for management or specific shareholders of not disclosing certain assets need to be also addressed. First, there exists a risk of litigation in connection with information

disclosed in a narrative format, even in the absence of an attempt to quantify IA as the French guidelines suggest. In the United States, the Management Discussion and Analysis section is governed by specific regulations and is subject to oversight by the Securities and Exchange Commission; this leads to a more legalistic approach to narrative reporting by companies (PwC, 2007). In addition, companies may find it difficult to find auditors willing to issue an opinion on their intangibles.

Second, situations in which executives or some of the main shareholders do not wish to disclose information on IA such as innovations to be patented or other assets with significant future financial benefit could raise questions about market manipulation.

Format of disclosure

In most jurisdictions, intangible assets continue to be recognised on the financial statements if their market value can be established through a transaction with a third party, as in the case of patents or trademarks which, when acquired as part of a merger, can be considered as part of goodwill and periodically revalued. The notion of "fair value" continues to dominate the thinking on asset recognition in IAS and IFRS. Many items, such as internally generated goodwill, brands, customer lists and some product development costs cannot be recognised. The recognition of intangibles as part of goodwill has been subject to criticism on the basis that "goodwill is like soup, we do not necessarily know what is inside" (Zambon, 2011).

Attempts to value intangibles have been advanced by the work of the International Valuation Standards Council (IVSC) and initiatives such as the Thésaurus-Bercy developed by the *Observatoire de l'Immateriel* in France (see Box 7.1). The IVSC, after four years of consultation with valuation professionals, auditors and users of reporting, released updated guidance on the valuation of intangible assets in 2010. Guidance Note 4 identifies the principal techniques used for the valuation of intangible assets such as brands, intellectual property and customer relationships, and provides guidance on how to apply them.

As a result of existing limitations on recognising intangible assets on company's balance sheets, disclosure has gravitated towards the narrative format. Generally speaking, narrative disclosure can take several forms: companies can publish an Intellectual Capital Statement[4] or include a description of their intangible assets in the Management Discussion and Analysis (MD&A) section or the report on environmental, social and corporate governance (ESG) and sustainability.

Narrative reporting need not be purely qualitative. It can include valuations and external validation of reported figures. Although many models can be used to disclose IA qualitatively, few are designed to provide a financial valuation of IA, and services for audit of valuations of IA are only emerging. A number of IA disclosure methodologies favour the use of KPIs, which can be tailored to an industry. This approach has been advocated by WICI's framework. It is also consistent with the findings of earlier OECD work recommending that companies release a few significant indicators – standardised, linked to a revenue stream, forward-looking and difficult to manipulate – to support more extensive contextual and narrative reporting (OECD, 2006).

However, KPIs do not appear to have taken root in the corporate sector. Only 15% of Fortune Global 500 companies report any KPIs, even though they are highly valued by the investor community (PwC, 2007). In some countries, nonetheless, disclosure of KPIs appears to be more advanced. For instance, in Sweden, over 85% of the top 30 listed companies claim to communicate non-financial KPIs in their annual reports (Arvidsson, 2011).

Finally, it is impossible to discuss IA reporting without touching on the channels for disclosure. So far, in evaluating the levels of disclosure, researchers have focused on annual financial reports. This is due in part to the assumption that what is communicated in these reports is a good proxy for IA reporting across all channels of communication and in part to the ease of accessing annual reports as compared to analyst briefings and bilateral discussions between companies and potential investors.

However, the usefulness of the annual report for disclosing new, previously undisclosed information has been questioned (ICAS, 2010), especially in the light of continuous reporting requirements. Unerman et al. (2007) found that preparers of financial statements did not consider the annual report an appropriate source of IA information and that companies in the United Kingdom disclosed less than a third of total IA in their annual report. Research confirms that a great deal of IA information is communicated in company road shows and private meetings between companies, investors and analysts (Holland, 2002). Investor conferences, although open to the public, give those in attendance access to information (Bushee et al., 2011).

Such conferences and bilateral briefings enable investors to make more informed trading decisions. One study found that a bilateral meeting between a publicly traded firm and an investor changes the probability of increasing a fund's position by 21% on average (Solomon and Soltes, 2011). This indicates that these channels of communication are effective in enabling companies to present the link between their value drivers and their strategy better and may fill important information gaps for investors.

Corporate governance and IA disclosure

The incentives for IA disclosure have already been touched on, primarily from the perspective of management and executives. Other governance variables, such as the composition of the board or the ownership structure of the company, could in principle have an impact on the disclosure of information on intangibles. As noted above, research on information requirements of boards in terms of intangibles management is lacking, so it is not surprising that little is known about the role that boards have played in stimulating external disclosure. Nonetheless, few governance variables are thought to facilitate IA disclosure.

Independence of the board appears to be positively correlated with enhanced IA disclosure. In one study of listed UK firms, researchers concluded that IA disclosure is positively correlated with a host of corporate governance factors, including independent directors and directors' breadth of experience (Li, Pike and Haniffa, 2011). In a sample of biotechnology companies in Australia, White et al. (2007) found that the level of voluntary IA disclosure was strongly related to board independence and company leverage. A study exploring the same question for European biotechnology firms also confirmed that the proportion of independent directors is positively related to IA disclosure (Cerbioni and Parbonetti, 2012). For other board characteristics such as the combination of chair and CEO posts, the evidence is mixed.

Companies with a concentrated ownership structure are generally found to be less likely to provide extensive intangibles disclosure. This may be explained by the fact that companies with such ownership structures are less responsive to investors' information needs since dominant shareholders have regular access to information (Li et al., 2008). A review of practices by listed firms in Singapore found that firms with concentrated ownership and those with a high level of executive director ownership were less likely to disclose information voluntarily, whereas state-owned companies were more likely to do

so (Firer and Williams, 2001). Concentrated ownership by professional investors appears to have a similar impact. One study of Mexican firms over 2005-07 found that an increase in institutional investor shareholdings had a negative impact on IA disclosure (Hidalgo et al., 2010).

Uses of intangibles reporting

External disclosure of information on intangibles is useful only insofar as market participants understand it. While much analysis has focused on disclosure frameworks and practices, less is understood about the use of IA information by analysts (Abhayawansa and Guthrie, 2010). The evidence indicates that financial analysts are increasingly interested in and understand intangibles (Lev and Amir, 2003; Ousama et al., 2011). Financial institutions that provide credit have also demonstrated an interest in improving intangibles disclosure. For instance, the Spanish research project aimed at enhancing IA disclosure was funded by credit providers, both public and private.

One approach undertaken by researchers has been to look at analyst reports to see if IA disclosures are used in support of buy or sell recommendations (e.g. Arvidsson, 2003; Garcia-Meca and Martinez, 2007). From a review of the literature taking this approach, it can be concluded that analysts do make use of IA disclosures, particularly for high-growth companies, but that some information communicated by companies as part of their value creation story is not incorporated. Interviews and surveys of analysts, whether specific to one market or general across several markets, arrive at broadly the same conclusions.

Unsurprisingly, analysts appear to favour IA information that can be readily and easily integrated in their financial valuation models. For instance, information on cost and revenue synergies arising from business collaboration can be used in earnings and cash flow estimates but IA information that cannot be easily incorporated into company valuations is less frequently referred to in analyst reports. From this, it may be inferred that these indicators are not incorporated in analysts' models and decisions, even though analysts and other users of financial reporting might consider them as useful background to the overall company strategy.

Many market participants feel that IA reporting can contribute positively to the quality of narrative reporting. Indeed, IA information is prevalent among the non-financial reporting items identified by analysts as being useful (Abhayawansa and Guthrie, 2010). In addition, IA disclosure can help analysts answer specific questions about the innovation capacity of companies or their human resource strategy. Indeed, analysts often focus on certain types of IA information that might be relevant to their concerns.

IA information can be useful to users of reporting other than institutional or private shareholders. In this regard, it is important to note that the past few years have seen the emergence of boutique private equity firms and investment banks specialised in investing in firms characterised by significant intangible assets. These investors are looking for companies with intangible assets for development and commercialisation purposes, even before start-up (Ellis and Jarboe, 2010).[5] Such investors have the capacity to make use of more sophisticated IA reporting and are likely to have private channels for obtaining the relevant information and KPIs from companies even before investing in them.

With the exception of professional investors, most other investors are sensitive to the possibility of external verification of IA reporting. A few firms specialising in intangibles management now conduct such external verification, but this is, for the moment, a small and unregulated industry. Only in very few jurisdictions (e.g. Denmark) do auditors have guidelines for verifying IA statements. In the absence of such guidelines auditors may consider issuing an audit opinion on intangibles as an above-average risk.

Another concern is that owing to the variety of reporting frameworks, investors might not be able to use the reported information to compare companies. Lack of standardisation in the methodologies and the reported information is a major challenge, especially for less sophisticated investors. That is not to say that IA reporting is not relevant for smaller investors. A recent study from the Association of Chartered Certified Accountants indicated that the description of the company business model and KPIs were of interest to 60% of shareholders surveyed (ACCA, 2011).

Differences in national approaches to narrative reporting raise issues related to standardisation as a means of increasing the relevance of IA reporting to users of financial statements. However, given that companies appear increasingly to rely on alternative channels of communication – such as company road shows and private meetings between companies, investors and analysts – this gap may be addressed indirectly. This, in turn, raises questions about whether the entire debate on IA disclosure focuses on channels of corporate communication that may not be the main means of relaying information on intangibles.

Political economy of reform

This section examines intangibles disclosure from the political economy angle. From the above discussion, it can be concluded that globally, IA reporting practices have not advanced significantly in recent years despite the multitude of reporting frameworks available to companies. The adoption of IA reporting has been fraught with obstacles related to lack of harmonisation of standards, perceived risks associated with increased disclosure, the costs associated with issuing disclosure, and growing interest in other types of disclosure.

The advancement of IA reporting cannot be divorced from the overall discussion of narrative reporting, which is where intangibles are most often discussed. The latest financial crisis increased interest in better narrative reporting, as it shook the public's trust in corporate reporting and revealed the importance of non-financial information. A number of recent initiatives and consultations by the European Commission, the International Accounting Standards Board (IASB), the International Corporate Governance Network and other bodies have focused on enhancing standards for narrative reporting.

For example, in December 2010 the IASB issued a Practice Statement Management Commentary that provides a broad framework for the presentation of narrative reporting to accompany financial statements. It includes forward-looking information on corporate and intellectual capital resources in order to improve communication of non-financial factors relevant to company performance. That being said, prior work by the IASB noted that the current framework places serious limitations on the types of intangible assets that can be recognised on the balance sheet.

In 2008, the International Corporate Governance Network issued a Statement and Guidance on Non-Financial Reporting premised on the idea that "the fiduciary duty of institutional investors such as pension fund trustees and managers is to take into account all of the information which assists in identifying and mitigating risk and identifying sources of wealth creation". The guidance is quite general and essentially encourages companies to develop sustainability reports and to use KPIs in order to facilitate comparisons.

In 2011, the European Commission concluded a consultation on non-financial reporting which revealed a variety of views. Some stakeholders called for improvements but advocated a voluntary approach, others highlighted the need to clarify the existing EU framework. Overall, a majority of respondents indicated that reporting regimes differ significantly across member states and that the current framework makes it difficult for shareholders and investors to access disclosure provided by companies (EC, 2011). As a result, the Commission established an Expert Group on Disclosure of Non-financial Information and commissioned a further study analysing reporting practices in EU member states, including the need for integrated reporting and the demand for non-financial information.

In the search of better narrative reporting, considerable attention over the past few years has focused on the concept of ESG or sustainability reporting. This focus was arguably spurred by regulatory initiatives and demand by institutional investors. It is clear that the demand for ESG information by institutional investors generally, and socially responsible funds more specifically, has been on the rise.[6] However, investors' interest in ESG data appears to vary by country and it is currently unclear to what extent this disclosure drives specific investment decisions.

The work of the Global Reporting Initiative (GRI) has recently received significant attention. The GRI is a network-based organisation that has introduced an ESG reporting framework intended for use by companies irrespective of sector or size. Box 7.3 provides additional details on the GRI's reporting framework. It bears mentioning that the United Nations Principles for Responsible Investment (UNPRI) also seek to incorporate ESG principles into the decision-making processes of institutional investors. When this chapter was prepared, close to 1 000 parties, over half of them investment managers, had signed up to these principles.

The adoption of IA disclosure frameworks also has to be viewed in the context of the discussions on integrated reporting, which seek to link ESG and sustainability reporting with financial reporting. On the most general level, an integrated report is a single document that contains measures of financial and non-financial performance and the relationships between them. Beyond this basic definition, there is currently no consensus on what integrated reporting stands for, with the result that there are significant differences in the outcomes sought by organisations promoting this reporting concept.

In August 2010, the GRI and the Accounting for Sustainability Project (A4S) announced the formation of the International Integrated Reporting Committee (IIRC). The A4S promotes better disclosure outcomes through connected reporting so as to provide a forward-looking perspective on actions to manage risks and opportunities related to sustainability issues. The IIRC brings together representatives of corporate, accounting, securities and regulatory bodies to create a globally accepted integrated reporting framework that encompasses financial, environmental, social and governance information in a standardised format. The Secretariat of the IIRC is primarily supported by A4S, the GRI and the International Federation of Accountants and receives additional assistance from a number of other organisations.

Box 7.3. The Global Reporting Initiative Framework

The GRI's reporting framework sets out principles and performance indicators, which organisations can use to measure and report their economic, environmental and social performance. The framework is based on the *Sustainability Reporting Guidelines*, last updated in March 2011. The current version of the guidelines was extended to cover human rights, community impact and gender issues. The GRI is currently working on the next generation of these guidelines.

It has developed reporting templates for the electric utilities, financial services, mining and minerals, and food processing sectors as well as for non-profit organisations. Other sectoral templates are currently under development, as are national annexes. Hundreds of companies all over the world have adopted and are adopting the GRI methodology. The GRI compiles and features on its website a list of reports that comply with its methodology.

The adoption of this framework appears to be growing significantly. One KPMG survey found that nearly 80% of Fortune 250 companies and about 70% of the largest companies in the 20 largest markets refer to the GRI Guidelines. However, it is notable that the GRI itself considers only about 10 companies as being fully compliant with the standard from a universe of about 1 800 companies using it.

The GRI reporting framework and the reporting inspired by it show a weak link to intangible assets and their value drivers. For instance, the GRI framework includes metrics on human capital. However, the vast majority of proposed metrics (e.g. number of employees covered by bargaining agreements, rate of injury, etc.) are not those that could inform users of corporate reporting about the value drivers in a company. Some of the metrics proposed by the GRI's framework appear only very indirectly linked to the value creation process and aim instead to inform stakeholders about the various ESG parameters that are measurable and can be easily reported.

The first important step taken by the IIRC was the release of a discussion paper on integrated reporting in 2011. The IIRC is currently refining this document, which will present a reporting framework based on global consultations. The GRI's Guidelines are expected to shape the ESG content for the integrated reporting architecture developed by the IIRC. The IIRC has invited companies to apply to its pilot programme and a few dozen have volunteered so far. As a next step, the IIRC intends to work with regulators to seek a high-level agreement on the new standard, possibly in the form of a G20 endorsement.

Inspired by this and other efforts, some jurisdictions have begun promoting ESG/sustainability reporting specifically or integrated reporting more generally and a few have issued national frameworks. For instance, the Integrated Reporting Committee of South Africa released a Framework for Integrated Reporting in January 2011; as of July 2010 companies listed on the Johannesburg Stock Exchange are required to produce an integrated report. South Africa is for the moment the only jurisdiction to have explicitly adopted an integrated reporting framework based on the IIRC's model; however other countries now require better disclosure of ESG and sustainability policies by companies.

For example, since 2009 the Danish Commerce and Companies Agency has required the country's largest companies, state-owned enterprises and institutional investors to state in their annual reports whether they have corporate responsibility policies and how they implement them. The Swedish government announced in 2007 that all state-owned companies must produce sustainability reports in accordance with the GRI Guidelines. In some jurisdictions, such as the United Kingdom, companies are required to include KPIs that reflect critical success factors in the Enhanced Business Review.

The debate regarding the adoption of integrated reporting is ongoing without, for the moment, any consensus among policy makers, accountants and other experts. On one end of the spectrum are those who argue that all listed companies should be encouraged to adopt integrated reporting practices within the next few years. On the other end of the spectrum are those who consider that integrated reporting frameworks are insufficiently developed to provide a useful reporting model for companies and that, more often than not, instead of a truly integrated report, companies produce a report which adds unconnected layers of extra-financial information.

Since the OECD's 2006 report, *Intellectual Assets and Value Creation*, pressure from investors for public disclosure of intangibles appears low – at least in listed companies – owing in part to a shift in focus to disclosure deficiencies highlighted by the financial crisis and in part to emerging interest in ESG and sustainability reporting. This begs the question of whether interest in ESG, sustainability or integrated reporting has acted to advance or impede IA reporting. In principle, some overlap between IA and ESG reporting is plausible; indeed, research confirms the presence of IA disclosures in ESG reporting. For instance, Cordazzo (2005) looked at whether IA information can be found in ESG reports and noted a significant overlap of data.

A study of IA disclosures in sustainability reports in Portuguese firms found that information on intangibles is more likely in sustainability reports of listed companies and in firms with greater application of the GRI framework (Oliveira and Rodriguez, 2010). A study of Italian listed companies found increasing presence of IA information in corporate social responsibility (CSR) reports (Passetti et al., 2009). Despite growing interest in the potential overlap between IA and ESG/sustainability reporting, the jury is still out. Many researchers question the extent of possible integration of IA and CSR reporting, and some claim that they have widely different objectives. For instance, Mouritsen (2011) suggests that IA reporting is meant to describe value creation, whereas CSR reporting aims to explain value distribution.

Discussions about the possible integration of IA disclosure in integrated reporting generally and in the IIRC framework specifically have not advanced far. The IA disclosure debate has focused on the development of models that can capture how intangible assets contribute to the value creation process, whereas the integrated reporting agenda has focused primarily on linking the various components of financial and non-financial reporting. Linking ESG reporting with financial reporting is proving challenging enough; linking IA disclosure to financial reporting adds an additional layer of complexity.

One of the most important challenges to advancing the IA disclosure agenda is standardisation and comparability of reported information. The EFFAS Commission on Intellectual Capital (2008) noted that standardisation and reliability are vital for developing KPIs that are useful for the financial community. As mentioned earlier, there are dozens of private and some government-supported IA management and disclosure models, with different conceptions of intangibles and desired reporting outcomes. The variety of frameworks promoting ESG or sustainability disclosure frameworks adds to the choice of reporting models but also to the confusion for companies about the relative value of adopting one or another of these.

Finally, it is difficult to address the political economy of intangibles reform without considering the ongoing review and revisions of accounting frameworks. Insofar as the current accounting norms do not allow for the recognition of most types of intangibles, all efforts to promote IA disclosure continue to focus on narrative reporting. Going forward,

the renewed interest in extra-financial reporting provides an opportunity to embed the IA disclosure agenda in this debate. The following section outlines possible policy options to encourage companies to report more effectively on their intangibles and to allow for better comparability and consistency of reported information.

Policy options

For all of the reasons enumerated above, reporting on intangibles remains controversial and relatively slow to develop. Most initiatives to support better intangibles disclosure have been driven by the private sector or professional associations. So far, few governments have chosen to establish national guidelines, leaving IA reporting subject to market demand, the perceived need of companies to provide it, and the availability of internal resources. This can be attributed to policy makers' view that IA disclosure is best left to market dynamics and investor demand, as well as to the complexities of regulating or even providing recommendations on IA disclosure, considering the industry- and company-specific nature of intangibles.

Going forward, the fundamental question is what can be done to stimulate better corporate disclosure on intangible capital. One obvious policy option would be to leave the nature and scope of IA disclosure entirely up to companies and the development of disclosure frameworks to private/academic initiatives. In most jurisdictions, this is indeed what has been happening so far.

In principle, policy makers could support IA disclosure by establishing voluntary recommendations and guidelines or by backing existing private-sector initiatives. Some evidence of market participants' support for voluntary IA disclosure guidelines exists.[7] There is however no support for making such guidelines more than voluntary. For instance, in Denmark, where national IA disclosure guidelines were introduced in 2002, a survey of about 1 000 local companies found that they were interested in IA reporting but did not wish mandatory national or EU guidelines because they saw KPIs as unique to their firm (Mouritsen, 2011).

Another avenue open to policy makers is supporting mechanisms to facilitate IA reporting. Such measures could include, for example, support to young enterprises by coaching them on how data collection and reporting frameworks could be introduced. Public support for academic initiatives that promote IA reporting through pilot projects might also have a positive impact. For instance, in Spain, the Ministry of Science and Innovation is currently supporting a project with the BBVA (a financial institution) and a number of venture capital companies are looking at how to promote IA reporting in companies (Sanchez, 2011).

Policy makers could also consider measures to encourage the use of intangibles as collateral (Athena Alliance, 2009). Another example of a supporting policy that could potentially stimulate IA disclosure is the introduction of frameworks for auditors to review disclosure. Denmark is unique in that its Accounting Law requires companies with significant intangible assets to report them and provides guidelines to auditors regarding review of intangibles. In connection with these, policy makers could also pronounce on the preferred standard or format of disclosure (e.g. IC statement, integrated in narrative reporting, consolidated with ESG reporting).

Another area in which policy makers could potentially have an impact is engagement in international co-ordination to address this complex policy issue. So far, better co-ordination has been achieved in the area of integrated reporting, and the IIRC has played

an instrumental role. WICI has attempted to play the same co-ordination role for the IA disclosure agenda, but so far, it does not work directly with policy makers. No other body with a global reach has emerged so far to play this role.

Important progress would also be made by establishing expenditure classifications – i.e. standards for reporting intangibles on companies' profit and loss statements - that would promote consistency in data collecting and reporting. This would require the development of standards for reporting spending on intangibles to become a part of the Generally Accepted Accounting Principles (GAAP). Such standards need not entail any requirement to produce uncertain assessment of the market value of intangibles or imply any need to capitalize these expenditures. Instead, new and globally accepted classifications would allow firms to categorise in a consistent way the items of intangibles-related expenditure that are currently treated as undifferentiated intermediate expenditures (i.e. as intermediates of undefined type). Among other benefits, such standardised classification would greatly improve the availability and quality of data for use by national statistical authorities, financial intermediaries and external investors.

Annex 7.A1. Methods of measuring intangibles

Name	Year	Author	Description of measure
ICU Report	2009	Sanchez (2009)	ICU is a result of an EU-funded project to design an IC report specifically for universities. It contains three parts: Vision of the institution; Summary of intangible resources and activities; System of indicators.
EVVICAE™	2008	McCutcheon (2008)	Developed by the Intellectual Assets Centre in Scotland as a web-based EVVICAE toolkit based on the work of Patrick H. Sullivan (1995/2000).
Regional Intellectual Capital Index (RICI)	2008	Schiuma et al. (2008)	Uses the concept of the Knoware Tree with four perspectives (hardware, netware, wetware, software) to create a set of indicators for regions.
Dynamic monetary model	2007	Milost (2007)	The evaluation of employees is done with analogy to the evaluation of tangible fixed assets. The value of an employee is the sum of an employee's purchase value and the value of investments in an employee, less the value adjustment of an employee.
IAbM	2004	Japanese Ministry of Economy, Trade and Industry.	Intellectual asset-based management (IAbM) is a guideline for IC reporting introduced by the Japanese Ministry of Economy, Trade and Industry. An IAbM report should contain: Management philosophy; Past to present report; Present to future; Intellectual asset indicators. The design of indicators largely follows the MERITUM guidelines.
SICAP	2004	EU	An EU-funded project to develop a general IC model specially designed for public administrations and a technological platform to facilitate efficient management of public services. The model structure identifies three main components of intellectual capital: public human capital, public structural capital and public relational capital.
National Intellectual Capital Index	2004	Bontis (2004)	A modified version of the Skandia Navigator for nations: national wealth is comprised by financial wealth and intellectual capital (human capital + structural capital).
Topplinjen/ Business IQ	2004	Sandvik (2004)	A combination of four indices; Identity Index, Human Capital Index, Knowledge Capital Index, Reputation Index. Developed in Norway by the consulting firm Humankapitalgruppen.
Public sector IC	2003	Bossi (2003)	An IC model for the public sector, which builds on Garcia (2001) and adds two perspectives to the traditional three which are of particular importance for public administration: transparency and quality. It also identifies negative elements that generate intellectual liability. The concept of intellectual liability represents the space between ideal management and real management, one of the duties a public entity must fulfil for society.
Danish guidelines	2003	Mouritsen et al. (2003)	A recommendation by a government-sponsored research project for how Danish firms should report their intangibles publicly. Intellectual capital statements consist of a knowledge narrative, a set of management challenges, a number of initiatives and relevant indicators.
IC-dVAL™	2003	Bonfour (2003)	"Dynamic Valuation of Intellectual Capital". Indicators from four dimensions of competitiveness are computed: resources and competencies, processes, outputs and intangible assets (structural capital and human capital indices).
Intellectus model	2002	Sanchez-Canizares (2007)	Intellectus Knowledge Forum of Central Investigation on the Society of Knowledge. The model is structured into 7 components, each with elements and variables. Structural capital is divided into organisational capital and technological capital. Relational capital is divided into business capital and social capital.

Name	Year	Author	Description of measure
FiMIAM	2002	Rodov and Leliaert (2002)	Assesses monetary values of IC components through a combination of measurements of tangible and Intangible assets. The method seeks to link the IC value to market valuation over and above book value.
IC Rating™	2002	Edvinsson (2002)	An extension of the Skandia Navigator framework incorporating ideas from the Intangible Assets Monitor, rating efficiency, renewal and risk.
Value Chain Scoreboard™	2002	Lev (2002)	A matrix of non-financial indicators arranged in three categories according to the cycle of development: discovery/learning, implementation, commercialisation.
MERITUM guidelines	2002	MERITUM Guidelines (2002)	An EU-sponsored research project, which yielded a framework for management and disclosure of intangible assets in 3 steps: define strategic objectives; identify the intangible resources; actions to develop intangible resources. Three classes of intangibles: human capital, structural capital and relationship capital.
EFQM	2001	Caba and Sierra (2001)	An IC measuring model for the public sector based on the European Foundation Quality Management Model (EFQM). It integrates the elements from the EFQM model in the three blocks that compose intellectual capital: human capital, structural capital and relational capital.
Intangible assets statement	2001	Garcia (2001)	An IC measuring model for the public sector based on the IAM with indicators of growth/renovation, efficiency and stability.
Knowledge Audit Cycle	2001	Schiuma and Marr (2001)	A method for assessing six knowledge dimensions of an organisation's capabilities in four steps. 1) Define key knowledge assets. 2) Identify key knowledge processes. 3) Plan actions on knowledge processes. 4) Implement and monitor improvement, then return to 1).
Value Creation Index (VCI)	2000	Baum et al. (2000)	Developed by Wharton Business School, together with Cap Gemini Ernst & Young Center for Business Innovation and Forbes. It estimates the importance of different nonfinancial metrics in explaining the market value of companies. Different factors for different industries.
The Value Explorer™	2000	Andriessen and Tiessen (2000)	Accounting methodology proposed by KMPG for calculating and allocating value to 5 types of intangibles: assets and endowments; skills & tacit knowledge; collective values and norms; technology and explicit knowledge; primary and management processes. Described in Journal of IC 2000.
Intellectual Asset Valuation	2000	Sullivan (2000)	Methodology for assessing the value of intellectual property.
Total Value Creation, TVC™	2000	Anderson and McLean (2000)	A project initiated by the Canadian Institute of Chartered Accountants. TVC uses discounted projected cash flows to re-examine how events affect planned activities.
Knowledge Capital Earnings	1999	Lev (1999)	Knowledge capital earnings are calculated as the portion of normalised earnings (3-year industry average and analysts' consensus future estimates) over and above earnings attributable to book assets. Earnings then used to capitalise knowledge capital.
Inclusive Valuation Methodology (IVM)	1998	McPherson (1998)	Uses hierarchies of weighted indicators, which are combined and focuses on relative rather than absolute values. Combined value added = monetary value added combined with intangible value added.
Accounting for the Future (AFTF)	1998	Nash H. (1998)	A system of projected discounted cash flows. The difference between AFTF value at the end and the beginning of the period is the value added during the period.
Investor assigned market value (IAMV™)	1998	Standfield (1998)	Takes the company's true value to be its stock market value and divides it into tangible capital + (realised IC + IC erosion + SCA (sustainable competitive advantage).
Calculated Intangible Value	1997	Stewart (1997)	The value of intellectual capital is considered to be the difference between the firm's stock market value and the company's book value. The method is based on the assumption that a company's premium earnings, i.e. the earnings greater than those of an average company in the industry, result from the company's IC.

Name	Year	Author	Description of measure
Economic Value Added (EVA™)	1997	Stern and Stewart (1997)	Calculated by adjusting the firm's disclosed profit with charges related to intangibles. Changes in EVA provide an indication of whether the firm's intellectual capital is productive or not. EVA is the property of the consulting firm Sternstewart and one of the most common methods.
Value Added Intellectual Coefficient (VAIC™)	1997	Pulic (1997)	An equation that measures how much and how efficiently intellectual capital and capital employed create value based on the relationship to three major components: capital employed, human capital and structural capital.
IC-Index™	1997	Roos et al. (1997)	Consolidates all individual indicators representing intellectual properties and components into a single index. Changes in the index are then related to changes in the firm's market valuation.
Technology Broker	1996	Brooking (1996)	Value of intellectual capital of a firm is assessed based on a diagnostic analysis of a firm's response to 20 questions covering four major components of intellectual capital: human-centred assets, intellectual property assets, market assets and infrastructure assets.
Citation- Weighted Patents	1996	Dow Chemical (1996)	A technology factor is calculated based on the patents developed by a firm. Measurement of intellectual capital and its performance is based on the impact of research and development efforts on a series of indices, such as number of patents and cost of patents to sales turnover, which describe the firm's patents. The approach was developed by Dow Chemical and is described by Bontis (2001).
Holistic Accounts	1995	Rambøll Group	Rambøll is a Danish consulting group, which since 1995 reports according to its own "holistic accounting" report. It is based on the EFQM Business Excellence model. It describes nine key areas with indicators: values and management, strategic processes, human resources, structural resources, consultancy, customer results, employee results, society results and financial results.
Skandia Navigator™	1994	Edvinsson and Malone (1997)	Intellectual capital is measured through the analysis of up to 164 metric measures (91 intellectually based and 73 traditional metrics) that cover five components: financial; customer; process; renewal and development; and human. The Skandia insurance company made it known, but Skandia no longer produces the report.
Intangible Asset Monitor	1994	Sveiby (1997)	Management selects indicators, based on the strategic objectives of the firm, to measure four aspects of creating value from 3 classes of intangible assets: people's competence, internal structure, external structure. Value creation modes are: growth, renewal, utilisation/efficiency and risk reduction/stability.
Balanced Score Card	1992	Kaplan and Norton (1992)	A company's performance is measured by indicators covering four major areas: financial perspective, customer perspective, internal process perspective and learning perspective. The indicators are based on the strategic objectives of the firm.
HR statement	1990	Ahonen (1998)	A management application of HRCA widespread in Finland. The HR profit and loss account divides personnel-related costs into three classes for human resource costs: renewal costs, development costs and exhaustion costs. 150 listed Finnish companies prepared an HR statement in 1999.
The Invisible Balance Sheet	1989	Sveiby (ed. 1989) The "Konrad" group	The difference between the stock market value of a firm and its net book value is explained by three interrelated "families" of capital: human capital, organisational capital and customer capital. The three categories first published in this book in Swedish have become a *de facto* standard.

Source: Reproduced from Sveiby, 2010, "Methods for Measuring Intangible Assets", online article. Last updated 27 April 2010.

Notes

1. Indeed, when Andriessen did a similar analysis in 2004, he already identified approximately 30 methods.

2. Companies are generally not mandated to provide reporting on their intangibles, barring specific circumstances such as bankruptcy and reorganisation or in support of litigation or dispute resolution related, for instance, to infringement of intellectual property rights (Andriessen, 2004).

3. The authors explain this correlation by the fact that greater IA disclosure contributes to investor optimism and to higher IPO pricing, but that this optimism may not be sustained in the longer term.

4. A number of models such as those put forth by EU's MERITUM or InCas projects, favour the disclosure of a separate statement. However, this practice has not taken root and most companies make their IA disclosures part of their broader narrative reporting. This may be due to disappointing outcomes in Japan where companies tended to view their intellectual capital statements as a way to disclose their patents and trademarks.

5. Deutsche Bank, for instance, recently announced that it is currently managing 3 IC-focused funds totalling EUR 150 million and a number of smaller players blend the early-stage focus of venture capital (VC) with the lending competence of banks to target IC-intensive companies.

6. Investors in 23 countries examined in one study were shown to access ESG metrics provided by Bloomberg an estimated 34 million times in only two quarters of 2011 (Tonello, 2011); there has been a significant increase in the number of times these data are accessed.

7. The need to introduce national-level frameworks has been supported by some studies of IA disclosure (e.g. Sujan and Abeysekera, 2007).

References

Abdolmohammadi, M.J. (2005), "Intellectual Capital Disclosure and Market Capitalization", *Journal of Intellectual Capital*, Vol. 6 (3).

Abhayawansa, S. and J. Guthrie (2010), "Intellectual Capital and the Capital Market: A Review and Synthesis", *Journal of Human Resource Costing and Accounting*.

Aboody, D. and B. Lev (2002), "Information Asymmetry, R&D and Insider Gains", *The Journal of Finance*, December Issue.

Andriessen, D. (2004), "IC Valuation and Measurement: Classifying the State of Art", *Journal of Intellectual Capital*, Vol. 5.

Arvidsson, S. (2003), "Demand and Supply of Information on Intangibles". PhD Thesis, Lund University.

Arvidsson, S. (2011), "Disclosure of Non-Financial Information in the Annual Report", *Journal of Intellectual Capital*, Vol. 12, No. 2.

ACCA: Association of Chartered Certified Public Accountants (2011), "Predicting an Uncertain Future: Narrative Reporting and Risk Information. An Accountancy Futures Note".

APCA: Association of Public Certified Accountants (2010), "Hitting the Notes, but What's the Tune? An International Survey of CFO's Views on Narrative Reporting".

Susan Rose, Stephanie Shipp, Bhavya Lal and Alexandra Stone (2009). " Frameworks for Measuring Innovation: Initial Approaches." Athena Alliance, Working Paper 6.

Bukh, P.N., C. Neilsen, P. Gormsen and J. Mouritsen (2005), "Disclosure of Information on Intellectual Capital in Danish IPO Prospectuses", *Accounting, Auditing and Accountability Journal*, Vol. 18(6).

Bushee, B., M. Jung and G. Miller (2011), "Do Investors Benefit from Selective Access to Management?" Working Paper.

Cerbioni, F. and A. Parbonetti (2012), "Exploring the Effects of Corporate Governance on Intellectual Capital Disclosure: An Analysis of European Biotechnology Firms", forthcoming in *European Accounting Review*.

Clarke, M. (2011), "Intellectual Capital and Firm Performance in Australia", *Journal of Intellectual Capital*, Vol. 12, No. 4.

Cordazzo, M. (2005), "IC statements vs Environmental and Social Reports: An Empirical Analysis of Their Convergence in the Italian Context", *Journal of Intellectual Capital*, Vol. 6, No. 3.

Eccles, R. and G. Serafeim (2011), "Leading and Lagging Countries in Contributing to a Sustainable Society", Harvard Business School Working Knowledge.

Ellis, I. and P. Jarboe (2010), "Intangible Assets in Capital Markets." *Intellectual Assets Management*, May/June Issue.

European Commission (2006). "RICARDIS: Reporting on Intellectual Capital to Augment Research, Development and Innovation in SMEs", Directorate General for Research.

European Commission (2011), "Summary Report of the Responses Received to the Public Consultation on Disclosure of Non-Financial Information by Companies", Directorate for the Internal Market and Services.

EFFAS: European Federation of Financial Analysts Societies (2008), "Principles for Effective Communication of Intellectual Capital".

Firer, S. and M. Williams (2011), "Association Between the Ownership Structure of Singapore Publicly Traded Firms and Intellectual Capital Disclosures", *Corporate Governance and Intellectual Capital Archive Research Papers.*

Garcia-Meca, E. and I. Martinez (2007), "The Use of Intellectual Capital Information in Investment Decisions: an Empirical Study Using Analyst Reports", *International Journal of Accounting*, Vol. 42(1).

Hidalgo, R., E. Garcia-Meca and I. Martinez (2010), "Corporate Governance and Intellectual Capital Disclosure", *Journal of Business Ethics*.

Holland, J.B. (2002). "Fund Management, Intellectual Capital, Intangibles and Private Disclosure", Working Paper, Department of Accounting and Finance, University of Glasgow.

InCas (2010), European ICS Guideline.

InCas (2011), Conference call with Stefan Zickgraf, Project Coordinator.

IASB: International Accounting Standards Board (2010), *Practice Statement Management Commentary.*

ICAS: Institute of Chartered Accountants of Scotland (2010), "Intellectual Capital Reporting: Academic Utopia or Corporate Reality in a Brave New World?", prepared by V. Beattie and S. J. Thomson.

KPMG (2003), Non-executive directors' survey.

Lajili, K. and D. Zéghal (2005), "Labour Cost Voluntary Disclosures and Firm Equity Values: Is Human Capital Information Value-relevant?" *Journal of International Accounting, Auditing and Taxation,* Vol. 41(2).

Eli Amir & Baruch Lev & Theodore Sougiannis, 2003. "Do financial analysts get intangibles?," *European Accounting Review*, Taylor and Francis Journals, vol. 12(4), pages 635-659.

Li, J., R. Pike and R. Haniffa (2011), "Intellectual Capital Disclosure and Corporate Governance Structure in UK Firms", *Accounting and Business Research*, Vol. 38, No. 2.

Mouritsen, Jan (2011). Presentation to the Conference on Intangible Assets, Bercy, November.

OECD (2006), "Intellectual Assets and Value Creation: Implications for Corporate Reporting", OECD, Paris.
www.oecd.org/daf/ca/corporategovernanceprinciples/37811196.pdf

OECD (2007), "Intellectual Assets and Corporate Reporting: The Situation of Small Caps", *OECD, Paris.*
http://www2.oecd.org/oecdinfo/info.aspx?app=OLIScoteEN&Ref=DAF/CA/CG(2007)9/FINAL

OECD (2008), "Recent Developments in Intellectual Capital Reporting and their Policy Implications", *OECD Education Working Papers*, No. 17, OECD Publishing. doi: http://dx.doi.org/10.1787/227362757626.

Oliveira, L. and L.L. Rodriguez (2010), "Intellectual Capital Reporting in Sustainability Reports", *Journal of Intellectual Capital*, Vol. 11, No. 4.

Ousama, A., A. Fatima and A. Hafiz Majdi (2011), "Usefulness of Intellectual Capital Information: Preparers' and Users' Views", *Journal of Intellectual Capital*, Vol. 12, Issue 3.

Passetti, E., A. Tenucci, L. Cinquini and M. Frey (2009), *Intellect.al Capital Communication: Evidence from Social and Sustainability Reporting*, MPRA Paper 16589, University Library of Munich, Germany.

PwC: PricewaterhouseCoopers (2007), *Corporate Reporting – A Time For Reflection. A Survey of the Fortune 500 Companies' Narrative Reporting.*

Sanchez, Paloma (2011), Presentation to the Conference on Intangible Assets, Bercy, November.

Singh, I. and J-L. W. Mitchell Van der Zahn (2009), "Intellectual Capital Prospectus Disclosure and Post-issue Stock Price Performance", *Journal of Intellectual Capital,* Vol. 10, No. 3.

Solomon, D. and E. Soltes (2011), "What Are We Meeting For? The Consequences of Private Meetings with Investors", accessed through Social Science Research Network.

Sveiby, K.E. (2010), "Methods for Measuring Intangible Assets", online article. Last updated 27 April 2010.

Sujan, A and Abeysekera, I. (2007). "Intellectual capital reporting practices of the top Australian firms", *Australian Accounting Review*, 17 (42), 71-83.

Tonello, M. (2011), "The Role of the Board in Accelerating the Adoption of Integrated Reporting", The Conference Board, Adapted from a chapter in CSR Index.

Unerman J., J. Guthrie and L. Striukova (2007), *UK Reporting of Intellectual Capital*, ICAEW Centre for Business Performance, London.

Vafaei, A., D. Taylor and K. Ahmed (2011), "The Value Relevance of Intellectual Capital Disclosures", *Journal of Intellectual Capital*, Vol. 12, No. 3.

Webster, E. (2000), "The Growth of Enterprise Intangible Investment in Australia", *Information Economics and Policy*, Vol. 12.

White, Gregory, A. Lee, G. Tower, (2007). "Drivers of voluntary intellectual capital disclosure in listed biotechnology companies", *Journal of Intellectual Capital*, Vol. 8 Iss: 3 pp. 517 – 537.

Whiting, R.H. and J. Woodcock (2011), "Firm Characteristics and Intellectual Capital Disclosure by Australian Companies", *Journal of Human Resource Costing and Accounting.*

WICI: World Intellectual Capital Initiative (2011), "Concept Paper".

Zambon, Stefano (2009). IPR, Intangibles and Valuation: Visualising Information for Finance Access. Presentation to the World Intellectual Property Organisation. Rome 10-11 November 2009.

Chapter 8.

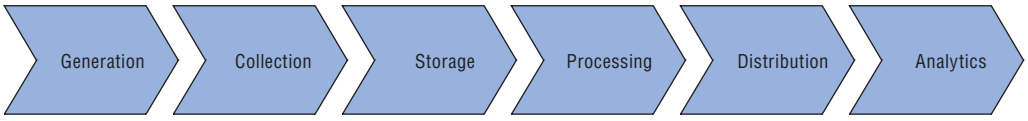
Exploring data-driven innovation as a new source of growth: Mapping the policy issues raised by "big data"

Several technological and socioeconomic trends, including the migration of social and economic activities to the Internet, and the falling costs of data collection, transport, storage and analytics, are leading to the generation of huge volumes of data – often referred to as big data. Big data now represents a core economic asset that can create significant competitive advantage for firms and drive innovation and growth. This chapter considers five sectors in which the use of data can stimulate innovation and productivity growth: online advertisement, health care, utilities, logistics and transport, and public administration.

Overall, the benefits that big data can create in these sectors include: the development of new data-based goods and services; improved production or delivery processes; improved marketing (by providing targeted advertisements and personalised recommendations); new organisational and management approaches, or significantly improved decision-making within existing practices; and enhanced research and development. Optimal public policy in this sphere has still to be identified. However, it is clear that to unlock the potential of big data, OECD governments need to develop coherent policies and practices for the collection, transport, storage and use of data. Among others, these policies cover issues such as privacy protection, open data access, the supply of skills and infrastructure, and measurement (better capturing the value of data in economic statistics).

This chapter explores the potential of the increasing generation and use of data streams as a resource for enabling the development of new industries, processes and products. While economic and social activities have long made use of data, the scale and influence of information and communication technologies (ICTs) that enable the economic exploitation of data are growing at an extraordinary pace. Declining costs along the data value chain (Figure 8.1.) have been a significant driver of the increasing generation and use of data, and economic and social activities increasingly migrate to the Internet thanks to the wide adoption of e-services in an increasingly participative web. The resulting phenomenon – commonly referred to as "big data" – signals the shift towards a data-driven economy, in which data enhance economic competitiveness and drive innovation and equitable and sustainable development.

Figure 8.1. The data value chain and life cycle



Note: This figure does not include the last phase, "Deletion", which is important for personal data but is considered less important in the context of "big data", where the default is to keep data for long periods, if not indefinitely. However, from a policy perspective "Deletion" may deserve a more prominent role. The output of the "Analytics" phase can generate additional data and feed back into the data value chain, leading to a new data life cycle.

To achieve their socioeconomic goals, OECD countries need coherent policy frameworks for the generation, collection, transport and use of data, particularly in areas such as consumer and user empowerment and privacy protection. As access to tools such as smart phones and other smart devices increases, the Internet has a tremendous capacity to enable "crowd sourcing" of consumer and user data in ways that can increase civic engagement and help citizens and consumers in their day-to-day activities. At the same time, these new sources of data, the presence of new actors with access to data, and the increasing ease of linking and transferring data on individuals all test the effectiveness of existing privacy frameworks. The potential policy implications spill over into areas such as access to data, skills and employment, competition, health, and government administration.

This report seeks first to provide a better understanding of the generation and use of data. It then explores the uses and value of big data across sectors and application areas, and finally describes the main policy opportunities and challenges.

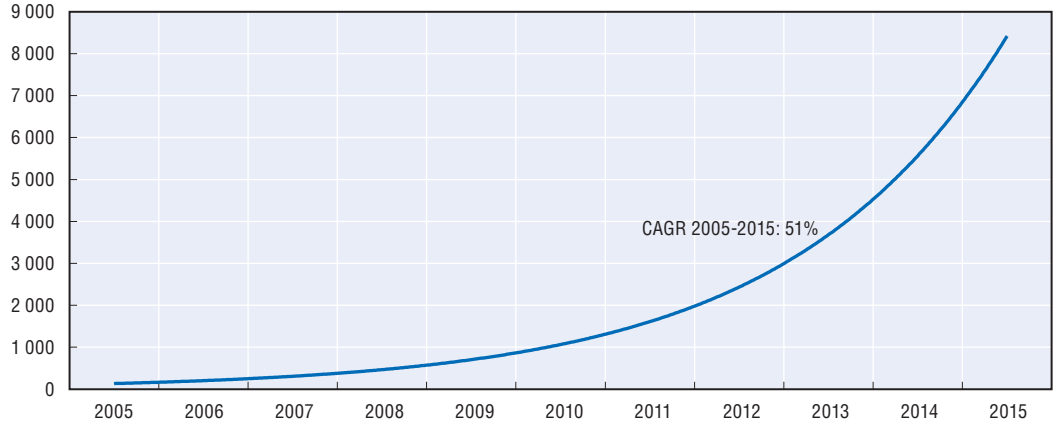
Understanding data and the drivers of their generation and use

The digitisation of nearly all media and the increasing migration of social and economic activities to the Internet (through e-services such as social networks, e-commerce, e-health and e-government) are generating petabytes (millions of gigabytes) of data every second. The social networking site Facebook, for example, is said to have over 900 million active participants around the world and to generate on average more than 1 500 status updates every second (Hachman, 2012; Bullas, 2011). With the increasing deployment and interconnection of (real-world) sensors through mobile and fixed networks (i.e. sensor networks), more and more offline activities are also digitally recorded, resulting in an additional tidal wave of data. Measurement in this area is somewhat speculative, but one source suggests that in 2010 alone, enterprises overall stored more than seven exabytes (billions of gigabytes) of new data on disk drives, while

consumers stored more than six exabytes of new data (MGI, 2011). This has led to an estimated cumulative data volume of more than 1 000 exabytes in 2010; some estimates suggest that this will multiply by a factor of 40 by the end of this decade (see Figure 8.2) (IDC, 2012).

Figure 8.2. Estimated worldwide data storage

in exabytes (billions of gigabytes)



Note: The compound annual growth rate (CAGR) describes the year-over-year growth rate at which worldwide data storage will grow over a specified period of time if it grows at a steady rate.

Source: OECD based on IDC Digital Universe research project.

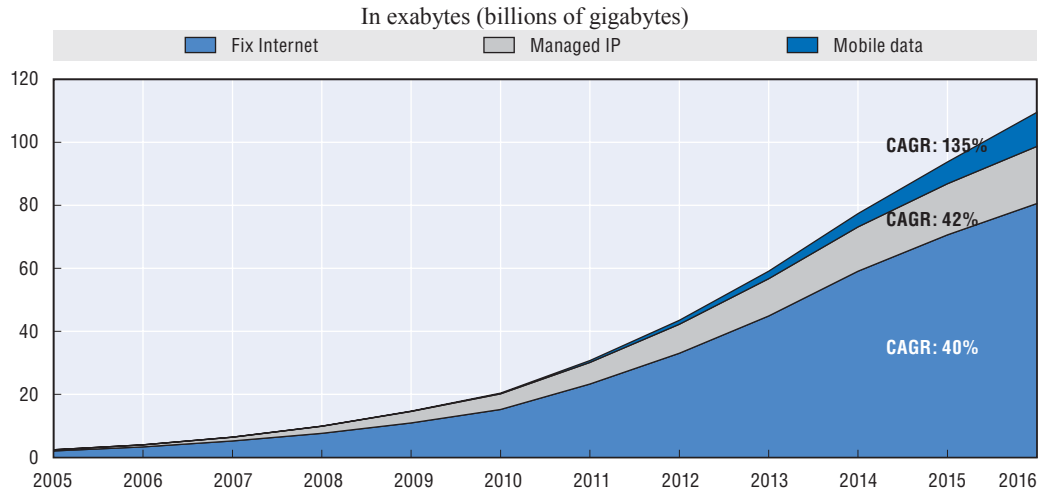
Data generation, collection and transport

The remarkable expansion of data is largely driven by the confluence of important technological developments, notably the increasing ubiquity of broadband access and the proliferation of smart devices and smart ICT applications such as smart meters, smart grids and smart transport based on sensor networks and machine-to-machine (M2M) communication. The large decrease in Internet access costs over the last 20 years has been a significant driver. In 2011, for example, consumers in France paid around the equivalence of USD 33 a month for a broadband connection of 51 Mbit/s compared to the equivalence of USD 75 for a (1 000 times slower) dial-up connection in 1995.[1] Mobile telephones have become a leading data collection device, combining geo-location data and Internet connectivity to support a broad range of new services and applications related to traffic, the environment or health care. Many of these services and applications rely on (or involve) the collection and use of personal data. In addition to increased and more efficient Internet access, most mobile devices are equipped with an increasing array of protocols over which to exchange data locally (e.g. Wi-Fi, Bluetooth, Near Field Communications [NFC] with peer-to-peer data transfer capabilities). They may also capture videos, images and sound (often tagged with geo-location information).

In 2011, there were almost six billion mobile subscriptions worldwide of which roughly 13% (780 million) were smart phones capable of collecting and transmitting geo-location data (ITU, 2012; Cisco, 2012). These mobile telephones generated approximately 600 petabytes (millions of gigabytes) of data every month in 2011 (Cisco, 2012).[2] Given that mobile phone penetration (subscriptions per 100 inhabitants) exceeds 100% in most OECD countries and that wireless broadband penetration is at nearly 50%, this source of data will grow significantly as smart phones become the prevalent personal

device. Cisco (2012) estimates that the amount of data traffic generated by mobile telephones will reach almost 11 exabytes (billions of gigabytes) by 2016, i.e. almost doubling every year (see Figure 8.3.).

Figure 8.3. Monthly global IP traffic, 2005-16



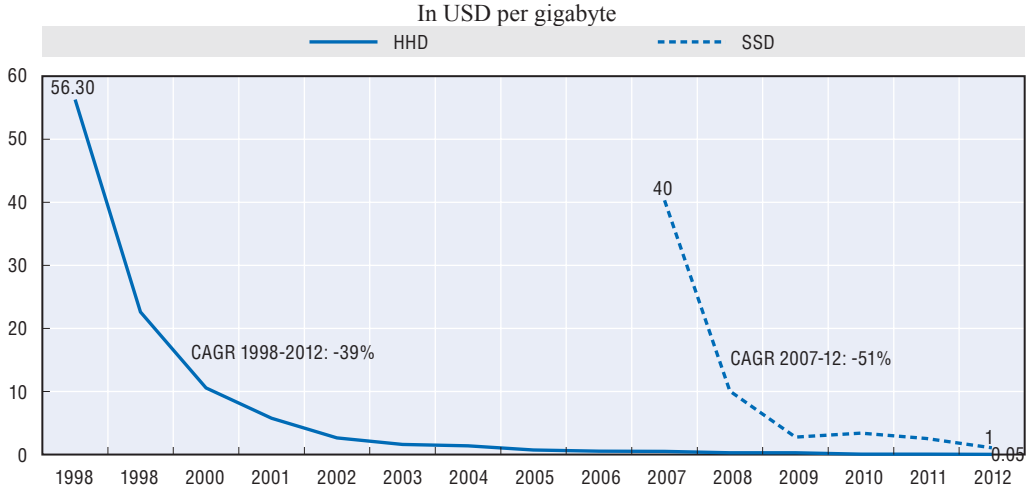
Source: OECD based on Cisco (2012), "Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2011–2016", White Paper, www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.pdf.

The growth in mobile data is not only due to the growing number of mobile telephones, which are expected to account for half of total mobile traffic in 2016 (Cisco, 2012). Other smart devices are proliferating even faster:[3] smart meters, for example, increasingly collect and transmit real-time data on energy (OECD, 2012a), and smart automobiles are now able to transmit real-time data on the state of the car's components and environment (OECD, 2012b).[4] Many of these smart devices are based on sensor and actuator networks that sense, and may be able to interact with, their environment over mobile networks. The sensors and actuators exchange data through wireless links "enabling interaction between people or computers and the surrounding environment" (Verdone et al., 2008, cited in OECD, 2009a). More than 30 million interconnected sensors are now deployed worldwide, in areas such as security, health care, the environment, transport systems or energy control systems, and their numbers are growing by around 30% a year (MGI, 2011).[5]

Data storage and processing

While the above-mentioned technological developments mainly drive the generation and transport of data, use of the data has been greatly facilitated by the declining cost of data storage, processing and analytics. In the past, the cost of storing data discouraged keeping data that were no longer, or unlikely to be, needed. But storage costs have decreased to the point at which data can generally be kept for long periods if not indefinitely. This is illustrated, for example, by the average cost per gigabyte of consumer hard disk drives (HDDs), which dropped from USD 56 in 1998 to USD 0.05 in 2012, an average decline of almost 40% a year (Figure 8.4). With new generation storage technologies such as solid-state drives (SSDs), the decline in costs per gigabyte is even faster.

Figure 8.4. Average data storage cost for consumers, 1998-2012

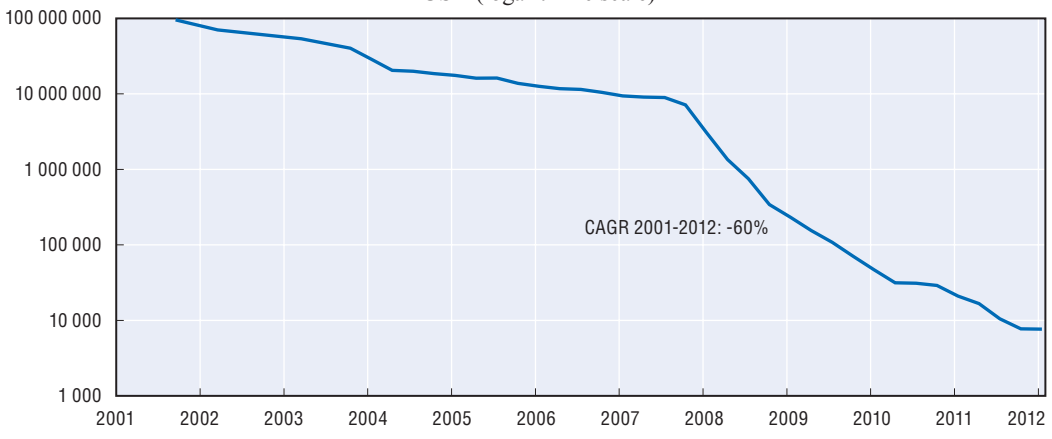


Note: Data for 1998-2011 are based on average prices of consumer-oriented drives (171 HDDs and 101 SSDs) from M. Komorowski (www.mkomo.com/cost-per-gigabyte), AnandTech (www.anandtech.com/tag/storage) and Tom's Hardware (www.tomshardware.com/). The price estimate for SSD in 2012 is based on Shah (2011) referring to Gartner.

Source: OECD based on Pingdom (2011), "Would you pay $7,260 for a 3 TB drive? Charting HDD and SSD prices over time", 19 December, http://royal.pingdom.com/2011/12/19/would-you-pay-7260-for-a-3-tb-drive-charting-hdd-and-ssd-prices-over-time.

Moore's Law, which holds that processing power doubles about every 18 months, relative to cost or size, has largely been borne out. This is particularly noticeable in data processing tools, which have become increasingly powerful, sophisticated, ubiquitous and inexpensive, making data easily searchable, linkable and traceable, not only by governments and large corporations but also by many others. In genetics, for example, DNA gene sequencing machines can now read about 26 billion characters of the human genetic code in less than a minute, and the sequencing cost per genome has dropped by 60% a year on average from USD 100 million in 2001 to less than USD 10 000 in 2012 (Figure 8.5).

Figure 8.5. Sequencing cost per genome, 2001-11



Source: OECD based on United States National Human Genome Research Institute (www.genome.gov/sequencingcosts/).

Cloud computing has played a significant role in the increase in data storage and processing capacity. It has been described as "a service model for computing services based on a set of computing resources that can be accessed in a flexible, elastic, on-demand way with low management effort" (OECD, 2012c).[6] In particular, for small and medium-sized enterprises (SMEs), but also for governments that cannot, or do not want to, make heavy upfront investments in ICTs, cloud computing enables organisations to pay for supercomputing resources via a pay-as-you-go model.[7]

Open source software (OSS) applications that cover the full range of solutions needed for big data, including storage, processing and analytics, have also contributed significantly to making big data analytics accessible to a wider population. Many big data tools developed initially by Internet firms are now spreading across the economy as enablers of new data-driven goods and services. For instance, Hadoop, an open source programming framework for distributed data management, was inspired by a paper by Google employees Dean and Ghemawat (2004). It was funded initially by Yahoo!, deployed and further developed by Internet firms such as Amazon,[8] Facebook,[9] and LinkedIn,[10] then offered by traditional providers of databases and enterprise servers such as IBM,[11] Oracle,[12] Microsoft,[13] and SAP[14] as part of their product lines, and is now used across the economy for data-intensive operations in companies as diverse as Wal-Mart (retail), Chevron (energy) and Morgan Stanley (financial services).

New participants are entering the data market to trade and exchange data or purchase data-related services. Increasingly specialised data analysts and data brokers offer data for uses such as targeted advertisement, employment background checks, issuing of credit and law enforcement. The number of firms offering data has grown significantly in recent years. At the time of writing, privacyrights.org listed 180 online data brokers registered in the United States alone. Data brokers range from specialised business-to-business companies to simple localisation services.[15] They include companies such as LexisNexis, which claims to conduct more than 12 million background checks a year, and BlueKai Exchange, which claims to be the world's largest data marketplace for advertisers, with data on more than 300 million consumers and more than 30 000 data attributes. According to its website, BlueKai Exchange processes more than 750 million data events and transacts over 75 million auctions for personal information a day.

Defining "big data": Volume, velocity and variety, but also value

All the trends described above are present along the data value chain in Figure 8.1. It is no surprise that these large-scale trends have led some market players to see big data as a new paradigm (Autonomy, 2012; Zinow, 2012). However, the literature offers no clear definition of "big data". Existing definitions tend to focus on volume. Many authors simply describe "big data" as "large pools of data" (McGuire et al., 2012). Loukides (2010) defines it as data for which "the size of the data itself becomes part of the problem". The McKinsey Global Institute (MGI, 2011) similarly defines it as data for which the "size is beyond the ability of typical database software tools to capture, store, manage, and analyse".[16] The problem with such definitions is that they are in continuous flux, as they depend on the evolving performance of available storage technologies.

Furthermore, volume is not the only important characteristic. The speed at which data are generated, accessed, processed and analysed is also sometimes mentioned, and analysts have come to use readily available data to make real-time "nowcasts" ranging from purchases of autos to flu epidemics to employment/unemployment trends in order to improve the quality of policy and business decisions (Choi and Varian, 2009; Carrière-

Swallow and Labbé, 2010). The Billion Price Project (BPP), launched at MIT and spun off to a firm called PriceStats, collects more than half a million prices on goods (not services) a day by "scraping the web". Its primary benefit is its capacity to provide real-time price statistics that are timelier than official statistics. In September 2008, for example, when Lehman Brothers collapsed, the BPP showed a decline in prices that was not picked up until November by the official Consumer Price Index (Surowiecki, 2011) (Box 8.2). Data analytics are also used for security purposes, such as real-time monitoring of information systems and networks to identify malware and cyberattack patterns. The security company ipTrust, for instance, uses Hadoop to assign reputation scores to IP addresses to identify traffic patterns from bot-infected machines in real time (Harris, 2011).

In some cases, big data is defined by the capacity to analyse a variety of mostly unstructured data sets from sources as diverse as web logs, social media, mobile communications, sensors and financial transactions. This requires the capability to link data sets; this can be essential as information is highly context-dependent and may not be of value out of the right context. It also requires the capability to extract information from unstructured data, i.e. data that lack a predefined (explicit or implicit) model. Estimates suggest that the share of unstructured data in businesses could be as high as 80% to 85% and largely unexploited or underexploited. In the past, extracting value from unstructured data was labour-intensive. With big data analytics silos of unexploited data can be linked and analysed to extract potentially valuable information in an automated, cost-effective way.

The potential for automatically linking sets of unstructured data can be illustrated by the evolution of search engines. Web search providers such as Yahoo! initially started with highly structured web directories edited by people. These services could not be scaled up as online content increased. Search providers had to introduce search engines which automatically crawled through "unstructured" web content.[17] Yahoo! only introduced web crawling as the primary source of its search results in 2002. By then Google had been using its search engine (based on its PageRank algorithm) for five years, and its market share in search had grown to more than 80% in 2012.[18]

These three properties – volume, velocity and variety – are considered the three main characteristics of big data and are commonly referred to as the three Vs (Gartner, 2011).[19] However, these are technical properties that depend on the evolution of data storage and processing technologies. Value is a fourth V which is related to the increasing socioeconomic value to be obtained from the use of big data. It is the potential economic and social value that ultimately motivates the accumulation, processing and use of data. It therefore appears appropriate to go beyond the purely technical aspects of volume, velocity and variety to look at the socioeconomic dimension of big data as a "new factor of production" (Gentile, 2011; Jones 2012).

The increasing use and value of data across the economy

As data storage and processing become increasingly sophisticated, ubiquitous and inexpensive, organisations across the economy are using large data flows for their daily operations. Brynjolfsson et al. (2011) estimate that the output and productivity of firms that adopt data-driven decision making are 5% to 6% higher than would be expected from their other investments in and use of information technology. These firms also perform better in terms of asset utilisation, return on equity and market value. Growing investments in data management and analytics partly reflect the increasing economic role

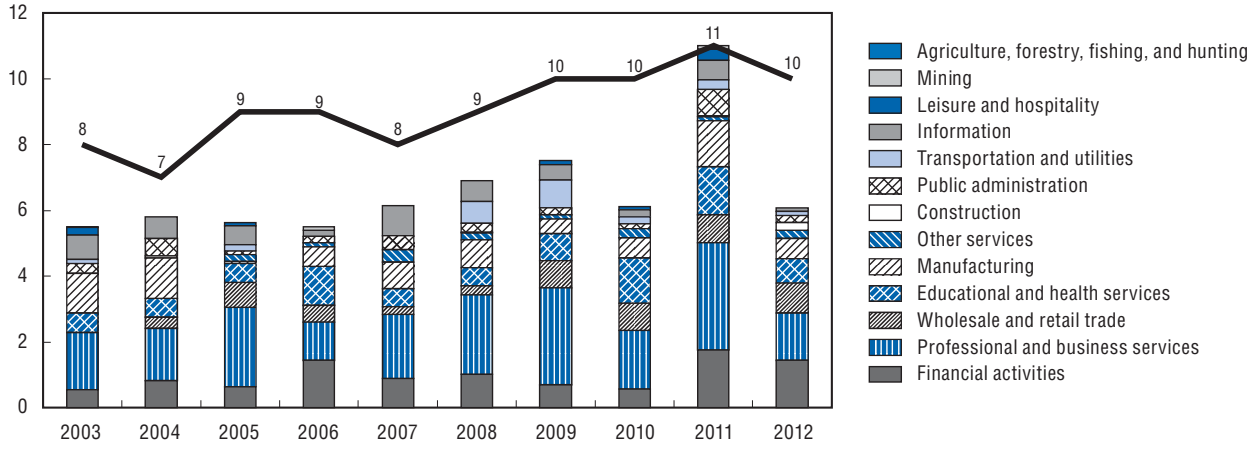
of data. For example, the market value of relational database management systems alone was worth more than USD 21 billion in 2011, having grown on average by 8% a year since 2002. Of perhaps greater interest for big data is the demand for non-relational (noSQL) database systems and business intelligence (BI) and analytics software, which has increased significantly in recent years as data analytics continue to evolve, in particular for data-driven decision making.[20]

The amount of data involved may differ significantly across sectors, as some are more data-intensive than others. According to MGI (2011), data intensity (measured as the average amount of data per organisation) is highest in financial services (including securities and investment services and banking), communication and media, utilities, government, and discrete manufacturing. In these sectors, each organisation stored on average more than 1 000 terabytes (one petabyte) of data in 2009. A similar ranking can be deduced from the estimated number of data management and analytics professionals (data scientists) per 1 000 employees in each sector. The underlying assumption is that sectors employing more data scientists per 1 000 employees are more data-intensive (see Figure 8.6).[21]

According to population surveys in the United States, the number of sectors employing one or more database administrators per 10 000 employees has increased over the last nine years. In 2012, the five industries with the largest share of database administrators were: financial activities (22 database administrators per 10 000 employees); professional and business services (12); wholesale and retail trade (6); manufacturing (6); and information (5 together with public administration and other services). The share of database administrators in these sectors has also increased significantly in recent years, with a remarkable peak of more than 160 database administrators per 10 000 employees in the United States in 2011.[22] Most of the data-intensive sectors also tend to have a high ICT intensity (ICT expenditure as a share of output); however, the mining sector had a negligible number of database administrators.[23]

Figure 8.6. Data intensity of the United States economy, 2003-12

Number of database administrators per 10 000 employees by sectors (left scale),
Number of sectors with more than one database administrator per 10 000 employees (right scale)



Source: OECD based on the Current Population Survey (March supplement), United States, 2012.

Differences in data intensity suggest that the value of data may differ significantly among sectors (OECD, 2012d).[24] Empirical studies confirm this context dependency not only at the firm level, but also at the employee level (Spiekermann et al., 2001; Acquisti et al., 2011). This makes any assessment of macroeconomic effects much more difficult, and shows the need for case studies to understand the effects in particular sectors or parts of the data value chain.[25]

The following sections briefly present the potential value of data in five sectors. These sectors have been identified in the literature and in previous OECD work as areas of high potential for the use of data as a source of innovation and productivity growth (Cebr, 2012; MGI, 2011; Villars et al., 2012; OECD 2009b; 2012a; 2012b; 2012c). The sectors are: (online) advertisement, public administration, health care, utilities, and logistics and transport. Some of these sectors have been chosen because they have been under-exploiting their data, although they are data-intensive (public administrations, utilities to some extent). Other sectors are less data-intensive today but will face growing amounts of new data, such as click-stream data (online advertisement), geo-location data (transport), smart meter data (utilities), and health records (health care), which, if fully exploited, could generate additional benefits. Together these sectors account on average for roughly a quarter of total value added in ten OECD countries[26] for which data are available. Overall, the promise of big data lies in one or more of the following innovation-related areas:

- Use of data for the creation of new products (goods and services). This includes using data as a product (data products) or as a major component of a product (data-intensive products).
- Use of data to optimise or automate production or delivery processes (data-driven processes). This includes the use of data to improve the efficiency of distribution of energy resources ("smart" grids), logistics and transport ("smart" logistics and transport). Data can be central to new organisational and management approaches in firms or for significantly improving existing practices (data-driven organisation and data-driven decision making) (Brynjolfsson et al., 2011). And data can also be employed to improve marketing, for instance by providing targeted advertisements and personalised recommendations or other types of marketing-related discrimination (data-driven marketing).
- Use of data to enhance research and development (data-driven R&D). This includes new data-intensive methods for scientific exploration by adding a "new realm driven by mining new insights from vast, diverse data sets" (EC, 2010) (see Box 8.1).

Box 8.1. Data-driven science and research

Measurement has always been fundamental to science. The advent of new instruments and methods of data-intensive exploration has prompted some to suggest the arrival of "data-intensive scientific discovery", which builds on the traditional uses of empirical description, theoretical models and simulation of complex phenomena (BIAC, 2011). This could have major implications for how discovery occurs in all scientific fields. Some have challenged the usefulness of models in an age of massive datasets, arguing that with large enough data sets, machines can detect complex patterns and relationships that are invisible to researchers. The data deluge, it is argued, makes the scientific method obsolete, because correlations are enough (Anderson, 2008; Bollier, 2010).

…/…

Box 8.1. Data-driven science and research *(continued)*

New instruments such as super colliders or telescopes, but also the Internet as a data collection tool, have been instrumental in new developments in science, as they have changed the scale and granularity of the data being collected. The Digital Sky Survey, for example, which started in 2000, collected more data through its telescope in its first week than had been amassed in the history of astronomy (*The Economist*, 2010), and the new SKA (square kilometre array) radio telescope could generate up to 1 petabyte of data every 20 seconds (EC, 2010). Furthermore, the increasing power of data analytics has made it possible to extract insights from these very large data sets reasonably quickly. In genetics, for instance, DNA gene sequencing machines based on big data analytics can now read about 26 billion characters of the human genetic code in seconds. This goes hand in hand with the considerable fall in the cost of DNA sequencing over the last five years (Figure 8.4).

These new developments, scaled across all scientific instruments and across all scientific fields, indicate the potential for a new era of discovery and raise new issues for science policy. These issues range from the skills that scientists and researchers must master to the need for a framework for data repositories which adheres to international standards for the preservation of data, sets common storage protocols and metadata, protects the integrity of the data, establishes rules for different levels of access and defines common rules that facilitate the combining of data sets and improve interoperability (OSTP, 2010).

Online advertisement

Data generated when consumers use the Internet can create value and give firms opportunities to improve their operations and market their products more effectively. This data-driven marketing is enabled, for example, by the click-stream data collected using some combination of software code such as web-bugs[27] and cookies[28] that allow advertisers to track customers' browsing habits. For individual firms, the exploitation of click-stream data provides new means of improving the management of customer relationships. In the past, when a customer interacted with a firm offline, the information trail was scattered and limited. A firm could only collect scanner data from the checkout for customers using loyalty cards to infer what broader range of products might interest that customer. With click-stream data, firms now possess much more information. For example, firms now have information about the website that directed the user to the firm, whether the user used a search engine, what search terms were used to reach the firm's website. This allows businesses to allocate their marketing budget more effectively and to target websites that reach their most valuable customers. Furthermore, firms can find out exactly what the user looks at on a web page. This enables them to improve users' online experience based on empirical evidence and statistical methods such as A/B testing[29] rather than simply web developers' experience and subjective impressions.[30]

The collection of data is not limited to the firm's website. By using service providers such as social networking sites and advertising networks, firms can also collect data generated elsewhere. Such data are increasingly available through data markets and can be combined with data from sources such as census data, real estate records, vehicle registration and so forth. These enhanced user profiles are then sold to advertisers looking for consumers with particular profiles in order to improve behavioural targeting. For example, comScore, a data broker based in the United States, collects data on the websites visited by over 2 million panellists worldwide, including the search terms they use on search engines and their online purchase and shopping history. comScore then repackages this information to sell reports and data services that illuminate e-commerce sales trends, website traffic and online advertising campaigns. Such reports are sold to Fortune 500 companies and media companies.

Overall, the revenue generated by online advertisement has grown much faster, especially in the last five years, than traditional advertising channels did in their first 15 years. In the first quarter of 2012, online advertising revenues of the top 500 advertisers in the United States, for example, reached USD 8.4 billion, according to the latest IAB Internet Advertising Report (BusinessWire, 2012). This is USD 1.1 billion (15%) more than in the first quarter of 2011. In 2011, AdWords generated more than USD 20 million a month on average from the top 20 websites. This was largely due to the increasing ability to target potential customers and measure results. However, the added value is not limited to advertisement revenue. There are also benefits for consumers. According to McKinsey (2010), consumers in the United States and Europe received EUR 100 billion in value in 2010 from advertising-supported web services. This is three times more than current revenue from advertising and suggests that the consumer value created is greater than advertising revenues would indicate.[31]

Governments and public-sector agencies

The public sector is an important source and user of data. It is in fact one of the economy's most data-intensive sectors. In the United States, for example, public-sector agencies stored on average 1.3 petabytes (millions of gigabytes) of data in 2011,[32] making it the country's fifth most data-intensive sector. However, evidence suggests that the public sector does not exploit the full potential of the data it generates and collects, nor does it exploit the potential of data generated elsewhere (MGI, 2011; Cebr, 2012; Howard, 2012). However, improved access to and re-use of public-sector data (PSI) offers many potential benefits, such as improved transparency in the public sector, more efficient, innovative or more personalised delivery of public services, and more timely public policy and decision making.[33]

Estimates suggest that better exploitation of data could significantly increase efficiency, with billions of savings for the public sector. According to MGI (2011), full use of big data in Europe's 23 largest governments might reduce administrative costs by 15% to 20%, creating the equivalent of EUR 150 billion to EUR 300 billion in new value, and accelerating annual productivity growth by 0.5 percentage points over the next ten years.[34] The main benefits would be greater operational efficiency (due to greater transparency), increased tax collection (due to customised services, for example), and fewer frauds and errors (due to automated data analytics). Similar studies of the United Kingdom show that the public sector could save GBP 2 billion in fraud detection and generate GBP 4 billion through better performance management by using big data analytics (Cebr, 2012).

These estimates do not include the full benefits for policy making to be realised from real-time data and statistics. Box 8.2 describes how such data could be used to better inform the policy-making process.[35] One area of growing interest in this context is internal security and law enforcement. CitiVox, for example, is a start-up that helps governments exploit non-traditional data sources such as SMS (text messages) and social media to complement official crime statistics. Current clients are governments in Central and South America, where a significant share of crimes are not reported.[36] By providing citizens digital means to report crimes, CitiVox's system allows individuals to remain anonymous. At the same time, policy makers and enforcement agencies can mine the incoming data for crime patterns that would not be detected (or not fast enough) through official statistics.

Box 8.2. Data proliferation and implications for official statistics

Torrents of data streaming across public and private networks can improve the quality of statistics in an era of declining responses to national surveys and can create close to real-time evidence for policy making in areas such as prices, employment, economic output and development, and demographics. Some of the new sources of statistics are search engine data derived from keywords entered by users searching for web content. Google Insights for Search, for example, provides statistics on the regional and time-based popularity of specific keywords. Where keywords are related to specific topics such as unemployment, Google Insights can provide real-time indicators for measuring and predicting unemployment trends. Askitas and Zimmermann (2009), for example, analyse the predictive power of keywords such as "Arbeitsamt OR Arbeitsagentur" ("unemployment office or agency") for forecasting unemployment in Germany. The authors find that the forecast based on these keywords indicated changes in trends much earlier than official statistics. Similar conclusions have been drawn by D'Amuri and Marcucci (2010) for the United States and by Suhoy (2010) for Israel.

Other statistics are created by directly "scraping" the web. The Billion Price Project (BPP), for example, collects price information over the Internet to compute a daily online price index and estimate annual and monthly inflation. The online price index is basically an average of all individual price changes across all retailers and categories of goods. More than half a million prices on goods (not services) are collected daily by "scraping" the content of online retailers' websites such as Amazon.com. This is not only five times what the US government collects, it is also cheaper because the information is not collected by researchers who visit thousands of shops as they do for traditional inflation statistics. Furthermore, unlike official inflation numbers, which are published monthly with a lag of weeks, the online price index is updated daily with a lag of just three days. In addition, the BPP has a periodicity of days as opposed to months. This allows researchers and policy makers to identify major inflation trends before they appear in official statistics. For example, in September 2008, when Lehman Brothers collapsed, the online price index showed a decline in prices, a movement that was not picked up until November by the CPI (Surowiecki, 2011).

Currently, while methods to mine these new sources are still in their infancy and need rigorous scientific scrutiny, their rapid take-up by policy makers is a harbinger of a growing trend. Governments in the United States, the United Kingdom, Germany and France and in major non-OECD countries such as Brazil have established a partnership with PriceStats, which manages the BPP index, to contribute to and use the index. In another example, the Central Bank of Chile has explored the use of Google Insight for Search to predict present (to "nowcast") economic metrics related to retail good consumption (Carrière-Swallow and Labbé, 2010).

Source: OECD (2012e), "Big Data and Statistics: Understanding the Proliferation of Data and Implications for Official Statistics and Statistical Agencies", internal working document.

Furthermore, the above estimates do not include benefits achieved through the provision of public-sector information, which is defined by the OECD (2008) Council Recommendation on *Enhanced Access and More Effective Use of Public Sector Information* as the wide range of commercially useable "information, including information products and services, generated, created, collected, processed, preserved, maintained, disseminated, or funded by or for the Government or public institution". Beneficial outcomes for economic and social life range from the weather to traffic congestion to local crime statistics to more transparent government functions, such as procurement or educational and cultural knowledge for the wider population in open journals and open data repositories as well as e-libraries.

As the potential of PSI has become more widely recognised, some governments have turned to "open data" initiatives that could accelerate the impact and role of PSI.[37] These initiatives are becoming a valuable means of developing complementary goods and services and have encouraged the emergence of "civic entrepreneurs" that provide social services based on public-sector data.[38] By providing access to and re-use of open government data, governments promote innovative service design and delivery, without the need to build new end-to-end solutions. For instance, citizens increasingly use

available PSI to develop mobile phone applications (apps) that facilitate access to existing services and provide new services (m-government).[39] Moreover, through collaboration with online communities, data quality can be improved and the integrity of government data double-checked.

Investments in PSI in the United States have been estimated at tens of billions of USD (Uhlir, 2009). Preliminary modelling suggests that over three decades, the benefits of open access to archives could exceed the costs by a factor of approximately eight (Houghton et al., 2010). Another study, Measuring European Public Sector Information Resources (MEPSIR) (EC, 2006) concludes that the direct PSI re-use market in 2006 for the EU25 plus Norway was worth EUR 27 billion. Based on MEPSIR (2006), Vickery (2012) concludes that "the direct PSI-related market would have been around EUR 32 billion in 2010".

Health care

The health-care sector sits on a growing mountain of data generated by the administration of the health system and the diffusion of electronic health records. Diagnostic tests, medical images and the banking of biological samples are also generating new data. There are now vast collections of medical images, with 2.5 petabytes (millions of gigabytes) stored each year from mammograms in the United States alone (EC, 2010).

To some extent what has been said about the benefits of data for the public sector is also true for the health sector, as better use of data can have significant impacts, both within the sector and across the economy. Health-sector data may improve the effectiveness, safety and patient-centeredness of health-care systems and also help researchers and doctors measure outcomes, identify previously unobserved correlations, and even forecast changes in essential clinical processes and interventions (Bollier, 2010). When population data from different sources are linked to health-sector data, some causes of illness can be better understood. An example is the analysis of environmental determinants of illnesses linked to nutrition, stress and mental health (OECD-NSF, 2011).[40]

The sharing of health data through electronic health records can facilitate access to medical care and may provide useful insights for product and services innovation, including research on new medicines and therapies. Other sources of personal health data may include remote monitoring applications that collect data on specific clinical conditions or on daily living conditions, for example to learn when a frail person needs help. Personal health data are also increasingly supplied by individuals and stored and exchanged on line through health-focused social networks. The social network PatientsLikeMe not only allows people with a medical condition to interact with, derive comfort and learn from other people with the same condition, it also provides an evidence base of personal data for analysis and a platform for linking patients with clinical trials. The business model depends on aligning patients' interests with industry interests; PatientsLikeMe sells aggregated, de-identified data to partners, including pharmaceutical companies and makers of medical devices, to help them better understand the actual experience of patients and the effective course of a disease. PatientsLikeMe also shares patient data with research collaborators around the world.

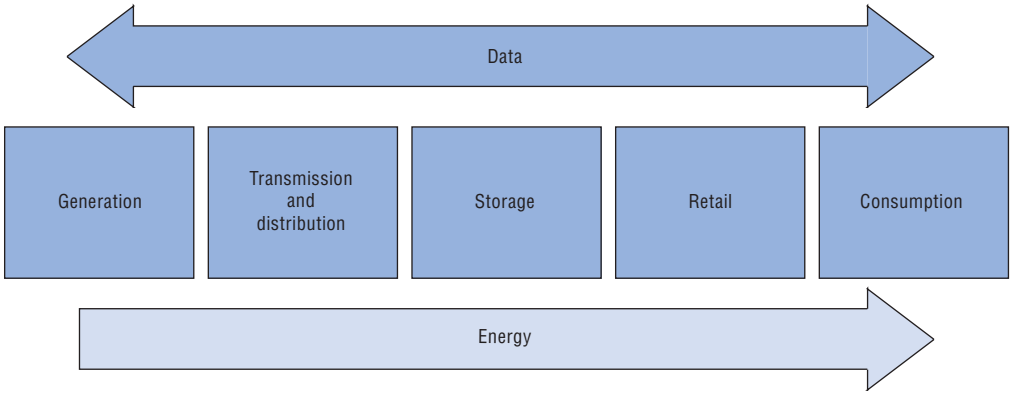
Large health providers such as Kaiser Permanente (a managed-care consortium in the United States) use these data sets to discover the unforeseen adverse affects of drugs such as Vioxx which were not detected in clinical trials but were discovered by mining the data generated as the drug was prescribed and used (MGI, 2011). The United Kingdom

National Institute of Health and Clinical Experience has also used large clinical datasets to investigate the cost effectiveness of new drugs and treatments, leading to improved outcomes at a lower cost. More generally, linked data could reduce the costs associated with under- or over-treatment; they could also help combat chronic diseases by determining behavioural causes and thus guide intervention before the onset of disease (Bollier, 2010). MGI (2011) estimates that big data could be used throughout the US health-care system – clinical operations, payment and pricing of services, and R&D – at a savings of more than USD 300 billion, two-thirds of which would come from reducing health-care expenditures by 8%. These estimates, however, do not include the benefits of data analytics for enabling timely public health policies through real-time statistics such as those provided by web search data to assess flu trends in real time (Polgreen et al., 2008; Ginsberg et al., 2009; Valdivia and Monge-Corella, 2010 as well as Box 8.2 on the use of new data sources for official statistics).

Utilities

"Smart" utilities are deployed for more efficient generation, distribution and consumption of energy, but increasingly also for other natural resources such as water. For example, "smart" grids are electricity networks with enhanced information and communication capacities that can address major electricity sector challenges along the value chain from energy generation to consumption (Figure 8.7). These challenges include managing consumption peaks, which are typically CO_2 expensive, and the integration of volatile renewable energy sources during energy generation and reducing losses in energy transmission and distribution.[41]

Figure 8.7. Stylised electricity sector value chain with energy and data flows



"Smart" utilities rely heavily on data collected through "smart meters" at households and other consumers of energy and resources. These smart devices enable bi-directional communication across the value chain, enabling not only real-time collection of consumption data but also the exchange of real-time price data and signals to control the turning on or shutting off of various appliances in households and industries. Estimates suggest that connecting one million homes to a smart grid may produce as much as 11 gigabytes of data a day; this could create significant challenges for data management and analytics (OECD, 2009b). In order to accommodate hourly readings, a network with a minimum capacity of up to 1 Mbit/s could be needed (GE, 2007; IEEE, 2009; OECD, 2009b). While the information feedback loop allows consumers to adjust their consumption to production capacities, utilities can now run data analytics to identify overall consumption patterns and forecast demand. This can help them adjust their

production capacities and pricing mechanisms to future demand.[42] Overall, according to GeSI (2008), the use of data-driven smart-grid applications could reduce CO_2 emissions by more than 2 gigatonnes (the equivalent of EUR 79 billion).

Furthermore, data collected from distribution networks allow utility providers to identify losses and leakages during the distribution of energy and other resources. By deploying smart water sensors in combination with data analytics, Aguas Antofagasta, a water utility in Chile, was able to identify water leaks throughout their distribution networks and reduce total water losses from 30% to 23% over the past five years, thereby saving some 800 million litres of water a year.

As in the case of public-sector data, opening smart meter data to the market has led to a new industry that provides innovative goods and services based on these data which have contributed to green growth and created a significant number of green jobs. Opower, for example, is a US-based start-up that partners with utility providers to promote energy efficiency based on smart-meter data analytics. The company successfully raised USD 14 million in venture capital (VC) funding in 2008 and USD 50 million two years later. Three years after its creation Opower employed more than 230 people.

Logistics and transport

The logistics and transport sector is less data-intensive but is facing growing amounts of data. These may make it possible to increase the efficiency of transporting goods and persons through smart routing and through new services based on smart applications.

Smart routing is based on the real-time traffic data that are used, but increasingly also collected, by navigation systems. Some of these systems are dedicated hardware devices, but the large majority of personal navigation systems are expected to be operated as software running on smart phones or integrated in automobiles. These applications are very data-intensive. For example, TomTom, a leader in navigation hardware and software, had in its databases in 2012 more than 5 000 trillion data points from its navigation devices and other sources, describing time, location, direction and speed of individual anonymised users,[43] and it adds 5 billion data points every day.[44] Overall, estimations by MGI (2011) suggest that the global pool of personal geo-location data was at least 1 petabyte in 2009, and growing by about 20% a year. By 2020, this data pool is expected to provide USD 500 billion in value worldwide in the form of time and fuel savings or 380 million tonnes of CO_2 emissions saved. This does not include value provided through other location-based services.

As well as navigation system providers such as TomTom, others also provide significant amounts of data. For example, mobile network operators use cell-tower signals to triangulate the location of mobile telephone users and to identify patterns related to accidents and congestions based on data analytics. These data and inferred information are sold to providers of navigation systems, but also to third parties such as governments. For example, the French mobile telecommunication services firm Orange uses its Floating Mobile Data (FMD) technology to collect mobile telephone traffic data to determine speeds and traffic density at a given point of the road network, and deduce travel time or the formation of traffic jams. The anonymised mobile telephone traffic data are sold to third parties, including government agencies, to identify hot spots for public interventions, but also to private companies such as Mediamobile, a leading provider of traffic information services in Europe.[45]

Another area in which the use of data promises significant benefits in the logistics and transport sector is the use of smart applications based on machine-to-machine (M2M) communication. Smart automobiles, for example, are increasingly equipped with sensors to monitor and transmit the state of the car's components as well as of the environment in which the car is moving. This enables services such as OnStar and Sync, which are offered by vehicle manufacturers to car owners and include theft protection and navigation and emergency services. New business models and new forms of fees and taxes, such as dynamic road pricing based on GPS and M2M data, are also providing significant added value. MGI (2011) estimates that by 2020 the use of automatic toll collection based on the location of mobile telephones will generate from USD 4 billion to USD 10 billion in value to final consumers and USD 2 billion in revenue to services providers.

Mapping the policy opportunities and challenges

With the increasing exploitation of data across the economy comes a wide array of policy opportunities and challenges, many of which were identified at the 2012 OECD Technology Foresight Forum, Harnessing data as a new source of growth – Big data analytics and policies (see Box 8.3).

Box 8.3. OECD Technology Foresight Forum 2012: Harnessing data as a new source of growth - Big data analytics and policies

The 2012 Technology Foresight Forum (the Foresight Forum), held on 22 October 2012, highlighted the potential of big data analytics as a new source of growth. It put big data analytics in the context of key technological trends such as cloud computing, smart ICT applications and the Internet of Things. It focused on the socioeconomic implications of harnessing data as a new source of growth and looked at specific areas: science and research (including public health), marketing (including competition) and public administration.

Participants discussed specific potential policy opportunities and challenges. They stressed the tremendous potential of big data in science and research (including for health care), retail, finance and insurance, and public-service delivery. They noted the opportunity costs of not using data and the need to measure the socioeconomic value of data use and re-use. Participants also discussed the changes needed in mindsets of individuals, businesses and policy makers to understand the "big data phenomenon" and to be able to capture the potential benefits while handling the associated risks. Among challenges, they frequently emphasised privacy and consumer protection in association with the issue of consent and the current limitations on anonymisation and de-identification due to big data analytics. They noted that big data analytics were changing the nature of digital identity and thus the relationship between identity and privacy.

Participants also drew attention to issues related to open *vs*. closed data and the related issue of data ownership and control. They discussed the implications of big data analytics for employment, and stressed the need for new skills and improved awareness across all industries and all organisational levels in order to ensure that the economy makes good use of data. In particular, they warned that big data may put white collar jobs at risk (including professional, managerial or administrative workers), just as the industrial revolution did for blue collar jobs (and workers mainly performing manual labour).

Participants considered that the ethical dimension of big data analytics is increasingly important. They cited rules of ethics such as "just because you can, doesn't mean you should". In this spirit, a speaker compared the big data phenomenon with nuclear energy in the early 20th century: "It's coming whether we want it or not. What we can do is promote the responsible use of big data".

Source: OECD, http://oe.cd/tff2012.

The following sections introduce policy issues raised by the application of large-scale data analytics across the economy. Some of these issues – related to privacy, open access to data, including public-sector information, ICT skills and employment, and infrastructure – are not new. In the case of privacy protection, problems related to "data mining" and "profiling" are long-standing. What is novel is that it is increasingly easy to infer information about individuals, even if they have never deliberately shared this information with anyone. As an illustration, Target, a United States retailer, knew that a teenage girl was pregnant before her father did (Hill, 2012). In a context in which the volume, variety, velocity and economic value of data are constantly increasing, policy issues related to intellectual property rights (IPR), competition, corporate reporting and taxation gain in importance. These policy issues are not discussed here. Specific issues related to the health sector were discussed at the Joint-Consultation of the OECD Health Care Quality Indicator Expert Group and the Working Party on Information Security and Privacy in May 2012. The challenges and opportunities of big data for national statistics agencies are examined in OECD (2012e).

Privacy and consumer protection

OECD member countries have adopted various mechanisms to protect the privacy of individuals as regards the processing of their personal data. These regulatory instruments largely reflect the "basic principles of national application" contained in the OECD (1980) Guidelines Governing the Protection of Privacy and Transborder Flows of Personal Data ("the Privacy Guidelines", see Box 8.4), which are currently under review.

The Privacy Guidelines define personal data as "any information relating to an identified or identifiable individual (data subject)". Any data that are not related to an identified or identifiable individual are therefore non-personal and are outside the scope of the Guidelines. However, data analytics have made it easier to relate seemingly non-personal data to an identified or identifiable individual (Ohm, 2010). Furthermore, big data applications may affect individuals using data which are generally considered non-personal (Hildebrandt and Koops, 2010). These developments challenge a regulatory approach that determines the applicability of rights, restrictions and obligations on the basis of the "personal" nature of the data involved. As the scope of non-personal data is reduced, the difficulty of applying existing frameworks effectively become more acute.

Many data-driven goods and services also raise issues for the application of the basic principles of data protection, such as purpose specification and use limitation.[46] These goods and services offer opportunities for beneficial re-use of personal data, often in ways not envisaged when they were collected. They also implicitly rely on the lengthy retention of information. As such, they stretch the limits of existing privacy frameworks, many of which take limits on the collection and storage of information, and on its potential uses, as a given (Tene and Polonetsky, 2012).

The increased complexity of data-driven goods and services also makes it more difficult to provide individuals with comprehensive and comprehensible information about the collection and use of personal data (see Box 4). The sheer scale of data processing lessens the ability of individuals to participate in the processing of their personal data (Cavoukian and Jonas, 2012). As the amount of personal data grows, and the number of actors involved in using them expands, it may be necessary to reconsider the appropriate roles of different types of actors. For commercial transactions, in particular, consumers' access to their personal data is being regarded as increasingly important for empowering consumers to drive innovation and enhance competition in the

marketplace. This access would help consumers make better informed decisions by being able to compare prices, get an overview of their transactions history, look at the value of their own data, and thus actively participate in the data-driven economy.[47]

When the Privacy Guidelines were adopted, data flows involved a limited number of data sources, which were connected through closed networks. This environment allowed policy makers to make a single actor (the "data controller") responsible for every aspect of processing (collection, use, security, data quality, etc.). The transition from a closed network environment to an open network environment has made it increasingly difficult to maintain this approach. Instead of discrete, well-defined transfers of information, many data-driven goods and services typically involve a multiplicity of information flows, with many different actors, each of which exercises varying degrees of control. This changed environment has introduced an additional level of complexity (Burdon, 2012). For example, services such as cloud computing and social networking often involve many different types of actor, each of which influences the collection and use of information to a different degree. These developments may imply the need for more adaptable and flexible allocation of responsibilities.

Box 8.4. Basic principles of national application of the OECD (1980) privacy guidelines (part 2)

Collection limitation principle

There should be limits to the collection of personal data and any such data should be obtained by lawful and fair means and, where appropriate, with the knowledge or consent of the data subject.

Data quality principle

Personal data should be relevant to the purposes for which they are to be used and, to the extent necessary for those purposes, should be accurate, complete and kept up-to-date.

Purpose specification principle

The purposes for which personal data are collected should be specified not later than at the time of data collection and the subsequent use limited to the fulfilment of those purposes or such others as are not incompatible with those purposes and as are specified on each occasion of change of purpose.

Use limitation principle

Personal data should not be disclosed, made available or otherwise used for purposes other than those specified in accordance with Paragraph 9 except:

a) with the consent of the data subject; or

b) by the authority of law.

Security safeguards principle

Personal data should be protected by reasonable security safeguards against such risks as loss or unauthorised access, destruction, use, modification or disclosure of data.

Openness principle

There should be a general policy of openness about developments, practices and policies with respect to personal data. Means should be readily available of establishing the existence and nature of personal data, and the main purposes of their use, as well as the identity and usual residence of the data controller.

Individual participation principle

An individual should have the right:

a) to obtain from a data controller, or otherwise, confirmation of whether or not the data controller has data relating to him;

…/…

Box 8.4. Basic principles of national application of the OECD (1980) privacy guidelines (part 2)
(continued)

b) to have communicated to him, data relating to him
1. within a reasonable time;
2. at a charge, if any, that is not excessive;
3. in a reasonable manner; and
4. in a form that is readily intelligible to him;

c) to be given reasons if a request made under subparagraphs (a) and (b) is denied, and to be able to challenge such denial; and

d) to challenge data relating to him and, if the challenge is successful to have the data erased, rectified, completed or amended.

Accountability principle

A data controller should be accountable for complying with measures which give effect to the principles stated above.

Source: OECD (1980), *Recommendation of the Council on Guidelines Governing the Protection of Privacy and Transborder Flows of Personal Data*, 23 September, OECD, Paris.

Although the Privacy Guidelines call for specification of purpose prior to the collection and use of personal data, they do not restrict the nature or types of purposes for which personal data may be used. This approach has left the contours of responsible data usage largely undefined. For example, one might ask: "Where does the boundary reside between, on the one hand, improving customer relationships, and, on the other, unfair consumer manipulation? When does risk optimisation become unfair discrimination?"

Open access to data

The linking and use of data across sectors can drive innovation and generate socioeconomic benefits. Examples includes the use of PSI across the economy by BrightScope or the sale of anonymised telecommunication data collected by Orange to traffic information service providers such as TomTom or MediaMobile. They suggest that open access to data can lead to significant economic benefits.

However, appropriate sharing of data across the economy requires more robust frameworks. Many sources of third-party data do not yet consider sharing their data, and economic incentives may not be aligned to encourage it (MGI, 2011). More needs to be known about pricing and licensing models, but also about ownership and control mechanisms, including intellectual property rights (IPR) regimes.[48] Objective pricing of information is notoriously complex, and identification of the different cost components may be somewhat arbitrary (Shapiro and Varian, 1998). For PSI in particular, the circumstances under which the public sector should produce value-added products from its assets continue to be debated. Many governments wish to recover costs, partly for budgetary reasons and partly on the grounds that those who benefit should pay. However, the calculation of benefits can be problematic. Moreover, as Stiglitz et al. (2000) have argued, if government provision of a data-related service is a valid role, generating revenue from that service is not.

The public sector has nevertheless led the way in opening up its data to the wider economy through various "open data" initiatives. The OECD (2008) Council Recommendation for *Enhanced Access and More Effective Use of Public Sector Information*, which is currently under review, describes a set of principles and guidelines

for access to and use of PSI; among these, openness is the first principle (Box 5). The Recommendation refers to the OECD (2005) *Principles and Guidelines for Access to Research Data from Public Funding*, which also highlight openness as their its principle. This latter Recommendation in particular specifies that "openness means access on equal terms for the international research community at the lowest possible cost, preferably at no more than the marginal cost of dissemination. Open access to research data from public funding should be easy, timely, user-friendly and preferably Internet-based". Open data initiatives are also emerging in the private sector. The Open Knowledge Foundation, for instance, has established an open data framework, which defines open data as "a piece of content or data (which) is open if anyone is free to use, reuse, and redistribute it – subject only, at most, to the requirement to attribute and/or share-alike".[49]

Box 8.5. Principles of the OECD (2008) Recommendation for Enhanced Access and More Effective Use of Public Sector Information

Openness. Maximising the availability of public sector information for use and re-use based upon presumption of openness as the default rule to facilitate access and re-use. Developing a regime of access principles or assuming openness in public sector information as a default rule wherever possible no matter what the model of funding is for the development and maintenance of the information. Defining grounds of refusal or limitations, such as for protection of national security interests, personal privacy, preservation of private interests for example where protected by copyright, or the application of national access legislation and rules.

Access and transparent conditions for re-use. Encouraging broad non-discriminatory competitive access and conditions for re-use of public sector information, eliminating exclusive arrangements and removing unnecessary restrictions on the ways in which it can be accessed, used, re-used, combined or shared, so that in principle all accessible information would be open to re-use by all. Improving access to information over the Internet and in electronic form. Making available and developing automated on-line licensing systems covering re-use in those cases where licensing is applied, taking into account the copyright principle below.

Asset lists. Strengthening awareness of what public sector information is available for access and re-use. This could take the form of information asset lists and inventories, preferably published on-line, as well as clear presentation of conditions to access and re-use at access points.

Quality. Ensuring methodical data collection and curation practices to enhance quality and reliability including through cooperation of various government bodies involved in the creation, collection, processing, storing and distribution of public sector information.

Integrity. Maximising the integrity and availability of information through the use of best practices in information management. Developing and implementing appropriate safeguards to protect information from unauthorised modification or from intentional or unintentional denial of authorised access to information.

New technologies and long-term preservation. Improving interoperable archiving, search and retrieval technologies and related research including research on improving access and availability of public sector information in multiple languages, and ensuring development of the necessary related skills. Addressing technological obsolescence and challenges of long-term preservation and access. Finding new ways for the digitisation of existing public sector information and content, the development of born-digital public sector information products and data, and the implementation of cultural digitisation projects (public broadcasters, digital libraries, museums, etc.) where market mechanisms do not foster effective digitisation.

…/…

Box 8.5. Principles of the OECD (2008) Recommendation for Enhanced Access and More Effective Use of Public Sector Information *(continued)*

Copyright. Intellectual property rights should be respected. There is a wide range of ways to deal with copyrights on public sector information, ranging from governments or private entities holding copyrights, to public sector information being copyright-free. Exercising copyright in ways that facilitate re-use (including waiving copyright and creating mechanisms that facilitate waiving of copyright where copyright owners are willing and able to do so, and developing mechanisms to deal with orphan works), and where copyright holders are in agreement, developing simple mechanisms to encourage wider access and use (including simple and effective licensing arrangements), and encouraging institutions and government agencies that fund works from outside sources to find ways to make these works widely accessible to the public.

Pricing. When public sector information is not provided free of charge, pricing public sector information transparently and consistently within and, as far as possible, across different public sector organisations so that it facilitates access and re-use and ensures competition. Where possible, costs charged to any user should not exceed the marginal costs of maintenance and distribution, and in special cases extra costs associated, for instance, with digitisation. Basing any higher pricing on clearly expressed policy grounds.

Competition. Ensuring that pricing strategies take into account considerations of unfair competition in situations where both public and business users provide value-added services. Pursuing competitive neutrality, equality and timeliness of access where there is potential for cross-subsidisation from other government monopoly activities or reduced charges on government activities. Requiring public bodies to treat their own downstream/value-added activities on the same basis as their competitors for comparable purposes, including pricing. Particular attention should be paid to single sources of information resources. Promoting non-exclusive arrangements for disseminating information so that public sector information is open to all possible users and re-users on non-exclusive terms.

Redress mechanisms: Providing appropriate transparent complaints and appeals processes.

Public private partnerships. Facilitating public-private partnerships where appropriate and feasible in making public sector information available, for example by finding creative ways to finance the costs of digitisation, while increasing access and re-use rights of third parties.

International access and use. Seeking greater consistency in access regimes and administration to facilitate cross-border use and implementing other measures to improve cross-border interoperability, including in situations where there have been restrictions on non-public users. Supporting international co-operation and co-ordination for commercial re-use and non-commercial use. Avoiding fragmentation and promote greater interoperability and facilitate sharing and comparisons of national and international datasets. Striving for interoperability and compatible and widely used common formats.

Best practices. Encouraging the wide sharing of best practices and exchange of information on enhanced implementation, educating users and re-users, building institutional capacity and practical measures for promoting re-use, cost and pricing models, copyright handling, monitoring performance and compliance, and their wider impacts on innovation, entrepreneurship, economic growth and social effects.

Source: OECD (2008), *OECD Recommendation for Enhanced Access and More Effective Use of Public Sector Information*, 16 June, C(2008)36, available at: http://acts.oecd.org/Instruments/ShowInstrumentView.aspx?InstrumentID=122&InstrumentPID=118&Lang=en&Book=False.

Cybersecurity risks

As the volume and value of data stored increases so does the risk of data breaches. According to company surveys, reported thefts of electronic data surpassed losses of physical property as the major crime problem for global companies for the first time in 2010 (Masters and Menn, 2010; Kroll, 2012). This demonstrates the increasing corporate value of intangible assets, such as data, as compared to tangible assets.

Data collected by the Privacy Rights Clearinghouse, for example, show that large-scale data breaches, i.e. those involving more than 10 million records, are becoming more frequent. Examples include the 2008-09 malicious software hack that compromised Heartland Payment Systems Inc. (an online payments and credit card company based in the United States), affecting more than 130 million credit and debit card numbers (Voreacos, 2009; Zetter, 2009), and the security breach of Sony's PlayStation Network and the Sony Online Entertainment systems in 2010-11 which resulted in the exposure of 104 million records of personally identifiable information including names, addresses, birthdates, passwords and logins, among others (Reuters, 2011; Seybold, 2011; Goodin, 2011).

Anecdotal evidence also shows an increasing number of so-called advanced persistent threats (APTs). These are typical cyberespionage incidents often targeting a sector's key organisations or key competitors to steal data or different forms of intellectual property and to reduce these organisations' competitive advantage. Operation Shady Rat was an APT that compromised more than 70 companies, governments and non-profit organisations in 14 countries (McAfee, 2011). Operation Red October targeted government, military, aerospace, research, trade and commerce, nuclear, and oil organisations in two dozen countries (DeCarlo, 2013).[50] Reports and statements by officials in the United Kingdom (Esposito, 2012) and the United States (NCIX, 2011) have noted an increase in industrial cyberespionage activities. Yet, the scale of the phenomenon is uncertain as victims are reluctant to disclose information about successful attacks (Severs, 2013).

As data usage today requires information systems and networks to be more open, organisations are obliged to adapt their security policy to the more open and dynamic environment in which data are widely exchanged and used. The OECD 2002 Security Guidelines, currently under review, were designed to promote an approach to security that enables rather than restricts such openness at the technical level (Box 8.6). Such an approach is particularly important for seizing the benefits of a data-driven economy.

Box 8.6. Principles of OECD (2002) Guidelines for the Security of Information Systems and Networks

1) Awareness: Participants should be aware of the need for security of information systems and networks and what they can do to enhance security.

2) Responsibility: All participants are responsible for the security of information systems and networks.

3) Response: Participants should act in a timely and co-operative manner to prevent, detect and respond to security incidents.

4) Ethics: Participants should respect the legitimate interests of others.

5) Democracy: The security of information systems and networks should be compatible with the essential values of a democratic society.

6) Risk assessment: Participants should conduct risk assessments.

7) Security design and implementation: Participants should incorporate security as an essential element of information systems and networks.

8) Security management: Participants should adopt a comprehensive approach to security management.

9) Reassessment: Participants should review and reassess the security of information systems and networks, and make appropriate modifications to security policies, practices, measures and procedures.

OECD (2002), *OECD Guidelines for the Security of Information Systems and Networks: Towards a Culture of Security*, OECD Publishing, doi: http://dx.doi.org/10.1787/9789264059177-en-fr.

Skills and employment

A pool of qualified personnel with skills in data management and analytics (data science) is essential for the success of a "smarter" data-driven economy (OECD, 2012f). However, these skills must also be specific to some extent, as they require an appropriate mix of advanced ICT skills, skills in statistics and specific knowledge of the sector involved (see *OECD Skills Strategy*, OECD 2012g). Demand for highly specialised skills is expected to intensify as data analytics proliferate, and a shortage of data scientists is likely in the near future. MGI (2011), for example, estimates that the demand for those with deep analytical skills in the United States could exceed supply by 140 000 to 190 000 positions by 2018. This does not include the need for an additional 1.5 million managers and analysts who can use big data knowledgeably.

In the past, there have been considerable mismatches between the supply of and demand for ICT skills in general and for software skills in particular. Shortfalls in domestic supply (owing to a large share of students leaving compulsory education, lack of educational courses and little training in the industry), restrictions on immigration of highly skilled personnel, or difficulties in international sourcing of development and analytical tasks requiring large amounts of interaction among employees are continuing challenges, as is the relatively low number of female employees in the ICT industry (OECD, 2012f).

However, data science skills are not only obtained from formal university or tertiary institution degree courses in specific study programmes such as computer science. Scientific fields that require the analysis of large data sets also provide a good source of data scientists. In fact, a significant number of data scientists have a degree in experimental physics, molecular biology, bioinformatics or computer science with an emphasis on artificial intelligence (Loukides, 2010; Rogers, 2012). Despite the availability of these skills across OECD economies, anecdotal evidence suggest that most employees working as data scientists are located in the United States.[51]

Beyond the high level of expected demand for data scientists, the full implications of big data for employment are not yet well understood. Increased labour productivity resulting from the use of data analytics may lead to the disappearance of some jobs that previously required human labour (e.g. Google's Driverless Car could replace taxi drivers). The ability to mine vast amounts of data to optimise logistics, customer relations and sales could also have a significant impact on jobs of a "transactional" nature (Brynjolfsson and McAfee, 2011). While productivity-enhancing, this structural change comes at a time when the economy is fragile and it may exacerbate the weak employment market and the bias towards higher skills and inequality in earnings.

Infrastructure

As noted earlier in the chapter, the availability of high-speed broadband access, in particular mobile broadband access, has greatly facilitated the collection, transport and use of data in the economy. It is estimated that households across the OECD area now have an estimated 1.8 billion connected smart devices (OECD, 2013a). The number could reach 5.8 billion in 2017 and 14 billion in 2022. This will require governments to address the issue of the migration to a new Internet addressing system (IPv6). The current IPv4 addresses are essentially exhausted, and mechanisms for connecting the next billion devices are urgently needed. IPv6 offers one solution. It is a relatively new addressing system that offers the possibility of almost unlimited address space, but adoption has been relatively slow.

Furthermore, as many data-intensive smart applications rely on machine-to-machine (M2M) communication, this raises regulatory challenges related to opening access to mobile wholesale markets to firms not providing public telecommunication services and to numbering policy and frequency policy issues (see Box 8.7).

Box 8.7. Transmitting data: A regulatory barrier to machine-to-machine communication

In the near future, the Internet will connect things as well as people. Companies will change how they design machines and devices. They will first define the data needed and then build the machine. Tens of billions of devices are likely to be connected by 2025. A new type of user of mobile networks will emerge – the million-device user (such as car, consumer electronics and energy companies, and health providers, whose vehicles and devices connect to the Internet). M2M communication will become standard.

Mobile networks are best geared to geographically mobile and dispersed users who want to be connected everywhere and all the time. However, a major barrier for the million-device user is the lack of competition once a mobile network provider has been chosen. The problem is the SIM card, which links the device to a mobile operator. By design, only the mobile network that owns the SIM card can designate which networks the device can use. In mobile phones the SIM card can be removed by hand and changed for that of another network. But when used in cars or other machines it is often soldered, to prevent fraud and damage from vibrations. Even if it is not soldered, changing the SIM at a garage, a customer's home, or on-site, costs USD 100-USD 1 000 per device.

Consequently, once a device has a SIM card from a mobile network, the company that developed the device cannot leave the mobile network for the lifetime of the device. Therefore, the million-device user can effectively be locked into 10- to 30-year contracts. It also means that when a car or e-health device crosses a border, the large-scale user is charged the operator's costly roaming rates. The million-device user cannot negotiate these contracts. It also cannot distinguish itself from other customers of the network (normal consumers) and is covered by the same roaming contracts.

There are many technological and business model innovations that a large-scale M2M user might want to introduce. However, at present, it cannot do so, because it would need the approval of its mobile network operator. Many innovations would bypass the mobile operator and therefore are resisted. The solution would be for governments to allow large-scale M2M users to control their own devices by owning their own SIM cards, something that is implicitly prohibited in many countries. It would make a car manufacturer the equivalent of a mobile operator from the perspective of the network.

Removing regulatory barriers to entry in this mobile market would allow the million-device customer to become independent of the mobile network and create competition. This would yield billions in savings on mobile connectivity and revenue from new services.

Source: OECD (2012b), "Machine-to-Machine Communications: Connecting Billions of Devices", *OECD Digital Economy Papers*, No. 192, OECD Publishing, doi: http://dx.doi.org/10.1787/5k9gsh2gp043-en.

Measurement

Improved measurement could facilitate the development of policies better tailored to the scale, benefits and risks of the expanding uses of data. It would mean better understanding the value added of data-driven activities, including data processing and data storage activities, identification of sectors in which data are a key intangible asset, and better recognition of the impact of framework conditions on the collection, distribution and use of data across the economy. At present, the value of data-driven activities is poorly captured in economic statistics and often insufficiently appreciated by organisations and individuals. Estimates by Mandel (2012) suggest, for example, that data-driven activities in the United States are underestimated in official economic statistics, with real GDP in the first half of 2012 rising by 2.3% rather than the official rate of 1.7%.

In the case of personal data, collection directly from individuals is often a non-explicit exchange for "free" services. The ability to combine and recombine varied data sets enables uses that were not anticipated when the data were collected, making valuation difficult for national statistics as well as for organisations and individuals. A further measurement challenge is related to the complexity of current data flows, including across borders, and the assessment of value created through the analytic techniques themselves.

Conclusion

There is already some evidence of the potential benefits of using data as a resource for new industries, processes and products and therefore for innovation and growth. The large-scale and comprehensive developments affecting all stages of the data value chain presented in this chapter underline the need to take a closer look at data as an intangible asset and a new source of growth.

However, this paper also describes issues that deserve more work in order to understand better the potential and challenges of big data. One is evaluation of the socioeconomic impact of data across the economy and another is the contribution of data to GDP growth. OECD (2012a) discusses the challenges of measuring the monetary value and impacts of personal data. In fact, the value of data of all sorts is poorly captured in economic statistics and financial reports and often insufficiently appreciated by organisations and individuals. The fact that the value of data is context-dependent shows the need for the case studies to be undertaken as part of the OECD's follow-up work on big data.

This paper has looked at important policy areas that should be addressed. A number of OECD instruments referred to here are currently under review (Privacy Guidelines, Security Guidelines, and the PSI Recommendation). The OECD will assess other areas of policy relevant to big data in greater depth during 2013 and 2014. These include the employment impact of data-driven automation, issues related to competition, and intellectual property rights.

Notes

1. This would be an average yearly decrease of 38% in the cost of shifting one bit per second.
2. See www.ted.com/talks/harald_haas_wireless_data_from_every_light_bulb.html.
3. The number of mobile wireless devices connected to the Internet across the globe is estimated to reach 50 billion by 2020 (OECD, 2011b).
4. The McKinsey Global Institute (MGI, 2011) estimates that the number of connected smart devices based on M2M will increase by more than 30% between 2010 and 2015 with the number of mobile-connected devices exceeding the world's population in 2012 (Cisco, 2012).
5. This trend is confirmed by available sales figures. According to the Semiconductor Industry Association for instance, sensors and actuators are the fastest-growing semiconductor segment with growth in revenue of almost 16% (USD 8 billion) in 2011.
6. Big data solutions are typically provided in three forms: software-only, as a software-hardware appliance or cloud-based (Dumbill, 2012a). Choices among these will depend, among other things, on issues related to data locality, human resources, and privacy and other regulations. Hybrid solutions (e.g. using on-demand cloud resources to supplement in-house deployments) are also frequent.
7. Due to economies of scale, cloud computing providers have much lower operating costs than companies running their own IT infrastructure, which they can pass on to their customers.
8. In 2009, Amazon introduced the Amazon Elastic MapReduce as a service to run Hadoop clusters on top of the Amazon S3 file system and Amazon Elastic Compute Cloud (EC2) (Amazon, 2009).
9. In 2010, Borthakur (2010) claimed that Facebook had stored 21 petabytes (million gigabytes) of data using the largest Hadoop cluster in the world. One year later, Facebook announced that the data had grown by 42% to 30 petabytes (Yang, 2011).
10. LinkedIn (2009) is using Hadoop together with Voldemort, another distributed data storage engine.
11. IBM is offering its Hadoop solution through InfoSphere BigInsights. BigInsights augments Hadoop with a variety of features, including textual analysis tools that help identify entities such as people, addresses and telephone numbers (Dumbill, 2012b).
12. Oracle provides its Big Data Appliance as a combination of open source and proprietary solutions for enterprises' big data requirements (Oracle, 2012). It includes, among others, the Oracle Big Data Connectors to allow customers to use Oracle's data warehouse and analytics technologies together with Hadoop, the Oracle R Connector to allow the use of Hadoop with R, an open-source environment for statistical analysis, and the Oracle NoSQL Database, which is based on Oracle Berkeley DB, a high-performance embedded database.

13. From 2011, Microsoft started integrating Hadoop in Windows Azure, Microsoft's cloud computing platform, and one year later in Microsoft Server. It is providing Hadoop Connectors to integrate Hadoop with Microsoft's SQL Server and Parallel Data Warehouse (Microsoft, 2011).

14. In 2012, SAP announced its roadmap to integrate Hadoop with its real-time data platform SAP HANA and SAP Sybase IQ (SAP, 2012).

15. Specialised business-to-business companies include firms such as LexisNexis, which offers a complete background check of all possible business-related information about potential business partners. Regular data brokers such as Intelius and Locate Plus provide information solutions for consumers and small businesses using public records and publicly available information. Their services help people find each other, verify the identities of individuals they encounter, manage risk and ensure personal safety, to name a few. Finally localisation services such as LocatePeople.org, MelissaData.com, and 123people.com provide personal addresses of individuals for data marketers, or offer simple services to localise people, their telephone numbers, e-mail addresses, etc.

16. See also Dumbill (2012a), for which "big data" is "data that exceeds the processing capacity of conventional database systems. The data is too big, moves too fast, or doesn't fit the strictures of your database architectures. To gain value from this data, you must choose an alternative way to process it".

17. See Watters (2012) for a comparison of Yahoo! and Google in terms of structured *vs.* unstructured data.

18. See http://marketshare.hitslink.com/search-engine-market-share.aspx?qprid=4.

19. This definition originated from the META Group (now part of Gartner) in 2001 (see Laney, 2001).

20. According to Gartner (2012), the worldwide market for BI, analytic applications and performance management (PM) software grew by more than 16% in 2012 (from USD 12 million in 2011 to USD 16 million in 2012). The top five vendors (SAP, Oracle, SAS Institute, IBM, and Microsoft) account for close to three-quarters of the market.

21. National statistics that provide occupational figures on data management and analytics professionals are a promising source for assessing data intensity not only by sector but also over time. This is only true if occupations related to data management and analytics can be identified in the occupation classification schemes.

22. In 2011, financial activities, professional and business services, information, and public administration were the sectors mainly contributing to the increase in share of database administrators in the United States.

23. According to data published by the World Information Technology and Services Alliance (WITSA), telecommunications (11.5%), financial services (6.6%), transport (5.1%), health care (4.1%) and government (3.8%) are the five most ICT-intensive sectors. Using ICT intensity as a proxy for data intensity assumes that data-intensive industries have higher ICT expenditure than industries with low data intensity. However, this assumption can be easily challenged, since data analytics require less investment in ICTs today (because of cloud computing). In a historical perspective, this approach can still be useful.

24. OECD (2012d) work on "Understanding the Economics of Personal Data", which surveyed methodologies for measuring the monetary value, highlighted the context dependency of the monetary value of personal data.

25. In other cases, they could be tied to specific data sets (e.g. social networking or click-stream data with specific uses).

26. Countries include Austria, Germany, Denmark, Finland, France, Hungary, Italy, Korea, the Netherlands and Slovenia.

27. Web-bugs are 1x1-pixel pieces of code that allow advertisers to track customers remotely. These are also sometimes referred to as beacons, action tags, clear GIFs, web tags, or pixel tags (Gilbert, 2008). Web-bugs are different from cookies, because they are designed to be invisible to the user and are not stored on the user's computer. With web-bugs, a customer cannot know whether they are being tracked without inspecting a webpage's underlying html code.

28. A cookie is simply a string of text stored by a user's web browser. Cookies allow firms to track customers' progress across browsing sessions. This can also be done using a user IP address, but cookies are generally more precise, especially when IP addresses are dynamic as in the case of many residential Internet services. Advertisers may also use a flash cookie as an alternative to a regular cookie. A flash cookie differs from a regular cookie in that it is saved as a Local Shared Object on an individual's computer, making it harder for users to delete using regular tools on their browser.

29. A/B Testing is a method used to test the effectiveness of strategies/future actions based on a sample that is split in two groups, an A-group and a B-group. While an existing strategy is applied to the (larger) A-group, another, slightly changed strategy is applied to the other group. The outcome of both strategies is measured to determine whether the change in strategy led to statistically relevant improvements. Google, for example, regularly redirects a small fraction of its users to pages with slightly modified interfaces or search results to (A/B) test their reactions. For more detail see Christian (2012).

30. For example, the online payment platform WePay designed its entire website through a testing process. For two months, users were randomly assigned a testing homepage, and at the end the homepage with the best outcome was selected (Christian, 2012).

31. This value does not include potential costs to consumers that may occur due to privacy violations, for example.

32. The public sector in the United States employed on average 1.6 database administrators per 1 000 employees in 2011.

33. Many of these potential benefits rely on personal data, obtained not only from third parties but also directly from individuals, for administering various programmes. Examples include various social service programmes, tax programmes or issuing licences. Some data are also commonly used to support hundreds of regulatory regimes ranging from voter registration and political campaign contribution disclosures to verification of employee identity and enforcement of the child support obligation. Other uses include maintaining vital records about major lifecycle events, such as birth, marriage, divorce, adoption and death; and operation of facilities such as toll roads and national parks.

34. It is necessary to exercise caution when interpreting these results as the methodologies used for these estimates are not necessarily explicit.

35. At a recent OECD meeting, government technology leaders underscored that such new data sources have great potential to complement existing evidence across all policy

domains and to unleash productivity in economic sectors with traditionally restricted productivity gains, but in which governments have historically had a significant impact, e.g. health, energy, education and government administration itself (OECD, 2012f).

36. Reasons for not reporting include intimidation of victims and witnesses, but also lack of trust in local authorities.

37. Examples of the "open data" movement include: the United States www.data.gov; the United Kingdom: www.data.gov.uk; and Spain: Aporta Web portal www.proyectoaporta.es.

38. For example, government data about the financial industry was previously available only through the US Securities and Exchange Commission (SEC) and the US Financial Industry Regulatory Authority (FINRA). However, BrightScope has made such information more usable, searchable and open to the public, and individuals can therefore make better informed financial decisions (Howard, 2012).

39. See forthcoming OECD work on mobile applications.

40. For example, at the OECD-APEC (2012) workshop, Anticipating the Needs of the 21st Century Silver Ageing Economy, held 12-14 September 2012 in Tokyo, Japan, participants concluded that the multi-factorial nature of Alzheimer's disease (AD) will require sophisticated computational capabilities to analyse big streams of behavioural, genetic, environmental, epigenetic and clinical data to find patterns. In neurodegenerative research, many organisations are building big data repositories and contributing to the development of databases and global data-sharing networks. In the United States alone, the Alzheimer's Disease Neuroimaging Initiative and the Parkinson's Disease (PD) Progression Markers Initiative gather brain images and biological fluids from people with or at risk for AD and PD, respectively. The US National Alzheimer's Coordinating Center has amassed longitudinal records from more than 25 000 people, and recently started assessments for fronto-temporal dementia as well. Records from those who inherited an AD-linked gene are part of the Dominantly Inherited Alzheimer Network.

41. In 2008, for example, around of 8% of electricity generated worldwide was lost before it reached the consumer. This is estimated to correspond to over 600 million tonnes of CO_2 emissions (OECD, 2012a). In the case of water distribution networks, estimates suggest that globally more than 32 billion cubic meters of treated water are lost annually through leakage (Kingdom et al., 2006).

42. This is not without any risks to security and privacy as smart meters can be subject to cyber attacks and even data collected legally can give insights into an individual's private life, such as whether he or she was at home at a given time and even an indication of what they were doing.

43. See www.youtube.com/watch?v=JnBoCq6vPwA.

44. TomTom reported intangible assets worth EUR 872 million at the end of 2011, or almost 50% of its total assets (or 70% of total if one exclude goodwill).

45. In January 2012, for example, Orange signed an agreement with Mediamobile, a leading provider of traffic information services in Europe, to use FMD data for its traffic information service V-Trafic (see www.traffictechnologytoday.com/news.php?NewsID=36182)

46. The purpose specification principle states that "the purposes for which personal data are collected should be specified not later than at the time of data collection and the

subsequent use limited to the fulfilment of those purposes or such others as are not incompatible with those purposes and as are specified on each occasion of change of purpose".

47. In 2011 in the United Kingdom, for example, the government launched a voluntary programme, Midata, with industry with a view to providing consumers with increased access to their personal data in a portable, electronic format (BIS, 2012).

48. Fornefeld (2009) notes that in Germany parallel systems of private and public weather stations have been developed following the failure of negotiations on commercial reuse of PSI.

49. See http://opendefinition.org/.

50. Operation Aurora targeted data and intellectual property repositories of high-technology companies such as Google (2010), Adobe Systems, Juniper Networks, and Rackspace. According to McAfee (2010), the primary goal of Operation Aurora was to gain access to and potentially modify intellectual property repositories in high-technology firms. The attack involved social engineering techniques, the exploitation of a zero-day vulnerability (of a web browser) and the use of distributed C&C botnet servers (Zetter, 2010). Operation Aurora was estimated to have affected more than 34 organisations, including Yahoo!, Northrop Grumman, Dow Chemical and Rand Corp. (Damballa, 2010).

51. See, for example, www.linkedin.com/skills/skill/Data_Science for the most frequent locations of people with "data science" in their skill profile. However, the high frequency of the United States could be due to the fact that the term "data science" is biased towards the United States.

References

Acquisti, A., L. John and G. Loewenstein (2011), "What is Privacy Worth?", mimeo, http://pages.stern.nyu.edu/~bakos/wise/papers/wise2009-6a1_paper.pdf. Amazon (2009), "Amazon Elastic MapReduce Developer Guide API", 30 November, http://s3.amazonaws.com/awsdocs/ElasticMapReduce/latest/emr-dg.pdf.

Anderson, C. (2008), "The End of Theory: The Data Deluge Makes the Scientific Method Obsolete", Wired Magazine 23 June, www.wired.com/science/discoveries/magazine/16-07/pb_theory/.

Askitas N. and K.N. Zimmermann (2010), "Google econometrics and unemployment forecasting", Technical report, SSRN 899, 2010, papers.ssrn.com/sol3/papers.cfm?abstract_id=1465341.

Autonomy (2012), "How to Leverage Big Data to Monetize Customer Experiences", White Paper, www.marketingpower.com/ResourceLibrary/Documents/Whitepapers/Autonomy%20Whitepaper%20Final%202.28.2012.pdf.

BIAC (2011), "BIAC Thought Starter: A Strategic Vision for OECD Work on Science, Technology and Industry", 12 October.

BIS: United Kingdom Department for Business Innovation & Skills (2012), "Next steps making midata a reality", News, 22 August, www.gov.uk/government/news/next-steps-making-midata-a-reality.

Bollier, D. (2010), "The Promise and Peril of Big Data", The Aspen Institute, Washington, DC.

Borthakur, D. (2010), "Facebook has the world's largest Hadoop cluster!", Hadoopblog, 9 May, http://hadoopblog.blogspot.fr/2010/05/facebook-has-worlds-largest-hadoop.html.

Brian, C. (2012), "The A/B Test: Inside the Technology That's Changing the Rules of Business", Wired.com, www.wired.com/business/2012/04/ff_abtesting/.

Brynjolfsson, E., L.M. Hitt and H.H. Kim (2011), "Strength in Numbers: How Does Data-Driven Decisionmaking Affect Firm Performance?", April 22, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1819486.

Brynjolfsson, E., A. McAfee (2011), "Race Against The Machine: How the Digital Revolution is Accelerating Innovation, Driving Productivity, and Irreversibly Transforming Employment and the Economy", 17 October.

Bullas, J. (2011), "50 Fascinating Facebook Facts And Figures", jeffbullas.com, 28 April, www.jeffbullas.com/2011/04/28/50-fascinating-facebook-facts-and-figures.

Burdon, M. (2010), "Privacy Invasive Geo-Mashups: Privacy 2.0 and the Limits of First Generation Information Privacy Laws", *University of Illinois Journal of Law, Technology and Policy*, Vol. 1, pp. 1-50.

BusinessWire (2012), "Internet Advertising Revenues Set First Quarter Record at $8.4 Billion", 11 June, www.businesswire.com/news/home/20120611005230/en/Internet-Advertising-Revenues-Set-Quarter-Record-8.4.

Carrière-Swallow, Y. and F. Labbé (2010), "Nowcasting with Google Trends in an Emerging Market", *Central Bank of Chile Working Papers*, No. 588, July.

Cavoukian, A. and J. Jonas (2012), "Privacy by Design in the Age of Big Data", www.privacybydesign.ca.

Cebr (2012), "Data equity: Unlocking the value of big data", Report for SAS, April.

Choi, H. and H. Varian (2009), "Predicting the Present with Google Trends", Discussion paper, Google, 10 April, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1659302.

Christian, B. (2012), "The A/B Test: Inside the Technology That's Changing the Rules of Business", *Wired*, 25 April, www.wired.com/business/2012/04/ff_abtesting.

Cisco (2012), "Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2011–2016", White Paper, www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.pdf.

Damballa (2010), "The Command Structure of the Aurora Botnet: History, Patterns and Findings", Damballa, 3 March, www.damballa.com/downloads/r_pubs/Aurora_Botnet_Command_Structure.pdf.

D'Amuri, F. and J. Marcucci (2010), "Google it! Forecasting the US unemployment rate with a Google job search index", SSRN, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1594132.

Dean J. and S. Ghemawat (2004), "MapReduce: Simplified Data Processing on Large Clusters", in Sixth Symposium on Operating System Design and Implementation (OSDI'04), December, San Francisco, CA, http://research.google.com/archive/mapreduce.html.

DeCarlo, M. (2013), "Kaspersky uncovers five-year cyber espionage campaign, Red October", Techspot, 14 January, www.techspot.com/news/51332-kaspersky-uncovers-five-year-cyber-espionage-campaign-red-october.html.

Dumbill, E. (2012a), "What is big data? An introduction to the big data landscape", O'Reilly Radar, 11 January, http://radar.oreilly.com/2012/01/what-is-big-data.html.

Dumbill, E. (2012b), "Big data market survey: Hadoop solutions", O'Reilly Radar, 19 January, http://radar.oreilly.com/2012/01/big-data-ecosystem.html.

EC: European Commission (2006), Measuring European Public Sector Information Resources (MEPSIR), "Final report of study on exploitation of public sector information – benchmarking of EU framework conditions", Executive summary and Final report Part 1 and Part 2, Brussels.

EC: European Commission (2010), "Riding the Wave: How Europe can gain from the rising tide of scientific data", Final report by the High-level Expert Group on

Scientific, October, http://cordis.europa.eu/fp7/ict/e-infrastructure/docs/hlg-sdi-report.pdf.

Esposito, R. (2012), "'Astonishing' Cyber Espionage Threat from Foreign Governments: British Spy Chief", ABC News, 25 June, http://abcnews.go.com/Blotter/astonishing-cyberespionage-threat-foreign-governments-british-spy-chief/story?id=16645690.

Fornefeld, M. (2009), "The Value to Industry of PSI: The Business Sector Perspective", Chapter 4, in: OECD, NRC (2009), *The Socioeconomic Effects of Public Sector Information on Digital Networks: Toward a Better Understanding of Different Access and Reuse Policies*, Workshop Summary, available at: www.nap.edu/openbook.php?record_id=12687&page=10.

Gartner (2011), "Gartner Says Solving 'Big Data' Challenge Involves More Than Just Managing Volumes of Data", Press release, www.gartner.com/it/page.jsp?id=1731916.

Gartner (2012), "Gartner Says Worldwide Business Intelligence, Analytics and Performance Management Software Market Surpassed the $12 Billion Mark in 2011", Press release, www.gartner.com/it/page.jsp?id=1971516.

GE (2007), "What is the real potential of the Smart Grid?", GE Energy Presentation, Autovation 2007, The AMRA International Symposium, 30 September-3 October, www.ge-energy.com/prod_serv/plants_td/en/downloads/real_potential_grid.pdf.

Gentile, B. (2011), "The New Factors of Production and the Rise of Data-Driven Applications", *Forbes*, 31 October, www.forbes.com/sites/ciocentral/2011/10/31/the-new-factors-of-production-and-the-rise-of-data-driven-applications/.

GeSI (2008), "SMART 2020: Enabling the low carbon economy in the information age". Available at: June, www.smart2020.org/_assets/files/02_Smart2020Report.pdf.

Gilbert, F. (2008), "Beacons, Bugs, and Pixel Tags: Do You Comply with the FTC Behavioral Marketing Principles and Foreign Law Requirements?", Journal of Internet Law, May.

Ginsberg, J., M.H. Mohebbi, R.S. Patel, L. Brammer, M.S. Smolinski and L. Brilliant (2009), "Detecting influenza epidemics using search engine query data". *Nature*, p. 1012-14 http://research.google.com/archive/papers/detecting-influenza-epidemics.pdf.

Goodin, D. (2011), "Sony says data for 25 million more customers stolen", *The Register*, 03 May, www.theregister.co.uk/2011/05/03/sony_hack_exposes_more_customers.

Google (2010), "A new approach to China", Google Official Blog, 13 January, googleblog.blogspot.fr/2010/01/new-approach-to-china.html.

Hachman, M. (2012), "Facebook Now Totals 901 Million Users, Profits Slip", PC Magazine, 23 April, available at: www.pcmag.com/article2/0,2817,2403410,00.asp.

Harris, D. (2011), "Hadoop Kills Zombies Too! Is There Anything It Can't Solve?", Gigaom, 18 April, http://gigaom.com/cloud/hadoop-kills-zombies-too-is-there-anything-it-cant-solve/.

Hildebrandt, M. and B.J Koops (2010), "The Challenges of Ambient Law and Legal Protection in the Profiling Era", *The Modern Law Review*, Vol. 73, No. 3, pp. 428-460.

Hill, K. (2012), "How Target Figured Out a Teen Girl Was Pregnant Before Her Father Did", *Forbes*, 16 February, www.forbes.com/sites/kashmirhill/2012/02/16/how-target-figured-out-a-teen-girl-was-pregnant-before-her-father-did/.

Houghton, J., B. Rasmussen and P. Sheehan (2010), "Economic and Social Returns on Investment in Open Archiving Publicly Funded Research Outputs", Report to SPARC, July, Centre for Strategic Economic Studies, Victoria University, www.cfses.com.

Howard, A. (2012), "Data for the Public Good", 17 February, O'Reilly Media.

IDC (2012), "The Digital Universe in 2020: Big Data, Bigger Digital Shadows, and Biggest Growth in the Far East", December, available at: www.emc.com/collateral/analyst-reports/idc-the-digital-universe-in-2020.pdf.

IEEE (2009), "Smart Grid Communications Preliminary Proposal to IEEE P802.15 Working Group for Wireless Personal Area Networks", 1 March.

ITU (2012), "Key ICT indicators for developed and developing countries and the world (totals and penetration rates)", www.itu.int/ITU-D/ict/statistics/at_glance/KeyTelecom.html, last accessed 7 December 2012.

Jones, S. (2012), "Why 'Big Data' is the fourth factor of production", *Financial Times*, 27 December, www.ft.com/intl/cms/s/0/5086d700-504a-11e2-9b66-00144feab49a.html.

Kingdom, B., R. Liemberger and P. Marin (2006), "The Challenge of Reducing Non-Revenue Water (NRW) in Developing Countries: How the Private Sector Can Help", *Water Supply and Sanitation Sector Board Discussion Paper Series*, Paper No. 8, December.

Kroll (2012), *Global Fraud Report: Economist Intelligence Unit Survey Results*, Annual Edition 2011/12, October, www.krolladvisory.com/media/pdfs/KRL_FraudReport2011-12_US.pdf.

Laney, D. (2001), "3D Data Management: Controlling Data Volume, Velocity, and Variety", META Group, 6 February, http://blogs.gartner.com/doug-laney/files/2012/01/ad949-3D-Data-Management-Controlling-Data-Volume-Velocity-and-Variety.pdf.

LinkedIn (2009), "Building a terabyte-scale data cycle at LinkedIn with Hadoop and Project Voldemort", SNA Project Blog, LinkedIn's Search Network and Analytics team, 16 June, http://project-voldemort.com/blog/2009/06/building-a-1-tb-data-cycle-at-linkedin-with-hadoop-and-project-voldemort/.

Loukides, M. (2010), "What is data science? The future belongs to the companies and people that turn data into products", O'Reilly Radar, 2 June, http://radar.oreilly.com/2010/06/what-is-data-science.html.

Mandel, M. (2012), "Beyond Goods and Services: The (Unmeasured) Rise of the Data-Driven Economy", Progressive Policy Institute, October, www.progressivepolicy.org/wp-content/uploads/2012/10/10.2012-Mandel_Beyon d-Goods-and-Services_The-Unmeasured-Rise-of-the-Data-Driven-Economy.pdf.

Masters, B. and J. Menn (2010), "Data theft overtakes physical losses", *Financial Times*, 18 October, www.ft.com/intl/cms/s/2/3c0c9998-da1a-11df-bdd7-00144feabdc0.html.

McAfee (2010), "Protecting Your Critical Assets: Lessons Learned from 'Operation Aurora'", White Paper, www.wired.com/images_blogs/threatlevel/2010/03/operationaurora_wp_0310_fnl.pdf.

McAfee (2011), "Revealed: Operation Shady RAT", 8 August, www.mcafee.com/us/resources/white-papers/wp-operation-shady-rat.pdf.

McGuire, T., J. Manyika and M. Chui (2012), "Why Big Data is the New Competitive Advantage", *Ivey Business Journal*, July/August, www.iveybusinessjournal.com/topics/strategy/why-big-data-is-the-new-competitive-advantage.

McKinsey (2010), "Consumers driving the digital uptake", Technical report, McKinsey and Company and IAB Europe, September.

MGI: McKinsey Global Institute (2011), "Big data: The next frontier for innovation, competition and productivity", McKinsey & Company, June, www.mckinsey.com/~/media/McKinsey/dotcom/Insights%20and%20pubs/MGI/Research/Technology%20and%20Innovation/Big%20Data/MGI_big_data_full_report.ashx

Microsoft (2011), "Microsoft Expands Data Platform With SQL Server 2012, New Investments for Managing Any Data, Any Size, Anywhere", Microsoft News Center, 12 October, www.microsoft.com/en-us/news/press/2011/oct11/10-12PASS1PR.aspx.

NCIX: National Counterintelligence Executive (United States) (2012), *Foreign Spies Stealing US Economic Secrets in Cyberspace: Report to Congress on Foreign Economic Collection and Industrial Espionage, 2009-2011*, NCIX, October, www.ncix.gov/publications/reports/fecie_all/Foreign_Economic_Collection_2011.pdf.

OECD (1980), *Recommendation of the Council on Guidelines Governing the Protection of Privacy and Transborder Flows of Personal Data*, 23 September, OECD, Paris.

OECD (2002), *OECD Guidelines for the Security of Information Systems and Networks: Towards a Culture of Security*, OECD Publishing. doi: http://dx.doi.org/10.1787/9789264059177-en-fr.

OECD (2007), *OECD Principles and Guidelines for Access to Research Data from Public Funding*, OECD Publishing. doi: http://dx.doi.org/10.1787/9789264034020-en-fr.

OECD (2008), *OECD Recommendation for Enhanced Access and More Effective Use of Public Sector Information*, 16 June, C(2008)36, available at: http://acts.oecd.org/Instruments/ShowInstrumentView.aspx?InstrumentID=122&InstrumentPID=118&Lang=en&Book=False.

OECD (2009a), "Smart Sensor Networks: Technologies and Applications for Green Growth", *OECD Digital Economy Papers*, No. 167, OECD Publishing. doi: http://dx.doi.org/10.1787/5kml6x0m5vkh-en.

OECD (2009b), "Network Developments in Support of Innovation and User Needs", *OECD Digital Economy Papers*, No. 164, OECD Publishing. doi: http://dx.doi.org/10.1787/5kml8rfvtbf6-en.

OECD (2011a), *OECD Skills Strategy: Towards an OECD Skills Strategy*, September, OECD, Paris, www.oecd.org/edu/47769000.pdf.

OECD (2011b), "Terms of Reference for the Review of the OECD Guidelines Governing the Protection of Privacy and Transborder Data Flows of Personal Data", *OECD Digital Economy Papers*, No. 185, OECD Publishing. doi: http://dx.doi.org/10.1787/5kg2b7l7pljk-en.

OECD (2012a), "ICT Applications for the Smart Grid: Opportunities and Policy Implications", *OECD Digital Economy Papers*, No. 190, OECD Publishing. doi: http://dx.doi.org/10.1787/5k9h2q8v9bln-en.

OECD (2012b), "Machine-to-Machine Communications: Connecting Billions of Devices", *OECD Digital Economy Papers*, No. 192, OECD Publishing. doi: http://dx.doi.org/10.1787/5k9gsh2gp043-en.

OECD (2012c), "Cloud Computing: The Concept, Impacts and the Role of Government Policy", internal working document.

OECD (2012d), "Exploring the Economics of Personal Data: A Survey of Methodologies for Measuring Monetary Value", *OECD Digital Economy Papers*, No. 220, OECD Publishing.
doi: http://dx.doi.org/10.1787/5k486qtxldmq-en.

OECD (2012e), "Big Data and Statistics: Understanding the Proliferation of Data and Implications for Official Statistics and Statistical Agencies", internal working document.

OECD (2012f), "ICT Skills and Employment: New Competences and Jobs for a Greener and Smarter Economy", *OECD Digital Economy Papers*, No. 198, OECD Publishing. doi: http://dx.doi.org/10.1787/5k994f3prlr5-en.

OECD (2012g), *Better Skills, Better Jobs, Better Lives: A Strategic Approach to Skills Policies*, OECD Publishing.
doi: http://dx.doi.org/10.1787/9789264177338-en.

OECD (2013), "Building Blocks for Smart Networks", *OECD Digital Economy Papers*, No. 215, doi: http://dx.doi.org/10.1787/5k4dkhvnzv35-en.

OECD-APEC (2012), OECD-APEC Workshop: Anticipating the Needs of the 21st Century Silver Ageing Economy: From Smart Technologies to Services Innovation, Main Conclusions And Options For Future Work, internal working document.OECD-NSF (2011), "OECD-NSF Workshop: Building a Smarter Health and Wellness Future", Summary of Key Messages, 15-16 February, internal working document.

Ohm, P. (2010), "Broken Promises of Privacy: Responding to the Surprising Failure of Anonymization", *UCLA Law Review*, Vol. 57, p. 1701-1777.

Oracle (2012), "Oracle: Big Data for the Enterprise", White Paper, January, www.oracle.com/us/products/database/big-data-for-enterprise-519135.pdf.

OSTP (2010), "Blue Ribbon Task Force on Sustainable Digital Preservation and Access, Sustainable Economics for a Digital Planet: Ensuring Long Term Access to Digital Information", February, http://brtf.sdsc.edu/biblio/BRTF_Final_Report.pdf.

Pingdom, R. (2011), "Would you pay $7,260 for a 3 TB drive? Charting HDD and SSD prices over time", 19 December, http://royal.pingdom.com/2011/12/19/would-you-pay-7260-for-a-3-tb-drive-charting-hdd-and-ssd-prices-over-time.

Polgreen, P.M., Y. Chen, D.M. Pennock and F.D. Nelson (2009), "Using internet searches for influenza surveillance", *Clinical Infectious Diseases*, Vol. 47, p.1443-1448, www.ncbi.nlm.nih.gov/pubmed/18954267.

Reuters (2011), "UPDATE 2-Sony breach could cost card lenders $300 mln", 28 April, www.reuters.com/article/2011/04/28/sony-creditcards-cost-idUSN2826485220110428.

Rogers, S. (2012), "What is a data scientist?", Guardian Datablog, 2 March, www.guardian.co.uk/news/datablog/2012/mar/02/data-scientist.

SAP (2012), "SAP Unveils Unified Strategy for Real-Time Data Management to Grow Database Market Leadership", Press release, 10 April, www.sap.com/canada/about/press/press.epx?pressid=18621.

Severs, H. (2013), "The Greatest Transfer of Wealth in History: how significant is the cyber-espionage threat?", theriskyshift.com, Essays, 17 January, http://theriskyshift.com/2013/01/cyber-espionage-the-greatest-transfer-of-wealth-in-history/.

Seybold, P. (2011), "Update on PlayStation Network and Qriocity", PlayStation.Blog, 26 April, http://blog.us.playstation.com/2011/04/26/update-on-playstation-network-and-qriocity/.

Shapiro, C. and H. Varian (1998), *Information Rules: A Strategic Guide to the Network Economy*, 1st Edition, 19 November, *Harvard Business Review Press*, Boston, MA.

Spiekermann, S., J. Grossklags and B. Berendt (2001), "E-privacy in 2nd Generation E-Commerce: Privacy Preferences Versus Actual Behavior", *Proceedings of the ACM Conference on Electronic Commerce*, pp. 38-47.

Stiglitz, J., P. Orszag and J. Orszag (2000), "Role of Government in a Digital Age", Computer and Communications Industry Association, October, www.ccianet.org/CCIA/files/ccLibraryFiles/Filename/000000000086/govtcomp_report.pdf.

Suhoy, T. (2009), "Query indices and a 2008 downturn: Israeli data", Technical Report, Bank of Israel, 2009, www.bankisrael.gov.il/deptdata/mehkar/papers/dp0906e.pdf.

Surowiecki, J. (2011), "A Billion Prices Now", *The New Yorker*, 30 May, p. 28.

Tene, O. and J. Polonetsky (2012), "Privacy in the Age of Big Data: A Time for Big Decisions", *Stanford Law Review Online*, Vol. 64, Symposium Issue, pp. 63-69.

The Economist (2010), "Data, data everywhere" 27 February.

Tucker, C. (2010), "The Economic Value of Online Customer Data", Background Paper #1, Joint WPISP-WPIE Roundtable "The Economics of Personal Data and Privacy: 30 Years after the OECD Privacy Guidelines", 1 December, www.oecd.org/sti/interneteconomy/theeconomicsofpersonaldataandprivacy30yearsaftertheoecdprivacyguidelines.htm#Background_Reports.

Uhlir, P. F. (2009), "The Socioeconomic Effects of Public Sector Information on Digital Networks: Towards Better Understanding of Different Access and Reuse Policies", Workshop Summary, National Academy of Sciences, Washington DC.

Valdivia A. and S. Monge-Corella (2010), "Diseases tracked by using Google Trends, Spain", *Emerging Infectious Diseases*, January, www.cdc.gov/EID/content/16/1/168.htm.

Vickery, G. (2012), "Review of Recent Studies on PSI Re-Use and Related Market Developments", *Information Economics*, XX, May, Paris.

Villars, R, C. Olofson and M. Eastwood (2012), "Big Data: What It Is and Why You Should Care", White Paper, IDC.

Voreacos, D. (2009), "Hacker Agrees to Plead Guilty in Second Computer Data Theft", Bloomberg, 9 December, www.bloomberg.com/apps/news?pid=newsarchive&sid=aE0.8o_7QcGc.Watters, A. (2012), "Embracing the chaos of data", O'Reilly Radar, 31 January, http://radar.oreilly.com/2012/01/unstructured-data-chaos.html.

Yang, P. (2010), "Moving an Elephant: Large Scale Hadoop Data Migration at Facebook", Facebook, 27 July, www.facebook.com/notes/paul-yang/moving-an-elephant-large-scale-hadoop-data-migration-at-facebook/10150246275318920.

Zetter, K. (2009), "TJX Hacker Charged With Heartland, Hannaford Breaches", Wired.com, 17 August, www.wired.com/threatlevel/2009/08/tjx-hacker-charged-with-heartland.

Zetter, K. (2010), "'Google' Hackers Had Ability to Alter Source Code", Wired.com, 3 March, www.wired.com/threatlevel/2010/03/source-code-hacks/.

Zinow, R. (2012), "Big Data, Mobile and Cloud combined – the new paradigm shift?", SAP, Presentation at the ECD Conference, 23 May, http://ecd-conference.de/wp-content/blogs.dir/46/files/2011/03/Zinow_SAP_1545_2.pdf.

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

The OECD is a unique forum where governments work together to address the economic, social and environmental challenges of globalisation. The OECD is also at the forefront of efforts to understand and to help governments respond to new developments and concerns, such as corporate governance, the information economy and the challenges of an ageing population. The Organisation provides a setting where governments can compare policy experiences, seek answers to common problems, identify good practice and work to co-ordinate domestic and international policies.

The OECD member countries are: Australia, Austria, Belgium, Canada, Chile, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The European Union takes part in the work of the OECD.

OECD Publishing disseminates widely the results of the Organisation's statistics gathering and research on economic, social and environmental issues, as well as the conventions, guidelines and standards agreed by its members.

OECD PUBLISHING, 2, rue André-Pascal, 75775 PARIS CEDEX 16
(92 2013 02 1 P) ISBN 978-92-64-19309-3 – No. 60725 2013

Supporting Investment in Knowledge Capital, Growth and Innovation

Contents

Introduction and overview

Chapter 1. Knowledge-based capital, innovation and resource allocation

Chapter 2. Taxation and knowledge-based capital

Chapter 3. Competition policy and knowledge-based capital

Chapter 4. Measuring knowledge-based capital

Chapter 5. Knowledge-based capital and upgrading in global value chains

Chapter 6. Knowledge networks and markets

Chapter 7. Corporate reporting and knowledge-based capital

Chapter 8. Exploring data-driven innovation as a new source of growth: Mapping the policy issues raised by "big data"

Consult this publication on line at ***http://dx.doi.org/10.1787/9789264193307-en.***

This work is published on the OECD iLibrary, which gathers all OECD books, periodicals and statistical databases.
Visit ***www.oecd-ilibrary.org*** for more information.

OECD*publishing*
www.oecd.org/publishing

ISBN 978-92-64-19309-3
92 2013 02 1 P

