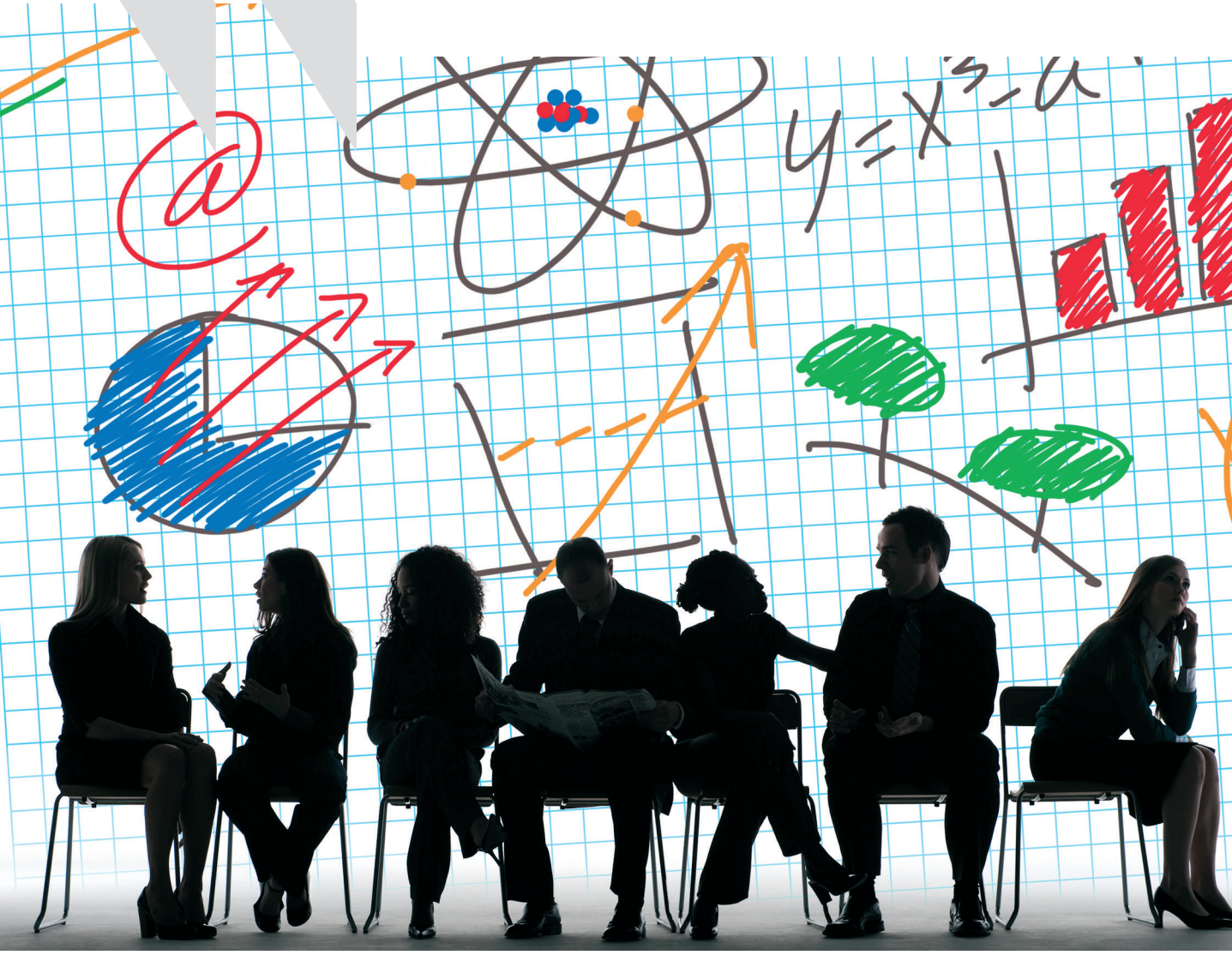
Measuring Innovation

A NEW PERSPECTIVE



OECD *Innovation Strategy*

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Measuring Innovation

A NEW PERSPECTIVE

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Foreword

Sound measurement of innovation is crucial for policy making. It helps policy makers to evaluate the efficiency of their policies and spending and to assess the contribution of innovation to achieving social and economic objectives, and it legitimises public intervention by enhancing public accountability. Yet, the measures of innovation currently available do not adequately take account of the full role of innovation in today's economy.

Measuring Innovation: A New Perspective selects indicators traditionally used to monitor innovation, and complements them with indicators from other domains that describe the broader context in which innovation occurs. It includes some experimental indicators that provide insight into new areas of policy interest. An important objective of the report is to highlight measurement gaps and propose action for advancing the measurement agenda. It draws mainly on OECD indicators or sources of comparable quality. Areas for which good-quality, internationally comparable indicators are not available or only very loose proxies exist are covered separately, using special "Gap pages" that point to measurement gaps that need to be filled.

The approach

The OECD Innovation Strategy takes a broad, horizontal approach. It recognises that to understand the nature of innovation and its impacts and to help monitor the functioning of innovation systems, it is necessary to move beyond aggregate numbers or indices, as these do not adequately reflect the diversity and linkages of innovation actors and processes. It is also necessary to go beyond science, technology and innovation indicators to draw on measures of education, of entrepreneurship, of economic, environmental and social outcomes and of the broader conditions for innovation, including framework conditions.

As a companion to *The OECD Innovation Strategy: Getting a Head Start on Tomorrow,* this publication presents a set of indicators that reflect the broad policy areas examined in that study. The selection of indicators builds on the assumption that:

- The appropriateness of a given set of indicators depends on its use.
- Indicators are not a substitute for causal relations, which are examined through complex empirical analysis, as reviewed in *The OECD Innovation Strategy: Getting a Head Start on Tomorrow.*
- Indicators should be identified on the basis of their policy relevance, analytical soundness, statistical quality and measurability (international, over time, prospects of improvement).

The aim of *Measuring Innovation* is threefold:

- To select "*positioning indicators*". These traditional indicators, with broad coverage of countries over time, can help countries to compare themselves to other countries and monitor their progress towards a desired national or supranational policy goal.
- To go beyond "*positioning indicators*" to tell a more nuanced story. The goal is to:
  - Give a more refined version of the positioning indicator, *e.g.* instead of using scientific publications as a proxy for research output in international comparisons, one might use "top-cited" scientific publications to "quality adjust" the indicator.
  - Show how the *positioning indicator* is linked to a policy leverage, *e.g.* if PISA scores in science are used to proxy basic scientific skills, a way to increase the scores is to increase access to and use of computers by children.
  - Proxy a policy mix or instrument that can be used to progress towards an outcome or target, *e.g.* if a country sets a target in terms of business R&D intensity (R&D/GDP), a policy mix indicator can provide a picture of the extent of direct or indirect public support to business R&D. Some of these indicators may be more experimental in nature, have less country coverage or even be first-time indicators. Some might eventually become part of the regularly produced OECD indicators repertoire.

- To advance the innovation measurement agenda. The OECD has worked for 50 years on the development of science, technology and innovation indicators. Today, innovation raises measurement challenges that are either new or require urgent attention. Short boxes point to measurement challenges and gaps that need to be addressed by the broader community (policy makers, researchers and statisticians) to improve the evidence base for policy making, as well as to recent and ongoing initiatives that will provide better measures in the near future. Special pages are dedicated to gaps for which no good-quality indicator could be identified. Key actions to address these gaps are proposed in "Towards a Measurement Agenda for Innovation".

The structure

Measuring Innovation is the outcome of a very ambitious project and is novel in many respects. It tries to satisfy multiple objectives and is targeted to a broad audience with varying levels of experience in the use of indicators. Its composite structure and look reflects the diversity of its aims. It is organised into three distinct parts.

Towards a Measurement Agenda for Innovation

This part builds on the OECD's half-century of indicator development and the challenge presented by the broad horizontal focus of the OECD Innovation Strategy. It summarises the main weaknesses of the current international measurement framework in this respect. It presents five key areas of action which, if endorsed, could be the basis for a forward-looking, longer-term, international measurement agenda. Its target audience is policy makers who care about evidence-based policy making, the broader research community working on innovation, and the statisticians who produce the data. This part of the publication builds on the following parts but is placed at the beginning to make the discussion of a longer-term strategy for innovation measurement more visible.

Innovation Today (Chapter 1)

Chapter 1 sets the stage in terms of the characteristics of innovation today by focusing on trends and aggregates. It is concerned with the following questions: What inputs (beyond R&D) does innovation entail? What complementary strategies are firms undertaking? How are actors linked in the innovation system and how "collaborative" is the innovation process? What indicators can be used to see how innovation contributes to global challenges such as climate change? It presents new indicators on investment in intangible assets and on trademarks, and innovation indicators drawn from innovation surveys. Traditional indicators based on patents and scientific publications are used to develop new indicators of science or innovation "hot spots" in certain technologies or locations. This part depends on indicators and short bullets to tell a story to policy makers about innovation today.

Beyond Positioning Indicators (Chapters 2, 3, 4, 5, 6)

This part is composed of thematic chapters that draw on traditional indicators and propose experimental ones to reflect the priorities for government action of the OECD Innovation Strategy. No attempt is made to choose a set of indicators for benchmarking purposes. On the contrary, the idea is to present traditional "positioning" indicators that have been, and can be, used to show where countries stand on a particular issue, and, on a facing page, to present more sophisticated or experimental indicators that go beyond simple "pointers". Ideally, these either complement the positioning indicators or point to potentially superior substitutes. The target audience of the thematic chapters is the policy analyst who has a certain level of sophistication in the use of indicators as well as all those who are engaged in producing indicators for policy making.

The five thematic chapters are: 1. Empowering People, 2. Unleashing Innovation in Firms, 3. Investing in Innovation, 4. Reaping the Returns from Innovation, and 5. Innovation for Global Challenges. These chapters also contain a few "Gap pages" that make a case for the development of new indicators in areas that lack high quality, internationally comparable indicators. The "Gap pages" discuss user needs, highlight the measurement challenges and propose a way forward. For example, owing to the lack of appropriate indicators, there is no chapter for the Governance of Innovation. Instead, a "Gap page" has been developed.

The thematic chapters are organised as double pages where the right- and left-hand pages are intended to complement each other. The left-hand page contains:

- A few lines (at the top) to show why it is relevant to monitor the "positioning" indicator in the context of an innovation strategy;
- One "positioning" indicator;
- A "Did you know?" frame that provides additional information from the source;
- A few paragraphs describing the use of the positioning indicator and the indicators on the right-hand page; and
- A small "Definitions" box used in the double page, for those who are not familiar with these particular indicators.

The elements of the right-hand page are:

- One or two figures that go beyond positioning indicators. While they provide a fresh perspective on a particular facet of innovation and frequently provide a better link to policies, these indicators suffer from less country coverage, and are frequently experimental in nature (first-time indicators) that have not benefited from the experience and refinement associated with the "positioning" (left-hand side) indicators; and
- A "Measurability" box that summarises the measurement challenges, gaps and recent initiatives.

All charts and underlying data can be downloaded via the StatLink in the page (hyperlink to a web page).

Acknowledgments

Measuring Innovation is an experimental effort, which draws on contributions from many individuals inside and outside the OECD Secretariat. The development of experimental indicators based on microdata relied on researchers' willingness to devote a considerable amount of their free time to this project. Groups such as the OECD Working Party on Science and Technology Indicators (NESTI) have been on the front line contributing data, valuable comments and ideas for the measurement agenda.

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Without the help and dedication of all, this collaborative effort would not have been possible. We hope to continue to build on this experiment and on this wider community to implement the longer-term measurement agenda.

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Acronyms, Country Groupings and Abbreviations

Acronyms

3G	Third generation of mobile communications technology
BERD	Business enterprise expenditure on research and development
CIS	Community Innovation Survey
DSL	Digital Subscriber Line
EPO	European Patent Office
EU	European Union
GBAORD	Government budget appropriations or outlays for R&D
GDP	Gross domestic product
HIV/AIDS	Human immunodeficiency virus (HIV); Acquired immunodeficiency syndrome (AIDS)
ICT	Information and communication technology
IP	Intellectual property
ISCED	International Standard Classification of Education
ISCO	International Standard Classification of Occupations
JPO	Japan Patent Office
LAN	Local area network
LMDS	Local multipoint distribution system
MMDS	Multichannel multipoint distribution service
PCT	Patent Co-operation Treaty
PRO	Public research organisation
R&D	Research and development
RD&D	Research, development and demonstration
S&T	Science and technology
SME	Small and medium-sized enterprise
SNA	System of National Accounts
PPP	Purchasing power parity
USD	United States dollar
USPTO	United States Patent and Trademark Office
Wi-Fi	Wireless fidelity
WiMAX	Wireless interoperability for microwave access

Country Groupings

BRIC countries	Brazil, the Russian Federation, India and People's Republic of China (China)
BRIIC countries	Brazil, the Russian Federation, India, Indonesia and China
EU19	Austria, Belgium, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, the Netherlands, Poland, Portugal, the Slovak Republic, Spain, Sweden and the United Kingdom
EU27	Austria, Belgium, Bulgaria, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, the Slovak Republic, Slovenia, Spain, Sweden and the United Kingdom
G20	Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Korea, Mexico, the Russian Federation, Saudi Arabia, South Africa, Turkey, the United Kingdom, the United States, and the European Union

Abbreviations

AU	Australia	**CA**	Canada	**CN**	China	**DE**	Germany	**DK**	Denmark	**ES**	Spain
FR	France	**GB**	United Kingdom	**JP**	Japan	**KR**	Korea	**NL**	Netherlands	**US**	United States

TOWARDS A MEASUREMENT AGENDA FOR INNOVATION

Towards a Measurement Agenda for Innovation builds on the OECD's half-century of indicator development and the challenge presented by the broad horizontal focus of the OECD Innovation Strategy. It identifies five broad areas in which international action is needed: develop innovation metrics that can be linked to aggregate measures of economic performance; invest in a high-quality and comprehensive statistical infrastructure to analyse innovation at the firm-level; promote metrics of innovation in the public sector and for public policy evaluation; find new and interdisciplinary approaches to capture knowledge creation and flows; promote the measurement of innovation for social goals and of social impacts of innovation. These five key areas of action, if endorsed, would be the basis for a forward-looking, longer-term, international measurement agenda for innovation. The development and implementation of such an agenda imply a relatively long time frame. It calls for the efforts of the statistical community but also the engagement of policy makers to define user needs and of researchers to use the data, analyse impacts and feed into the development of appropriate metrics and data infrastructures. It also requires the engagement of organisations, businesses, universities and the public sector, because the statistical system can only collect what it is feasible to measure inside organisations.

Measuring innovation: looking ahead

Measuring Innovation presents new measures and new ways of looking at traditional indicators. It builds on the OECD's half-century of indicator development to try to reflect adequately the diversity of innovation actors and processes and the linkages among them. It moves forward the Blue Sky measurement agenda on science, technology and innovation indicators (see Box 1) and draws on measures of education, entrepreneurship, economic, environmental and social outcomes, and the framework conditions that support or inhibit innovation. Its goal is to mirror the broad, horizontal focus of the OECD Innovation Strategy.

This is a challenge. For example, does basic education play a role in shaping the skills of future innovators? If so, how do we measure how well it does so? What measures can we use to capture the range of skills innovators need? Can we in fact define such skills? How does innovation relate to entrepreneurship and how do we define this? Entrepreneurship is already difficult to measure, but not all entrepreneurial activity consists of launching new ideas on the market, it might also include, for example, opening a new outlet or deciding to become a freelance writer.

Innovation is clearly part of a business strategy based on turning ideas into value. It generally means improved goods, services or processes. It sustains growth. Yet other forms of innovation respond to broader challenges. For example, encouraging interdisciplinary research, often viewed as a source of major breakthroughs, implies developing networks of researchers across disciplines and countries. What are the returns to innovation when different actors in different places create new knowledge? Who appropriates the returns? How can we measure the transmission mechanisms of new knowledge and their impacts on economic development? Finally, while innovation drives and sustains growth and helps tackle global challenges, it also affects society. What does a sustained rate of innovation imply for demand for labour and skills? What is its effect on the workplace, on communities and social habits? In sum, the current measurement framework, with its focus on the role of innovation in economic performance, falls short in terms of measuring the social impacts of innovation. This raises hard questions and calls for a rethinking of what constitutes an appropriate framework for measuring innovation.

In the shorter term, the challenge is to render statistical systems more flexible and responsive to the introduction of new and fast-evolving concepts. Ways of doing this include experimenting with satellite accounts, exploiting the potential of existing microdata, adding questions to existing surveys, adding topic-specific modules to main survey vehicles every *n* years or developing short turnaround surveys to meet special needs. Experimental and flexible approaches can progress at different speeds according to countries' specific priorities and resources. This will require co-ordination to prevent geographically fragmented research efforts over the long term and ensure that the results of successful experimentation in a limited number of countries are taken up by the international community. In the longer term, the challenge for the statistical community is to redesign surveys to address the relevant unit of innovation analysis. Should data be collected at the level of research laboratories to address questions about basic research? Is the enterprise group a more relevant unit of analysis than the enterprise when looking at innovation activity? Should innovation surveys use the establishment as the unit to look at the diffusion of new process technologies? Another challenge is to restructure data collection to maximise data-linking opportunities for research and the analysis of impacts. This also means finding ways of providing researchers with access to microdata while respecting confidentiality requirements.

The development and implementation of such an agenda imply a relatively long time frame. It calls for the efforts of the statistical community but also the engagement of policy makers to define user needs and of researchers to use the data, analyse impacts and feed into the development of appropriate metrics and data infrastructures. It also requires the engagement of organisations, businesses, universities and the public sector, because the statistical system can only collect what it is feasible to measure inside organisations.

Box 1 • **Key messages from the OECD Blue Sky Forum**

1. Research on innovation in the broad sense is currently fragmented. There is need for a general framework of analysis and greater coordination of research efforts. The goal is to understand the entire story of innovation, from inputs to economic and social impacts.
2. Indicator and related econometric research must move forward from innovation inputs and activities to include the outputs and impacts of innovation.
3. New methods of analysis are necessary to understand innovation processes, which will require improved data access, data linkages and the adoption of interdisciplinary approaches to data.
4. A marked improvement in the policy relevance of innovation research is required in order to create a science of science policy.

Source: OECD (2007), *Science, Technology and Innovation Indicators in a Changing World. Responding to Policy Needs*, OECD, Paris.

The work undertaken as part of the OECD Innovation Strategy has engaged the international community and has helped to move the measurement agenda forward. *Measuring Innovation* presents some "experimental" indicators and highlights some of the gaps in the current measurement framework, as well as some of the initiatives under way to address such gaps. A number of recommendations have emerged from this work and are presented below. In addition, Box 2 provides a summary of the key actions needed to take the measurement agenda forward.

Broader innovation matters for growth

The increasing recognition of innovation as a driver of economic growth and structural change has drawn greater attention to its nature, role and determinants. Innovation entails investment aimed at producing new knowledge. It is the result of a range of complementary intangible assets – not only R&D but also software, human capital and new organisational structures. In itself, innovation is not an objective. It needs to be placed in the broader context of its contribution to aggregate economic performance. The ability to explain productivity differences is what drives and informs policies designed by ministers of finance or of the economy.

> *Action 1*
>
> ***Improve the measurement of broader innovation and its link to macroeconomic performance***

Science, technology and innovation (STI) surveys need to be redesigned to take a broader view of innovation. Survey and administrative data need to be aligned with aggregate economic measures and become a visible part of the System of National Accounts (SNA). The goal is to help recognise the important role of STI policies in promoting economic growth.

The business, statistical and research communities are encouraged to work to:

- Measure and value intangible assets;
- Revisit the measurement framework for innovation to identify and prioritise areas for survey design and re-design; and
- Align survey and administrative data with economic aggregates to enable productivity analysis.

Going beyond targets and aggregates: understanding why and how innovation happens in firms

Targeting levels of spending on certain dimensions of innovation activity, such as R&D, has been a widely used policy tool in recent years. Spending on R&D is well measured, but it is important to know how to reach the target and what that target means in terms of innovation outcomes and impacts. R&D surveys can provide information about some of the inputs to innovation but give little information on the outputs of these processes. They tend to be more useful for measuring technology-based activities, which are only a subset of what is included in the broader concept of innovation, and they are often more relevant for manufacturing than for services. Similarly, patent data are useful for understanding certain innovation-related strategies, but they cannot measure the full extent of innovative activities and suffer from some well-known limitations. "Innovation surveys" were therefore developed to increase knowledge about innovation in firms with a view to developing effective innovation policies. They collect information about types of innovation, reasons for innovating (or not), collaboration and linkages among firms or public research organisations, and flows of knowledge, as well as quantitative data on sales from product innovations and spending on a range of assets beyond R&D.

However, knowing, for example, that 60% of a country's firms have introduced some type of innovation does not help to understand why and how innovation happened, what its impacts are on the economy and how it can be encouraged. Indicators should not simply provide a level and *Measuring Innovation* explores the potential of firm-level data tell a story about how that level was achieved. Using microdata from innovation surveys, it shows that firms introduce new products on the market without necessarily performing R&D. It shows that firms adopt complementary strategies. Terms such as "technological" or "non-technological" innovation or "open" innovation are simplifications and potentially misleading. Most innovative firms introduce both product and process innovations and also marketing or organisational innovations. They are part of the broader conditions and infrastructure of their national innovation system, which are often provided by government agencies. This is true of firms in both manufacturing and services. New empirical analysis based on these data and presented in *The OECD Innovation Strategy : Getting a Head Start on Tomorrow*, shows how different "modes" (complementary strategies) of innovation are positively correlated with economic performance. Chapter 1 presents the use of some of these indicators to highlight the nature of innovation today.

Action 2

Invest in a high-quality and comprehensive data infrastructure to measure the determinants and impacts of innovation

Sound evidence-based policy advice calls for a comprehensive, high-quality data infrastructure, including at the sub-national level. Its backbone is a reliable business register. It is important to be able to link different data sets and exploit the potential of administrative records. This can improve understanding and reduce respondent burden. For example, the ability to link innovation survey data to business practice surveys, ICT surveys or administrative databases on firm-level capital investment, earnings, value added and employment can substantially improve empirical research on the impacts of innovation. This can also reduce respondent burden if questions do not have to be repeated in the innovation survey.

However, there is no point to a first-class data infrastructure if it is not available to the research community. It is researchers who formulate relevant research questions and analyse the data. Of course, this requires measures to ensure data confidentiality in order to protect respondents and to avoid any real or perceived conflict of interest on the part of researchers.

Governments and the statistical and the research communities are encouraged to focus on:

- Improving business registers;
- Exploring the statistical potential of administrative records;
- Establishing a data infrastructure which exploits linkages across data sets and over time;
- Improving the data infrastructure at the sub-national level; and
- Improving the research community's access to this infrastructure while ensuring data confidentiality.

Going beyond traditional actors: addressing the role of government in innovation

Governments, including central and local government and various agencies, provide services to people and to businesses. They also define the boundaries within which innovation takes place through regulation of domestic activity and trade, and they play a major role in fostering innovation. Yet while universities and firms are covered by conventional indicators, current measures do not fully take account of the roles of individuals, consumers and government in the innovation process. There are several compelling reasons for developing metrics and definitions for innovation in the public sector and measures of policy efforts to foster innovation. There is a need to account for the use of public funds for innovation, improve learning outcomes and the quality of the provision of education or other public services.

Action 3

Recognise the role of innovation in the public sector and promote its measurement

Internationally agreed concepts and comparable metrics for studying innovation in the public sector do not yet exist. A framework for the measurement of public-sector innovation that is analogous to, but appropriately different from, the one used for business innovation (OECD/Eurostat [2005], *Oslo Manual*) would provide a basis for a more innovative approach to public activities and services and allow for comparisons and benchmarking. Because the concept of "public sector" encompasses very different organisational units (*e.g.* the public administration, the health sector, the education sector), it may be necessary to develop new concepts, such as innovation in education, and different metrics to encompass the public welfare aspects of innovation.

Governments and the statistical and research communities are encouraged to develop a measurement framework for innovation in the public sector that:

- Examines the extent to which concepts and metrics used in the context of business innovation can be used and adapted;
- Considers whether basic concepts and tools are relevant in light of the specificities of the public sector, in particular its complexity and heterogeneity, and its organisational and incentive structures; and
- Recognises that the public sector has multiple objectives, including innovation for social goals, which may require radically new thinking about what innovation is and how it takes place in that context.

Evaluation – typically of institutions, programmes and instruments, but recently more comprehensively of the overall "policy mix" or (public funding) "systems" – is essential to improve STI governance and to enhance the effectiveness and efficiency of innovation policies. New metrics are needed to support innovation policy making. Chapter 4 presents some "experimental" indicators on the mix of direct and indirect public support to R&D, as well as measures of public funding "modes" (*e.g.* institutional versus project funding). Work is needed to improve the international comparability of these indicators and to develop metrics for broader innovation (beyond R&D).

The policy, research and statistical communities are encouraged to:

- Promote the development of indicators that capture the nature, direction and intensity of policy actions for innovation at national and regional levels. This will make it possible to study the linkages between them and innovation performance and the relevance of policies in different innovation system contexts.

Capturing knowledge interactions

Workplaces can provide a fertile environment for interactions leading to innovation if effective management can ensure that the talents of individuals are being tapped. New measures are needed of the skills required and of ways in which the workplace promotes and makes use of such skills.

The production of new knowledge is often a collective process involving a significant number of individuals and organisations which requires communication and co-ordination. Knowledge produced in such a complex but structured way may have public good aspects. Such interactions or "networks" may be usefully tracked as part of the innovation measurement framework. Networks can be a means for "collective intelligence", and policies that seek to influence the rate and orientation of innovation have to take networks into account. For instance, technology transfer between universities and industries implies two-way communication. The mobility of the highly skilled implies knowledge flows across disciplines, sectors and borders. A "clever" and linked use of bibliometric, patent and other administrative data can help reveal how these multidisciplinary, transnational networks are evolving. However, while science and innovation activities increasingly rely on dispersed networks of actors, they sometimes tend to cluster in certain places or around certain institutions (*e.g.* a leading university or a research laboratory of a multinational corporation). To analyse the changing landscape of science, technology and innovation is likely to require new units of analysis with different geographical scope.

Finally, rapidly developing enabling technologies such as information and communication technologies (ICT), biotechnologies, and nanotechnologies draw on interdisciplinary research and tend to be "general purpose technologies" that can be used across a broad range of industries. A consistent measurement framework across technologies would make it possible to compare their impacts.

Action 4
Promote the design of new statistical methods and interdisciplinary approaches to data collection

The design of innovation policy should take into account the characteristics of technologies, people and locations, as well as the linkages and flows among them. New methods of analysis are needed to understand innovative behaviour, its determinants and its impacts at the level of the individual, the firm and the organisation.

The statistical and research communities should consider:

- Developing interdisciplinary approaches to data collection and new units of data collection;
- Improving the measurement of innovative activity in complex business structures, organisations and networks;
- Promoting the measurement of the skills required in innovative workplaces; and
- Promoting joint measurement of emerging and enabling technologies.

Going beyond economic goals: innovation for social goals and social impacts of innovation

Innovation may be part of a policy framework that addresses societal issues that go beyond day-to-day business innovation. This may require a concept of "policy-driven" innovation which can also respond to social challenges or address social needs. Some innovations that generate income for firms may, of course, reduce environmental impacts and improve social well-being. However, the current measurement framework focuses on the role of innovation in economic performance and has limited capacity to measure innovations that help address social goals, such as those associated with an ageing population or climate change.

Moreover, the current framework does not cover the social impacts of innovation. For example, to analyse the effects of policies that "foster innovative workplaces", it is necessary to measure both the adoption of innovative practices by companies and the impact of these practices on workers. It would be possible to do so, for example, through linked employer-employee surveys.

Action 5
Promote the measurement of innovation for social goals and of social impacts of innovation

It is important to promote the development of concepts and measures of innovation that reveal their impact on well-being or their contributions to achieving social goals.

The statistical and research communities are encouraged to work towards:

- Developing concepts and measures of innovations that address social needs; and
- Devising measurement tools that bridge the economic and social impacts of innovation activities.

Box 2 • **A measurement agenda for innovation: Key actions**

1. Improve the measurement of broader innovation and its link to macroeconomic performance

Science, technology and innovation surveys need to be redesigned to take a broader view of innovation and improved measurements are needed to link science, technology and innovation policies to economic growth. Key actions:

- Measure and value intangible assets;
- Revisit the measurement framework for innovation to identify and prioritise areas for survey design and re-design; and
- Align survey and administrative data with economic aggregates.

2. Invest in a high-quality and comprehensive data infrastructure to measure the determinants and impacts of innovation

Sound policy advice needs to rely on a high-quality and comprehensive data infrastructure, including at the sub-national level. The backbone of such infrastructure is a high quality business register. The ability to link different data sets and exploit the potential of administrative records will improve understanding and reduce respondent burden. Key actions:

- Improve business registers;
- Exploit the statistical potential of administrative records;
- Improve the data infrastructure at the sub-national level; and
- Establish a data infrastructure which combines data linkages with good researcher access to the data, while protecting business and individual confidentiality.

3. Recognise the role of innovation in the public sector and promote its measurement

There is a need to account for the use of public funds, measure the efficiency of producing and delivering public policies and services, and improve learning outcomes and the quality of the provision of public services via innovation. Key actions:

- Develop a measurement framework for innovation in the public sector for the delivery of public services, health and education; and
- Devise indicators that capture the nature, direction and intensity of public support for innovation, at national and sub-national levels.

4. Promote the design of new statistical methods and interdisciplinary approaches to data collection

Design of policies for innovation needs to take into account the characteristics of technologies, people and locations, as well as the linkages and flows among them. New methods of analysis that are interdisciplinary in nature are necessary to understand innovative behaviour, its determinants and its impacts at the level of the individual, the firm and the organisation. Key actions:

- Develop interdisciplinary approaches to data collection and new units of data collection;
- Improve the measurement of innovative activity in complex business structures, organisations and networks;
- Promote the measurement of the skills required in innovative workplaces; and
- Promote the joint measurement of emerging and enabling technologies.

5. Promote the measurement of innovation for social goals and of social impacts of innovation

The current measurement framework fails to measure the social impacts of innovation. The development of measures that provide an assessment of the impacts of innovation on well-being, or their contributions to achieving social goals, needs to be promoted. Key actions:

- Develop measures of innovation that address social needs; and
- Devise measurement tools that bridge the economic and social impacts of innovation activities.

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Chapter 1

INNOVATION TODAY

This chapter sets the stage for an examination of the characteristics of innovation today by focusing on trends and aggregates. It is concerned with the following questions: What inputs (beyond R&D) does innovation entail? What complementary strategies are firms undertaking? How are actors linked in the innovation system and how "collaborative" is the innovation process? What indicators can be used to see how innovation contributes to global challenges such as climate change? It presents new indicators on investment in intangible assets and on trademarks and new indicators drawn from innovation surveys. Traditional indicators based on patents and scientific publications are used to develop new indicators of science or innovation "hot spots" in certain technologies or locations. Indicators and the accompanying text tell policy makers a story about innovation today.

Sources of growth 20
New sources of growth 21
Intangible assets 22
Innovation beyond R&D 23
Protection of innovation 24
Trademarks 25
Mixed modes of innovation 26
Collaboration in innovation 27
Mapping hot research areas 28
Multidisciplinary and interdisciplinary research 29
New players in research 30
Scientific collaboration 31
Clusters of knowledge 32
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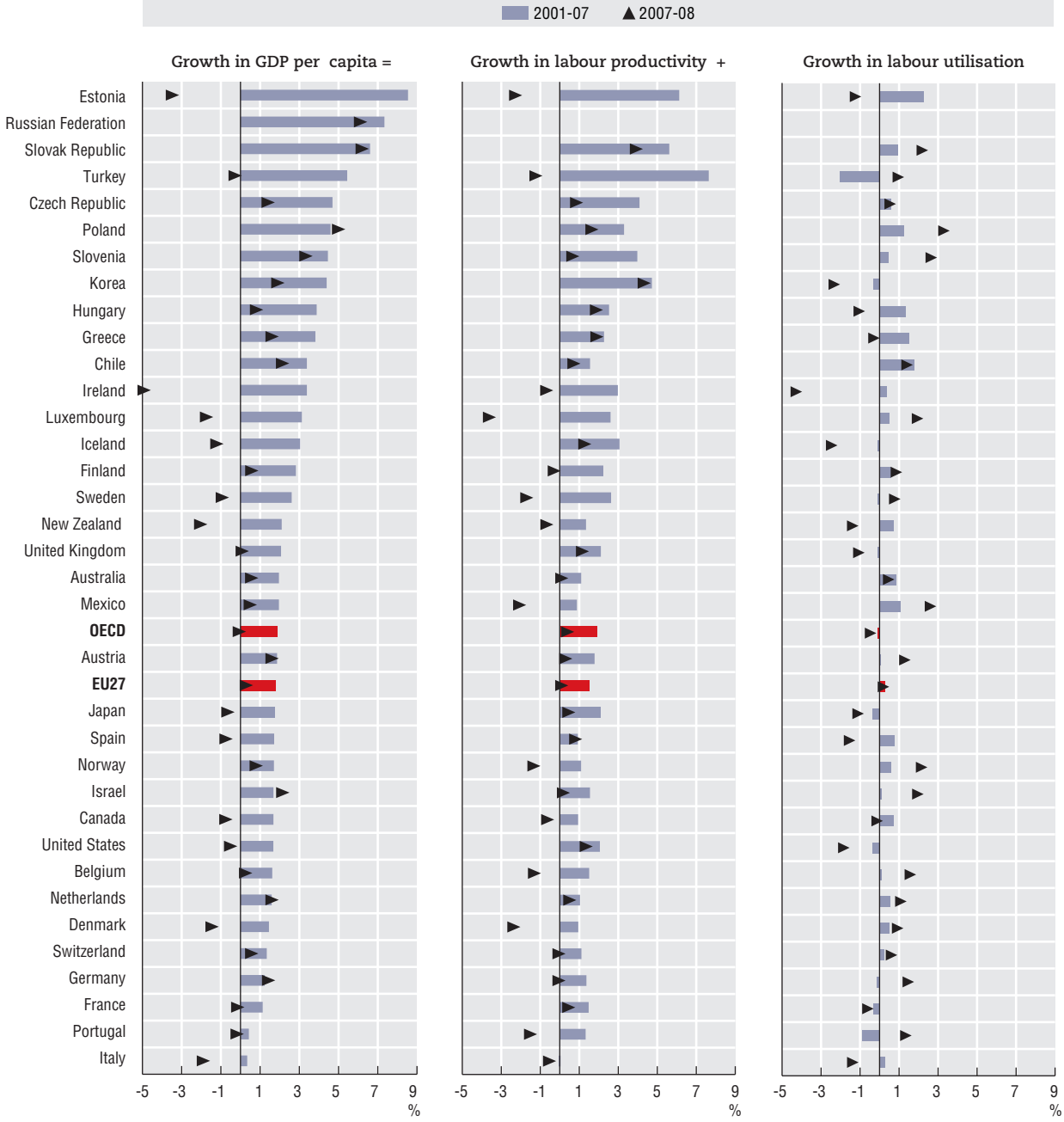
THE INNOVATION IMPERATIVE: FINDING NEW SOURCES OF GROWTH

Today's world faces extraordinary challenges. In particular, effects of the economic downturn will be felt for years to come. The measure used to gauge welfare is GDP per capita, and changes in welfare can result from changes in labour productivity (GDP per hours worked) and labour utilisation (hours worked per person employed). Slowing labour productivity was already eroding growth performance prior to the crisis (2007-08), which has made it even more imperative for countries to find new and sustainable sources of growth.

Decomposition of growth in GDP per capita, 2001-08

Total economy, percentage change at annual rate



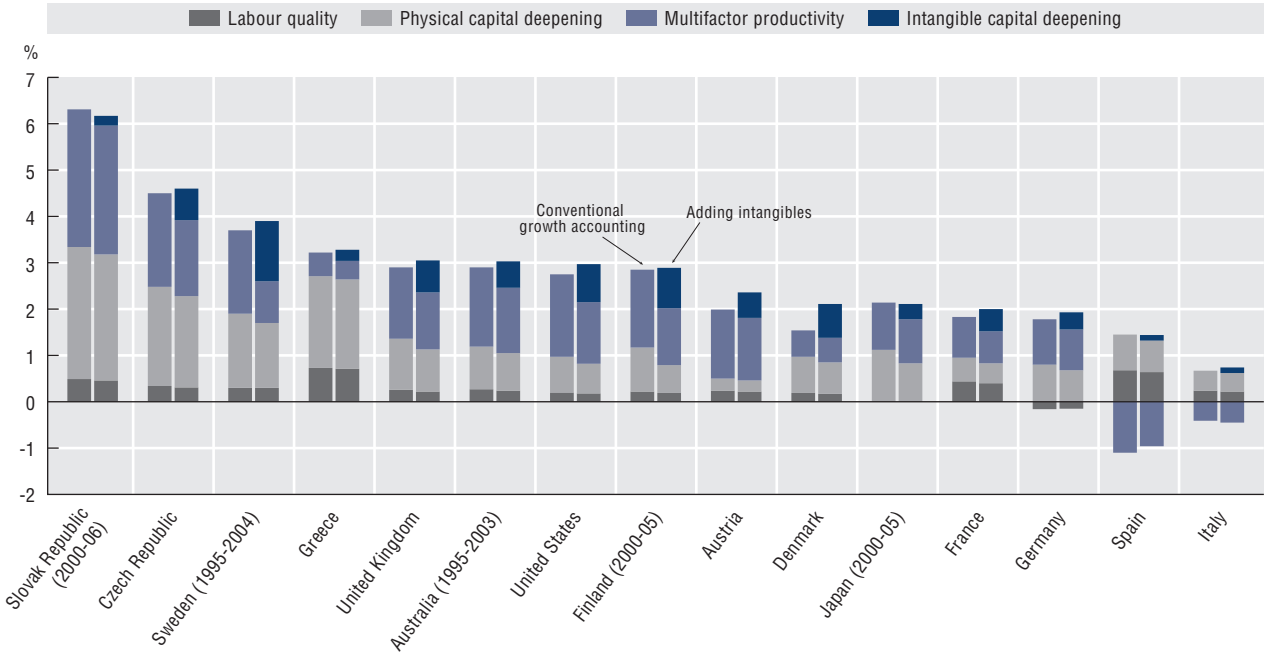
Source: OECD, Productivity Database, November 2009; *www.oecd.org/statistics/productivity* and for EU27; EUROSTAT, National Accounts Database, March 2010. See chapter notes.

StatLink http://dx.doi.org/10.1787/834500164468

NEW SOURCES OF GROWTH: THE CONTRIBUTION OF INTANGIBLE ASSETS

A new stream of research argues that firms' spending on new knowledge, i.e. investment in intangible assets, contributes to their output growth not only at the time of investment but also in later years. Estimates of the contribution of intangible assets to labour productivity growth show that, in some countries, they explain a good portion of multifactor productivity growth (a measure of technological change and the inability to fully measure the sources of economic performance).

Labour productivity growth: adding the contribution of intangible assets, 1995-2006



Note: These estimates are based on national studies. They do not yet reflect standardised methods and definitions.

How to read this figure

What happens when investment in intangible assets is added to the breakdown of labour productivity growth? The contribution of physical capital (machines and information and communication technologies – ICT) declines because investment in software becomes part of investment in intangible assets. Multifactor productivity (MFP) is related to more efficient use of labour and capital inputs, for example through improvements in the management of production processes, organisational change or more generally, R&D and innovation. MFP declines as investment in R&D and in other intangible assets related to innovation is accounted for as a distinct source of growth, "intangible capital deepening". Although the comparability of these estimates is still poor, owing to differences in data sources, methodologies and assumptions on deflators and depreciation rates, they are a first step in recognising the importance of investment in intangible assets for growth.

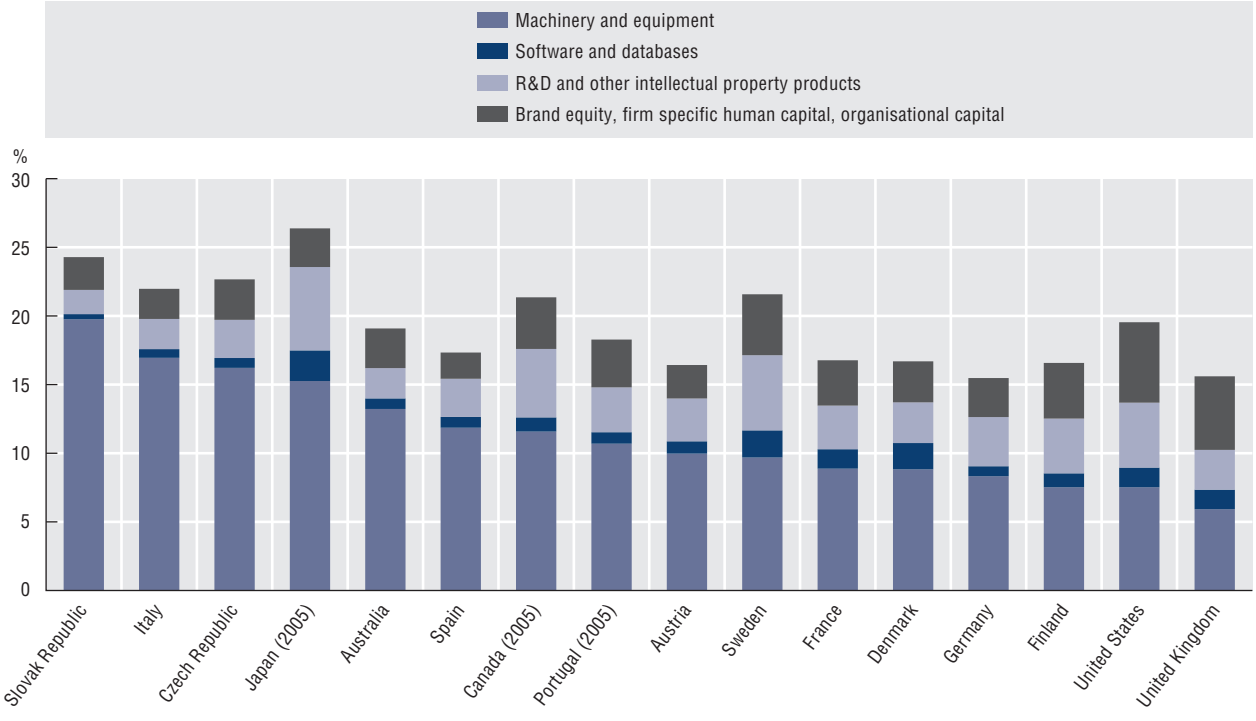
Source: OECD, based on research papers, 2009. See chapter notes.

StatLink http://dx.doi.org/10.1787/834524666054

INVESTING IN INTANGIBLE ASSETS

Innovation results from a range of complementary assets that go beyond R&D, such as software, human capital and new organisational structures. Investment in these intangible assets is rising and overtaking investment in physical capital (machinery and equipment) in Finland, Sweden, the United Kingdom and the United States.

Investment in fixed and intangible assets as a share of GDP, 2006



Note: These estimates are based on national studies. They do not yet reflect standardised methods and definitions.

What is included in intangible assets?

Using as their basis a seminal paper by C. Corrado, Hulten and Sichel (2006), researchers in 14 countries have computed aggregates for intangible investment. Software and databases provide a measure of *computerised information*. Scientific R&D, mineral exploration, copyright and licence costs, and other product development, design and research are a measure of *innovative property*. Brand equity, firm-specific human capital and organisational capital are taken as a measure of *economic competencies*. Some of these intangibles – software and, more recently, R&D – are now recognised by the international statistical community as capital assets and will be accounted for in the System of National Accounts (see the *OECD Handbook on Deriving Capital Measures of Intellectual Property Products*, 2010). More work is needed to harmonise the definition of intangible assets and collect data on an internationally comparable basis so as to better identify and measure new sources of growth.

Source: OECD, data on intangible investment are based on COINVEST, *www.coinvest.org.uk*, and national estimates by researchers. Data for fixed investment are OECD calculations based on EU KLEMS Database and OECD, Annual National Accounts Database, March 2010. See chapter notes.

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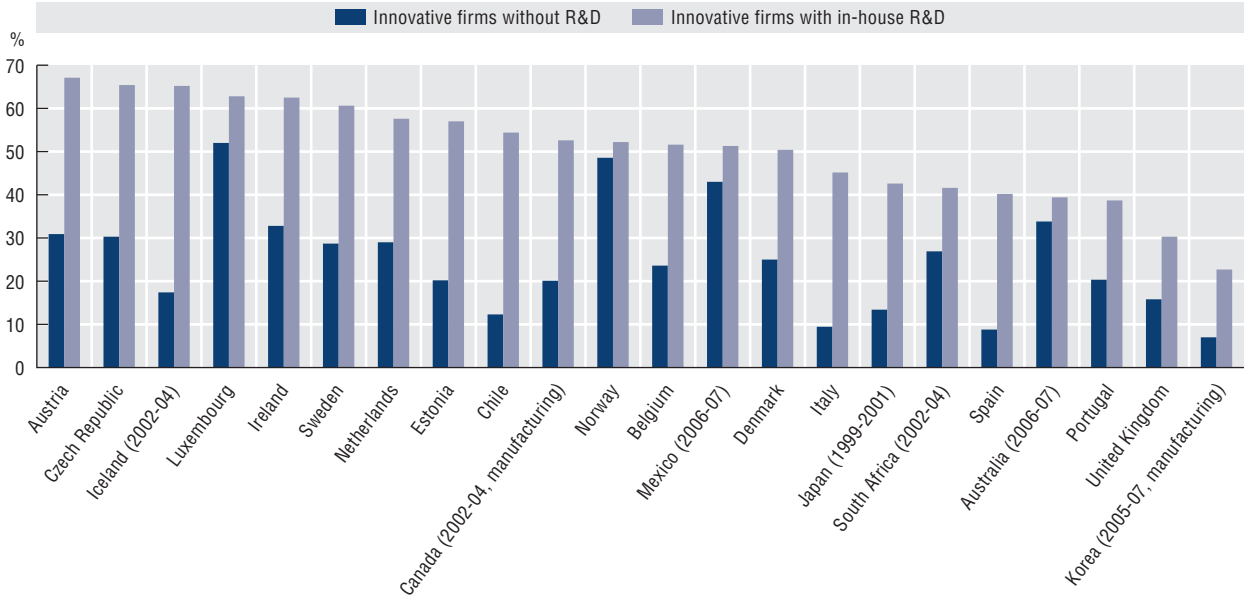
BROADER INNOVATION (BEYOND R&D)

Firms may introduce new products on the market without engaging in R&D. New indicators reveal that in Australia and Norway the propensity to introduce a new-to-market product innovation is similar whether or not the firm performs R&D.

New-to-market product innovators, 2004-06

As a percentage of innovative firms by R&D status



How to read this figure

A large share of firms develop their process, product, organisational or marketing innovations without carrying out any R&D. This holds true even for new-to-market innovators who successfully introduce innovations regarded as "technological". In Luxembourg 52% of non-R&D performers introduced new-to-market innovations as compared to 63% of in-house R&D performers.

How comparable are innovation surveys?

Innovation surveys are increasingly used to better understand the role of innovation in firms' performance, its determinants and the characteristics of innovative firms. Since 1992, the *Oslo Manual* (OECD and Eurostat, 2005) has provided a harmonised framework – with coherent concepts and tools – for undertaking comparable large-scale surveys of this type. Although cross-country comparability of innovation surveys based on the *Oslo Manual* is generally good and improving, certain differences may affect comparisons between CIS (Community Innovation Survey) and non-CIS countries, such as sectoral coverage (*e.g.* Canada and Korea conduct separate surveys for manufacturing and services), size thresholds, sampling methods and the unit of analysis. Another difference is the length of the reference period (*i.e.* firms are asked about their innovation activities over a defined period in the past) which varies between two (*e.g.* Australia, New Zealand) and three years (*e.g.* CIS countries, China, Japan). For the OECD Innovation microdata project, countries prepared these indicators using common definitions and statistical routines to ensure a high degree of comparability. As a result, there may in some cases be small discrepancies between the figures given here and the published national data. Not all countries run an innovation survey or participated in the OECD Innovation microdata project. For instance the United States does not have an innovation survey, hence it does not appear in the figure above or in other figures which make use of innovation survey data.

Source: OECD, Innovation microdata project based on CIS-2006, June 2009 and national data sources. See chapter notes.

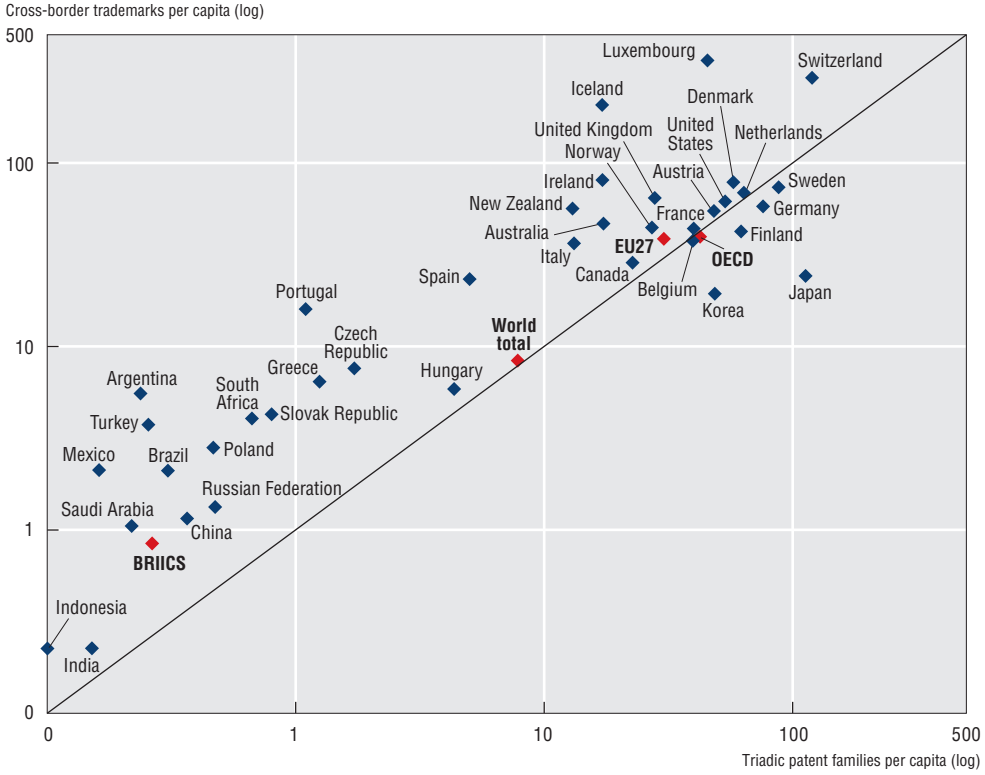
StatLink http://dx.doi.org/10.1787/834560317112

INNOVATION EVERYWHERE

New indicators based on trademarks point to a wealth of incremental and marketing innovations in addition to technological innovations. Countries with strong manufacturers or a specialisation in information and communication technology tend to turn to patents rather than trademarks. Countries with a large services sector tend to engage more in trademark protection. Catching-up countries have a lower propensity to innovate or to seek protection (patent or trademark) for their innovations than OECD countries.

Patents and trademarks per capita, 2005-07

Average number per million population, OECD and G20 countries



What is a triadic patent?

Triadic patent families are defined as those patents applied for at the European Patent Office (EPO), the Japan Patent Office (JPO) and the US Patent and Trademark Office (USPTO) to protect a same invention. Triadic patents are typically of higher value and eliminate biases arising from home advantage and the influence of geographical location.

What is a cross-border trademark?

Trademark counts are also subject to home bias, as firms tend to file trademarks first in their home country. Cross-border trademarks are here defined as applications at the USPTO except for the United States and countries with a high propensity to file trademarks in the United States (Australia, Canada, Israel, Mexico and New Zealand). For these countries, counts are based on the relative share of their filings at the JPO and the European Office for Harmonization in the Internal Market (OHIM). This method is used to obtain information on trademarks commercialised abroad, hence the name "cross-border trademarks".

Why use trademarks as indicators of innovation?

A trademark is a sign that distinguishes the goods and services of one undertaking from those of other undertakings. Firms use trademarks to launch new products on the market in order to signal novelty, promote their brand and appropriate the benefits of their innovations. It has been shown that the number of trademark applications is highly correlated with other innovation indicators. As their perimeter of application is very broad, they convey information not only on product innovations, but also on marketing innovations and innovations in the services sector. An advantage of using trademarks as an innovation indicator is that data on trademark applications are publicly available immediately after the filing. Trademark-based indicators can thus provide up-to-date information on the level of innovative activity. See chapter notes for more information.

Source: OECD, Patent Database, January 2010; USPTO Trademark BIB ACE Database (Cassis), June 2008; OHIM and JPO annual reports 2005-08; World Intellectual Property Organization (WIPO) Trademark Statistics, January 2010. See chapter notes.

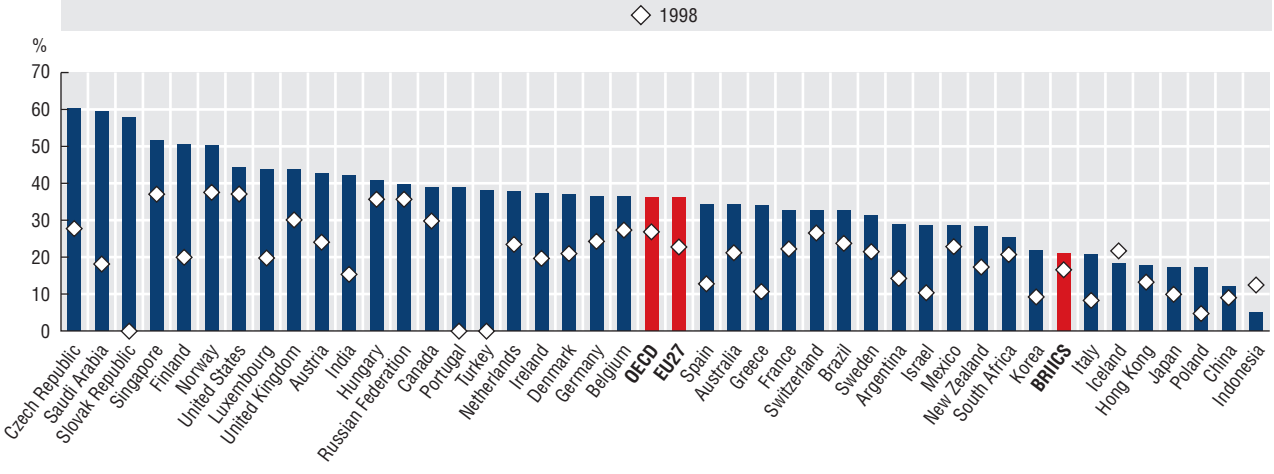
StatLink http://dx.doi.org/10.1787/834561767368

INNOVATION IN SERVICES IS RISING

The average share of trademark applications relating to service classes has increased over the last decade from 38% to 52%.

Service-related trademarks, 2008

As a percentage of total trademark filings



Source: OECD, based on USPTO Trademark BIB (Cassis) April 2009; OHIM Community Trademark Database, CTM Download, December 2009. See chapter notes.

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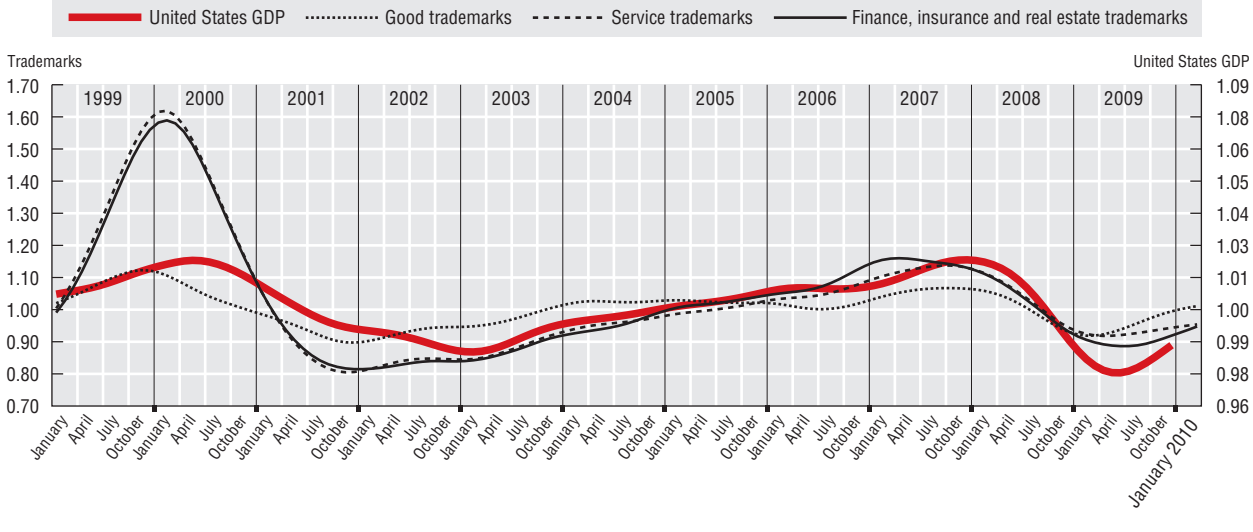
TRADEMARKS ARE A GOOD PREDICTOR OF ECONOMIC DOWNTURNS

The most recent data show that trademark activity has been strongly affected by the economic crisis, with a marked drop in filing from mid-2007. The decline is apparent in both services and goods, although the crisis has affected services more severely and innovation activity in the finance and insurance sectors more particularly.

Comparing cycles: United States gross domestic product and trademark applications at the USPTO, 1999-2010

By type of trademark, long-term trend = 1.0



Source: OECD, based on USPTO, Trademark Electronic Search System, April 2009, OHIM Community Trademark Database, CTM Download, December 2009. See chapter notes.

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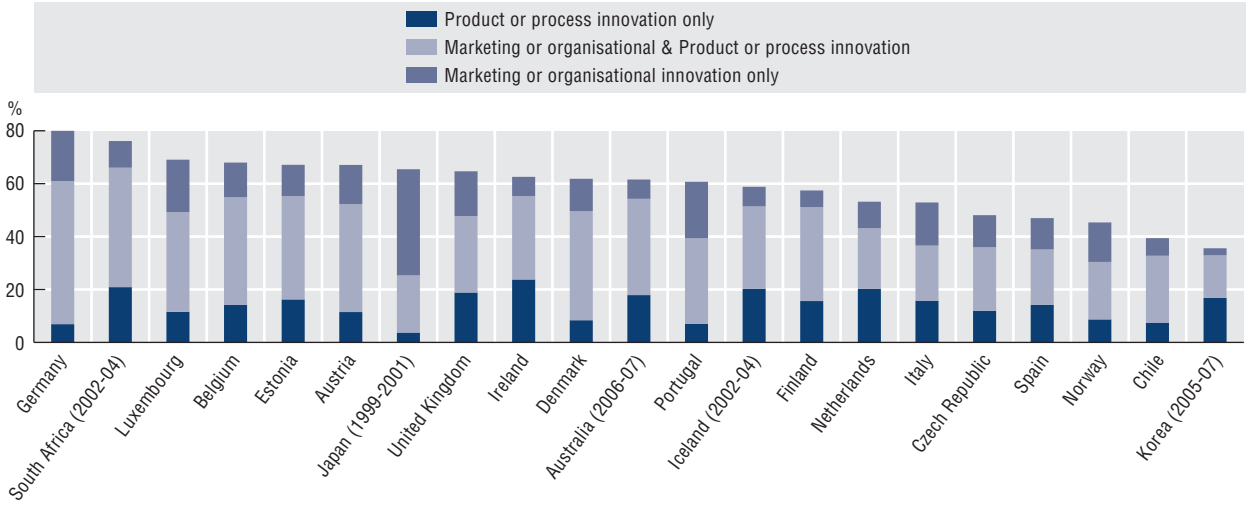
INSIDE FIRMS: MIXED MODES OF INNOVATION

Firm-level innovation data reveal complementary strategies. Terms such as "technological" or "non-technological" innovation are simplifications and to some extent misleading. Most innovative firms introduce both product and process innovations, as well as marketing or organisational innovations. This is true for firms in both manufacturing and services. There are, of course, differences by sector or firm size. For instance, a larger share of firms in services than in manufacturing introduce only marketing or organisational innovation.

Complementary innovation strategies in manufacturing, 2004-06

As a percentage of all manufacturing firms



Source: OECD, Innovation microdata project based on CIS-2006, June 2009 and national data sources. See chapter notes.

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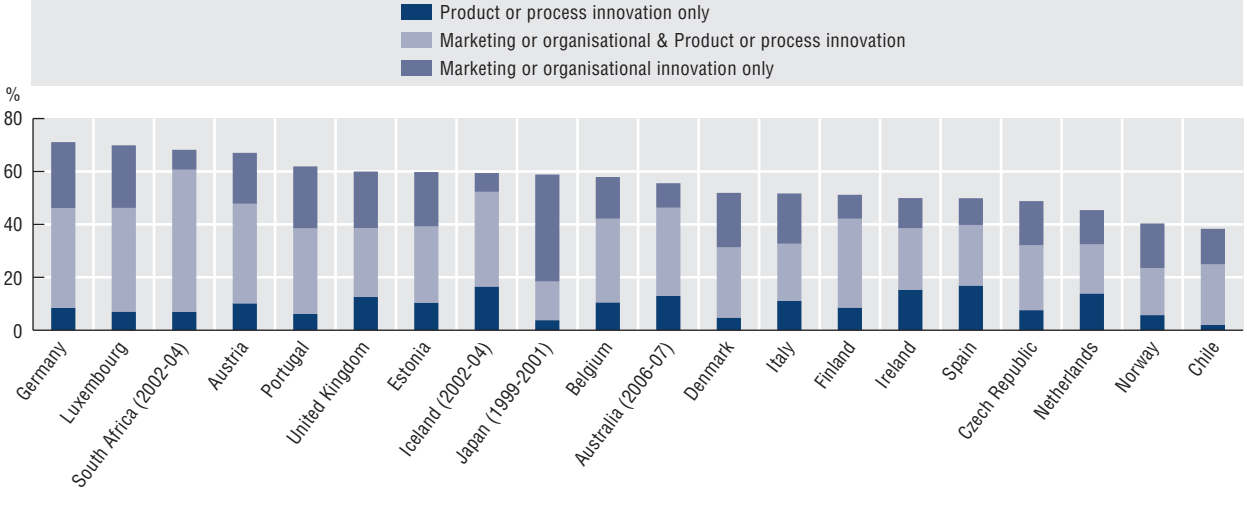
Complementary innovation strategies in services, 2004-06

As a percentage of all services firms



Source: OECD, Innovation microdata project based on CIS-2006, June 2009 and national data sources. See chapter notes.

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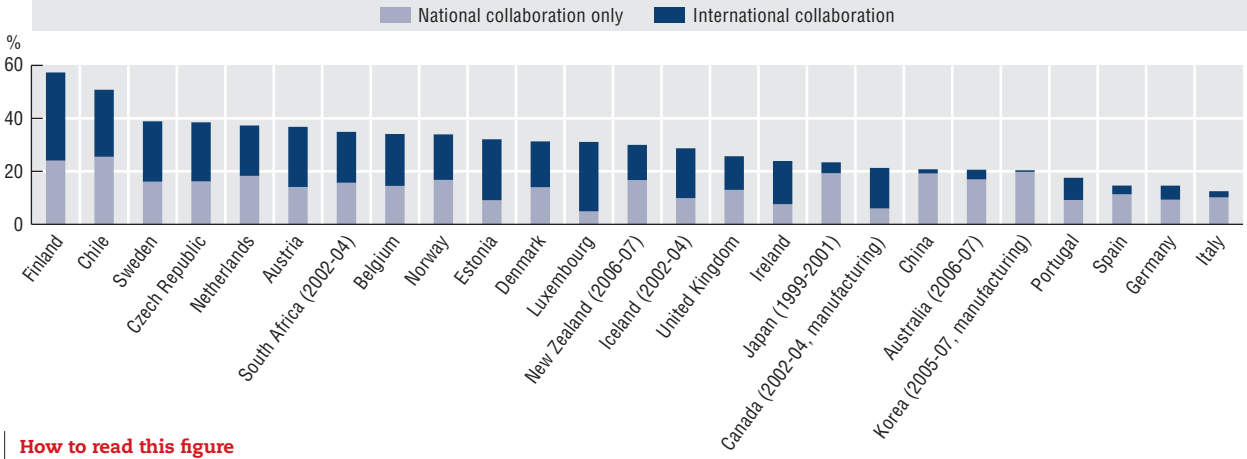
INSIDE FIRMS: COLLABORATION IS ESSENTIAL

New firm-level analysis reveals that firms that collaborate on innovation spend more on innovation than those that do not. This suggests that collaboration is likely to be undertaken to extend the scope of a project or to complement firms' competencies more than to save on costs. In most countries collaboration with foreign partners is as least as important as domestic co-operation. Collaboration is used in innovation processes whether firms perform a lot of R&D, a little R&D or no R&D at all. In this respect, policies that stimulate collaboration and network initiatives will have an impact on the entire spectrum of innovative firms.

Firms with national/international collaboration on innovation, 2004-06

As a percentage of innovative firms



How to read this figure

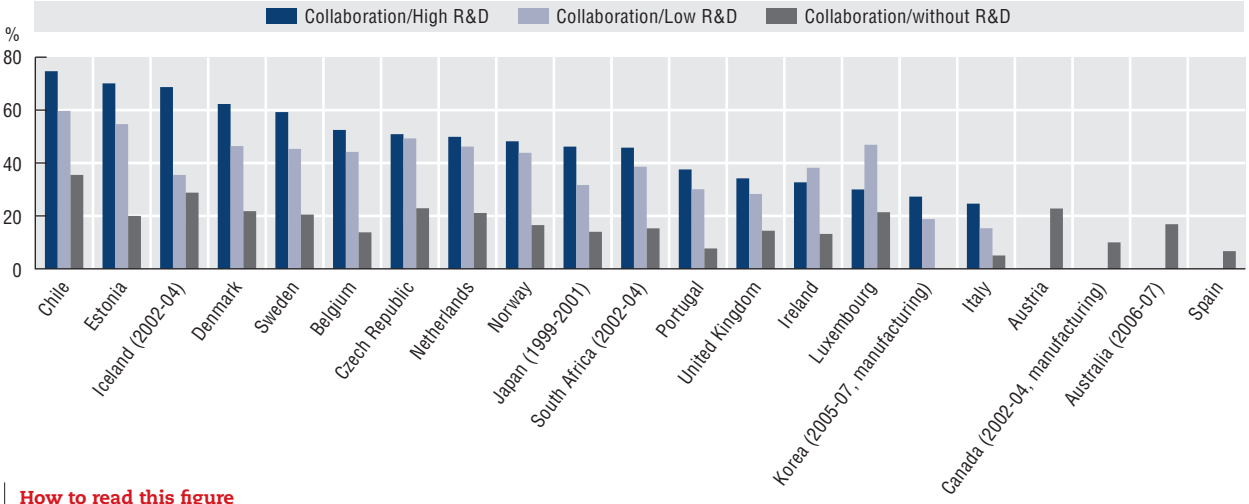
The share of innovative firms that engage in collaboration ranges from 57% in Finland to 12% in Italy. In Finland 24% of innovative firms engage in collaboration only with domestic partners, and about 33% also collaborate with foreign partners. China and Korea have the smallest share of innovative firms collaborating with foreign partners.

Source: OECD, Innovation microdata project based on CIS-2006, June 2009 and national data sources. See chapter notes.

StatLink http://dx.doi.org/10.1787/834841687576

Collaboration on innovation, 2004-06

As a percentage of innovative firms by R&D status



How to read this figure

In Chile, 74% of innovative firms in the top 25% of R&D performers (firms with the highest ratio of R&D spending/sales) have some form of collaboration, 60% of the other R&D performers collaborate, and 35% of innovative firms that do not perform any R&D still engage in collaboration.

Source: OECD, Innovation microdata project based on CIS-2006, June 2009 and national data sources. See chapter notes.

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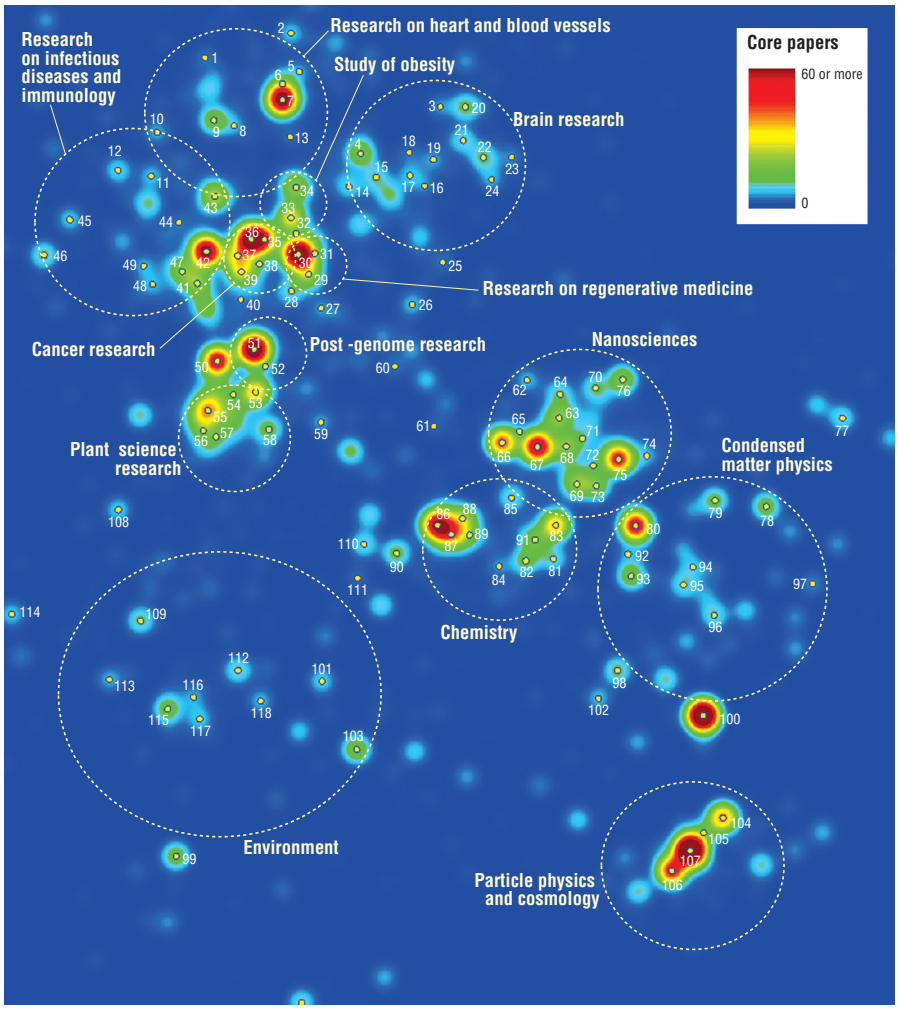
CONVERGENCE OF SCIENTIFIC FIELDS

Increasingly, innovations are achieved through the convergence of scientific fields and technologies. The interaction of research disciplines may also lead to new research areas. For example, "nanoscience" research has arisen from the interaction of physics and chemistry and is interdisciplinary in character. "Nanoscience" is also somewhat attracted to the life sciences, both directly and indirectly, as measured by co-citation links. While interactions between nanoscience and life sciences are not yet strong enough to establish a research domain, the space between them may become the ground for a new area, e.g. bio-nanoscience.

Hot research areas on a science map, 2008



Note: The yellow dots indicate the location of hot research areas. The numbers next to the yellow dots are the hot research areas' ID numbers. Gradations on the map correspond to the density of core papers. Warm colours represent greater concentrations of core papers, with colours becoming cooler as the density of core papers decreases.

What is a hot research area?

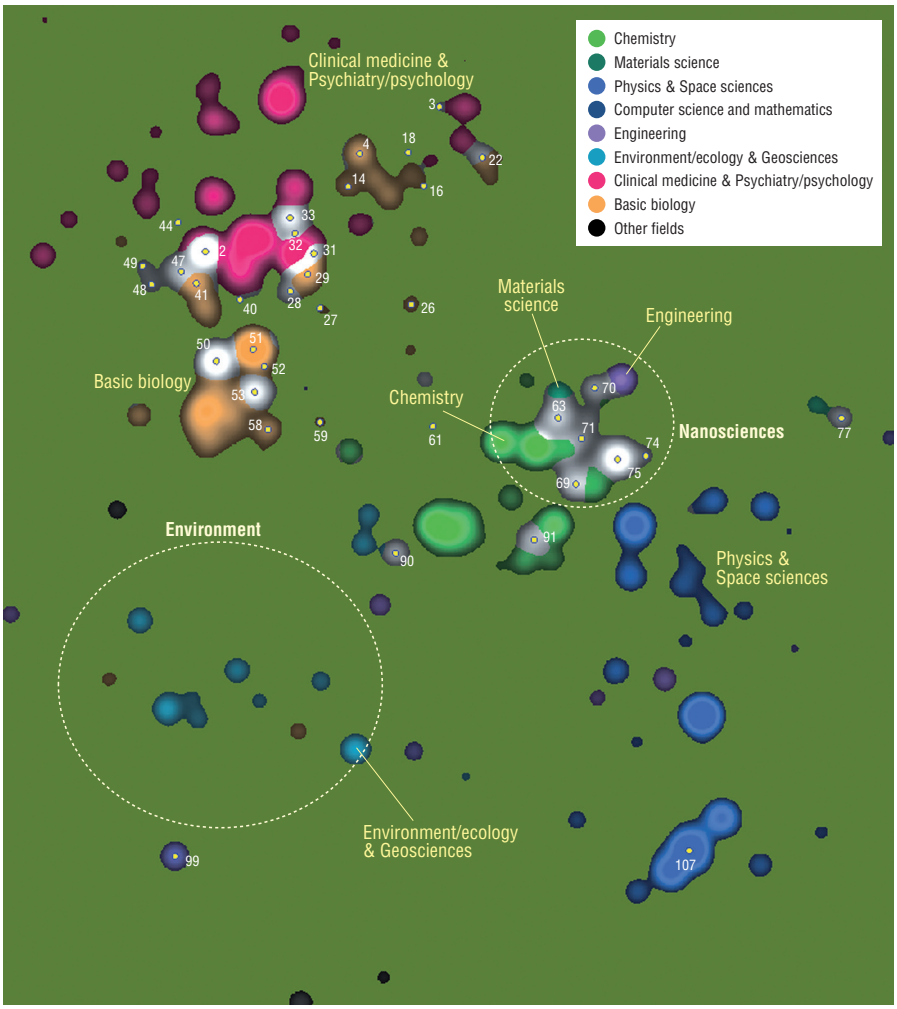
Knowledge creation and flows in cutting-edge research are transmitted through the exchange of information among researchers. Citation of scientific papers is one source of knowledge flows. Analysis of citations and the identification of core papers – those that play a central role in research areas – make it possible to examine research areas and the relations among them. Research areas are identified here via a two-stage clustering of the top 1% of highly cited research papers by using "co-citation" analysis. Co-citation involves a set of papers that is cited simultaneously in other papers. "Hot" research areas are characterised by a high level of citation activity.

Source: Saka, A., M. Igami and T. Kuwahara (2010), based on tabulations from Thomson Reuters' "Essential Science Indicators".

MULTIDISCIPLINARY AND INTERDISCIPLINARY RESEARCH

Science maps are helpful for distinguishing multidisciplinary research, e.g. environmental research, from interdisciplinary research, e.g. nanoscience. In the figure, research areas related to nanoscience stake out a clear domain between chemical synthesis and physics, while research areas related to the environment are spread out. Interdisciplinary research that relies on shared knowledge is created when fields such as physics and chemistry interact. Nanoscience typifies this phenomenon. In multidisciplinary research, various disciplines address scientific and social challenges independently rather than in collaboration and thus share research goals. Environmental research is of this type.

Locations of inter/multidisciplinary research areas on the science map, 2008



Note: Locations in which at least 60% of core papers in a given field are found have the colour corresponding to that field. Locations in which less than 60% of a given field's core papers are found are considered inter/multidisciplinary and do not carry a field colour. The yellow dots represent the locations of inter/multidisciplinary research areas.

How to read the science map

The science map can be regarded as a two-dimensional aerial map showing the accumulation of core papers and the formation of mountains of science. The unit of visualisation is research areas. Hot research areas are mountains that exceed a certain elevation. Research areas with a high degree of co-citation are located close together. For the science map, 647 research areas were obtained by clustering research papers. Because it would be difficult to show all 647 research areas, only hot research areas are shown.

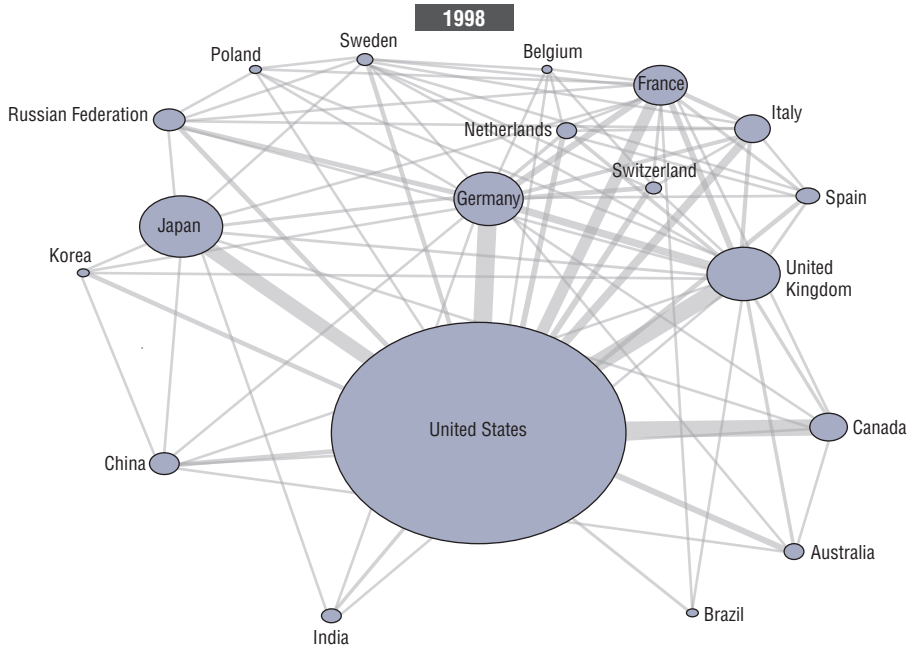
Source: Saka, A., M. Igami and T. Kuwahara (2010), based on tabulations from Thomson Reuters' "Essential Science Indicators".

NEW PLAYERS ON THE RESEARCH LANDSCAPE

New players are emerging on the research landscape and collaboration is intensifying.

Scientific articles and co-authorship, 1998 and 2008

Numbers based on whole counts



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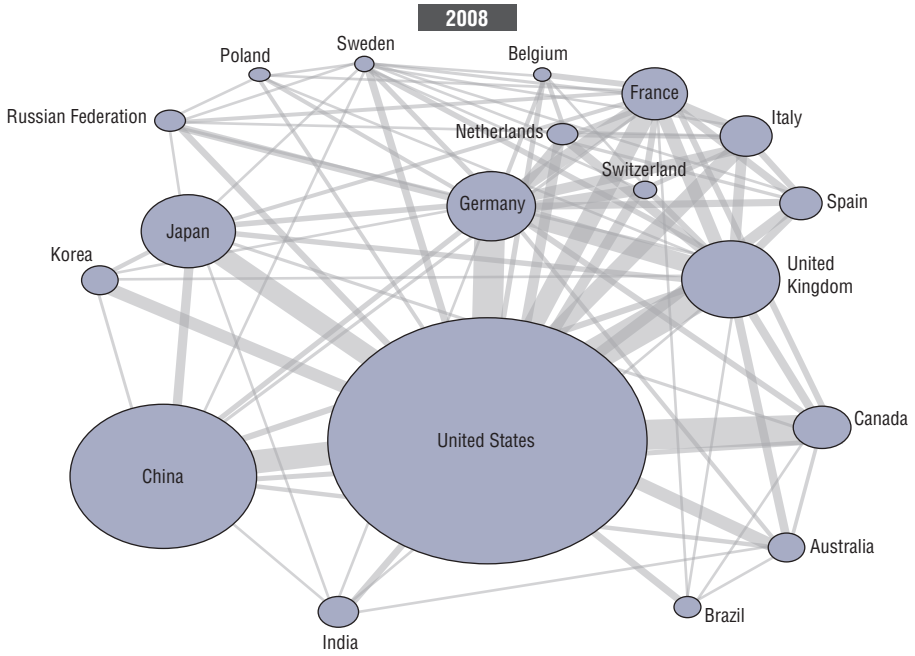


How to read this figure

The size of the bubbles reflects the number of scientific publications and the thickness of the link indicates the intensity of collaboration, *i.e.* co-authorship.

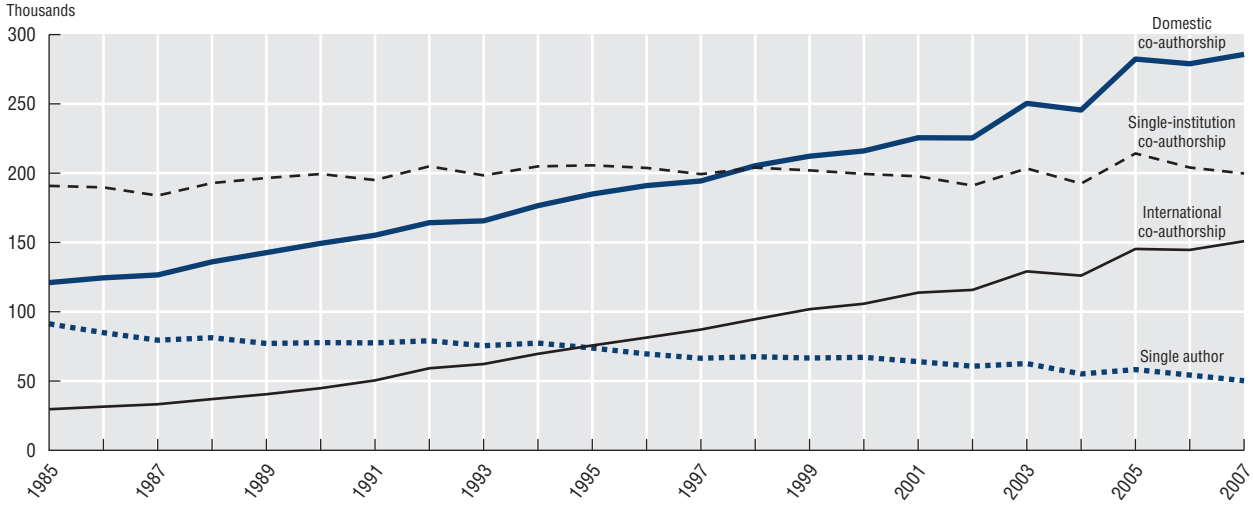
Source: OECD calculations, based on Scopus Custom Data, Elsevier, December 2009. See chapter notes.

StatLink http://dx.doi.org/10.1787/835027386353

INCREASING COLLABORATION IN SCIENCES

Production of scientific knowledge is shifting from individuals to groups, from single to multiple institutions, and from national to international. Researchers increasingly network across national and organisational borders. Europe's collaboration in the European research area increases, while the rest of the world reaches out to the BRIC (Brazil, Russian Federation, India and China) countries.

Trends in co-operation on scientific articles, 1985-2007



Source: OECD (2009), *OECD Science, Technology and Industry Scoreboard 2009;* based on Science Citation Index on CD-ROM (1981-2007) provided by Thomson Scientific and analysed by the National Institute of Science and Technology Policy in Japan. See chapter notes.

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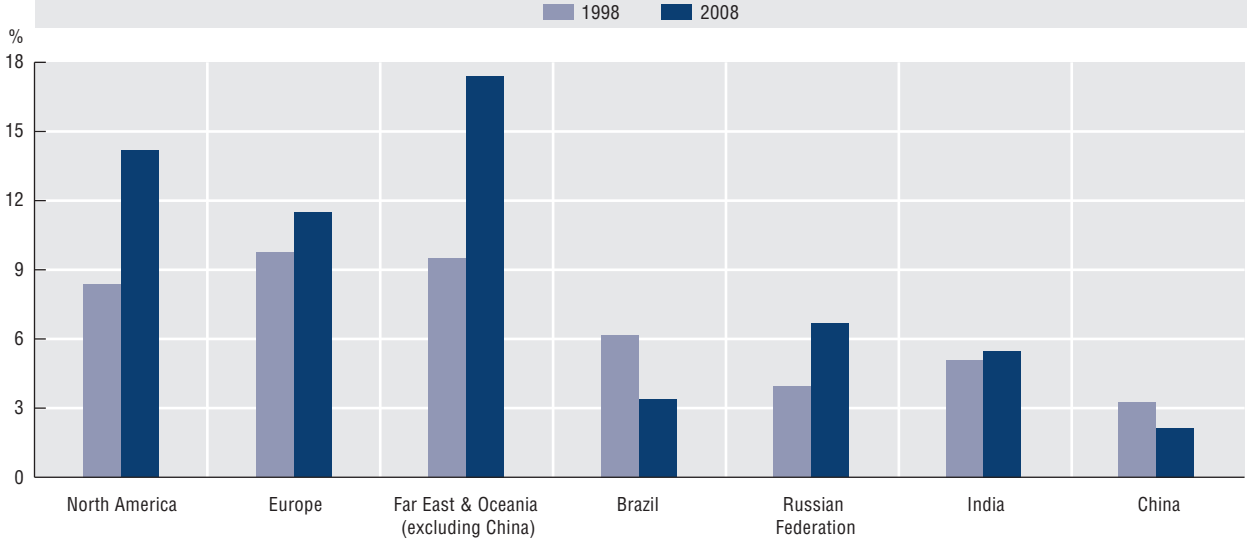
Scientific collaboration with BRIC countries, 1998 and 2008

As a percentage of total international co-authored articles



Source: OECD calculations, based on Scopus Custom Data, Elsevier, December 2009. See chapter notes.

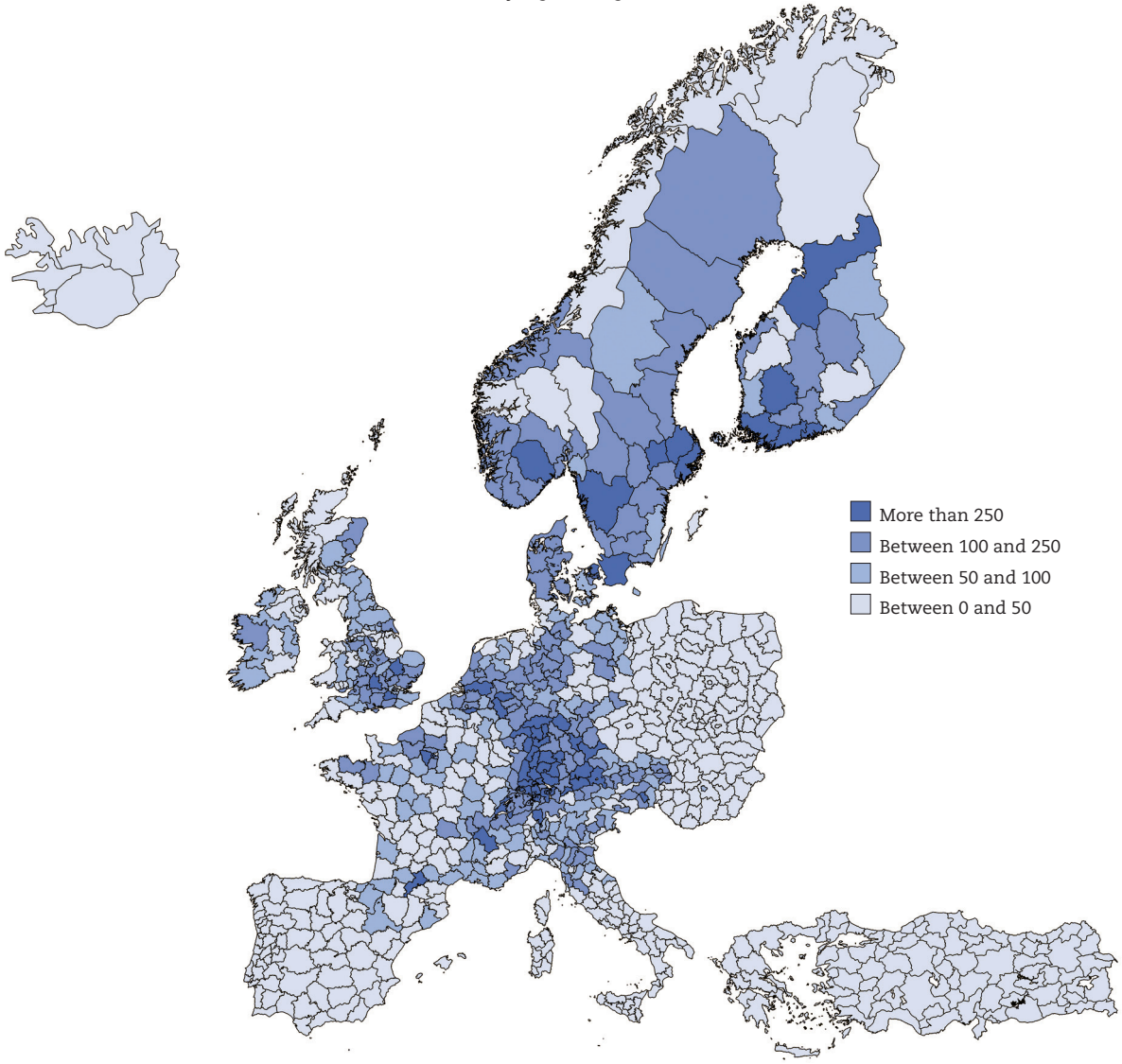
StatLink *http://dx.doi.org/10.1787/835142331125*

CLUSTERS OF KNOWLEDGE

Drivers of economic change, particularly globalisation and technological advances, are not necessarily "flattening" the world economy. While firms can access factors of production from anywhere, local knowledge is still relevant. In the United States, most patent applications come from just a few regions: California contributed more than 22% of patents originating in the United States. In Japan, the Southern-Kanto region accounted for nearly 49% of patent filings.

Patents per million inhabitants, Europe, average 2005-07

PCT filings, TL3 regions



Note: Counts are based on patent applications filed under the Patent Co-operation Treaty (PCT), at international phase, by priority date and inventor's region of residence, using fractional counts. The regional breakdown is provided at Territorial Level 3 (TL3).

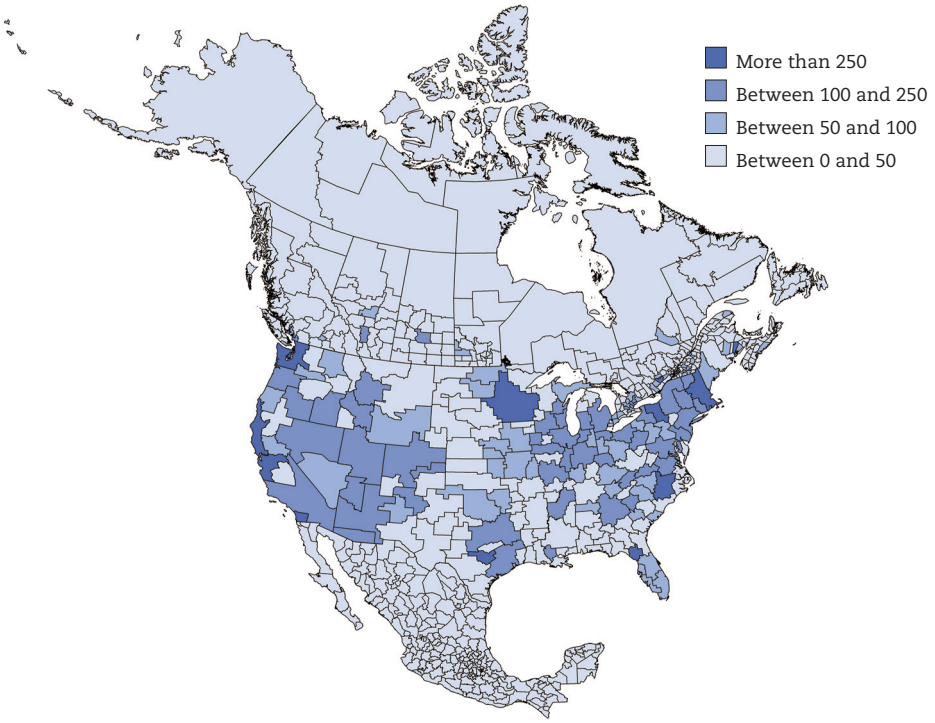
What are TL3 regions?

The OECD has classified regions within each member country. The classification is based on two territorial levels. The higher level (Territorial Level 2 – TL2) consists of 335 large regions; the lower level (Territorial Level 3 – TL3) is composed of 1 681 small regions. All regions are defined within national borders and in most cases correspond to administrative regions. Each TL3 region is contained within a TL2 region (except in Germany and the United States). This classification – which, for European countries, is largely consistent with the Eurostat classification – facilitates comparability between regions at the same territorial level.

Source: REGPAT Database, January 2010; OECD, Regional Database, July 2009.

Patents per million inhabitants, North America, average 2005-07

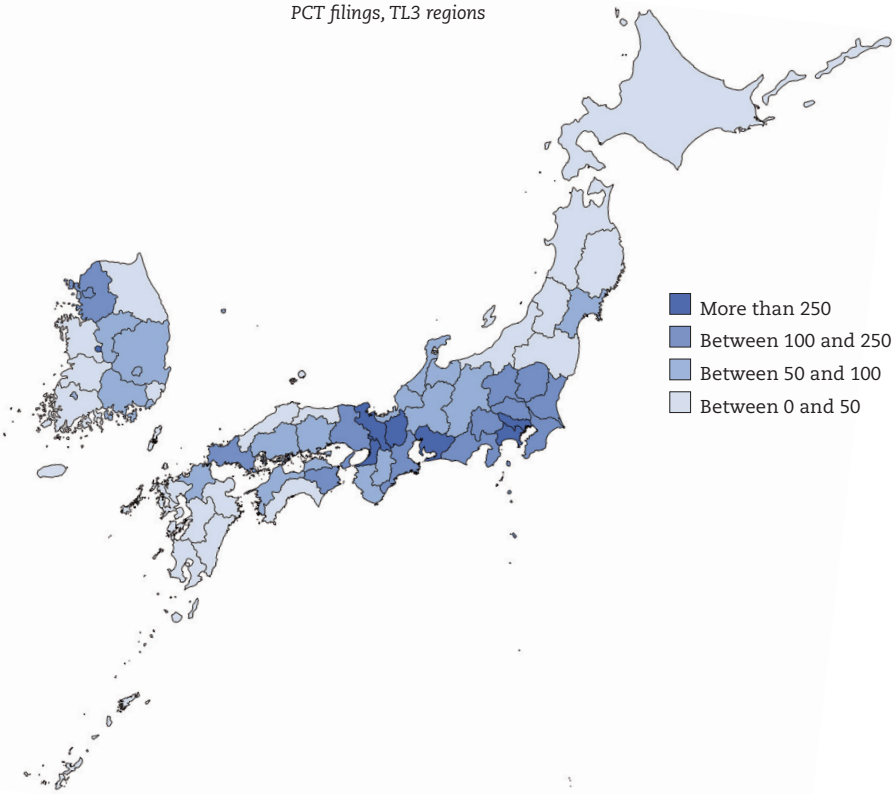
PCT filings, TL3 regions



Source: OECD, REGPAT Database, January 2010; OECD, Regional Database, July 2009.

Patents per million inhabitants, Japan and Korea, average 2005-07

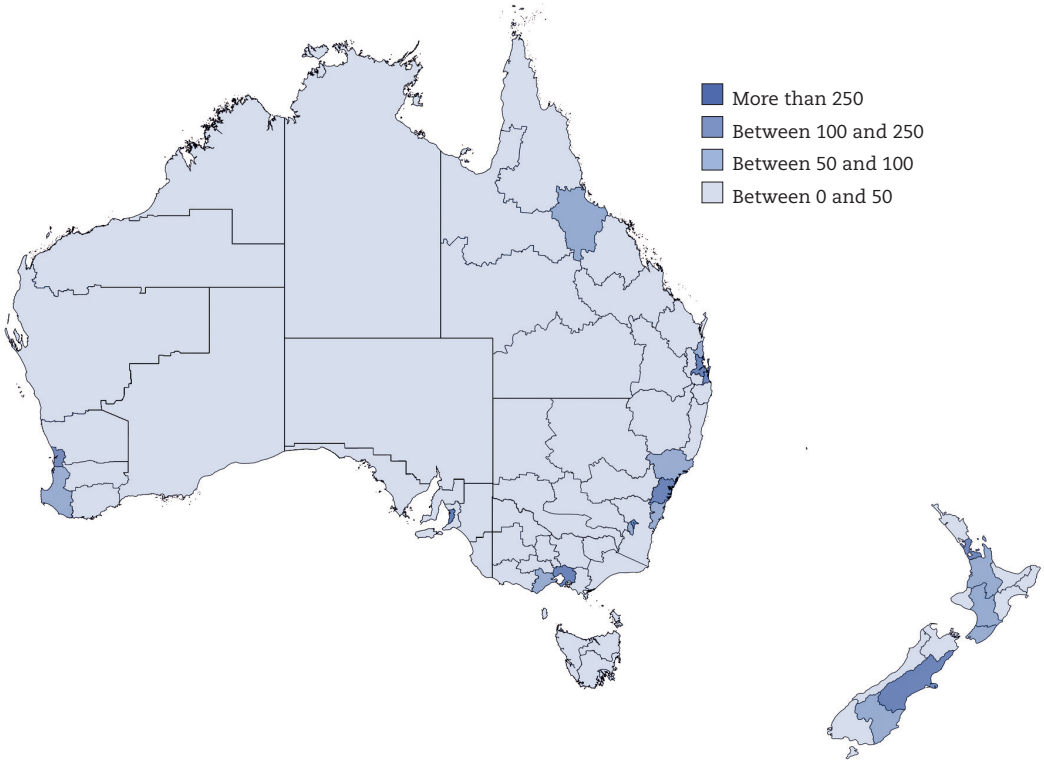
PCT filings, TL3 regions



Source: OECD, REGPAT Database, January 2010; OECD, Regional Database, July 2009.

Patents per million inhabitants, Australia and New Zealand, average 2005-07

PCT filings, TL3 regions



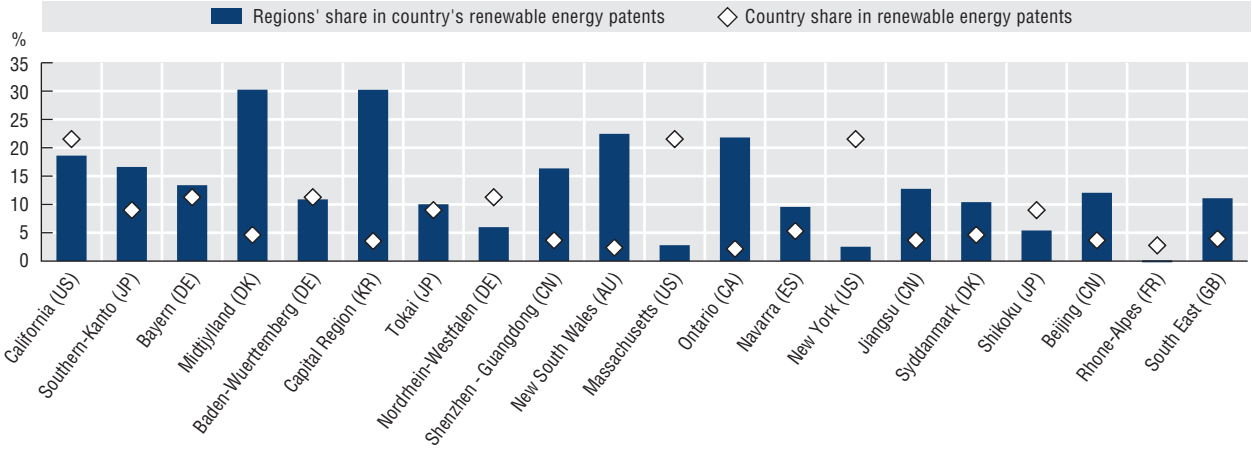
Source: OECD, REGPAT Database, January 2010; OECD, Regional Database, July 2009.

REGIONAL INNOVATION HOT SPOTS

Many of the leading firms in knowledge-intensive industries, such as information and communication technology and life sciences, have emerged in a limited number of regions. Such regions appear to provide more conducive environments for business innovation. Policy makers in other regions seek to replicate or nurture the positive environmental conditions offered by the best-performing regions.

Innovation hot spots in renewable energy, 2005-07

Patents of the world's top 20 patenting regions as a percentage of the country's renewable energy patents

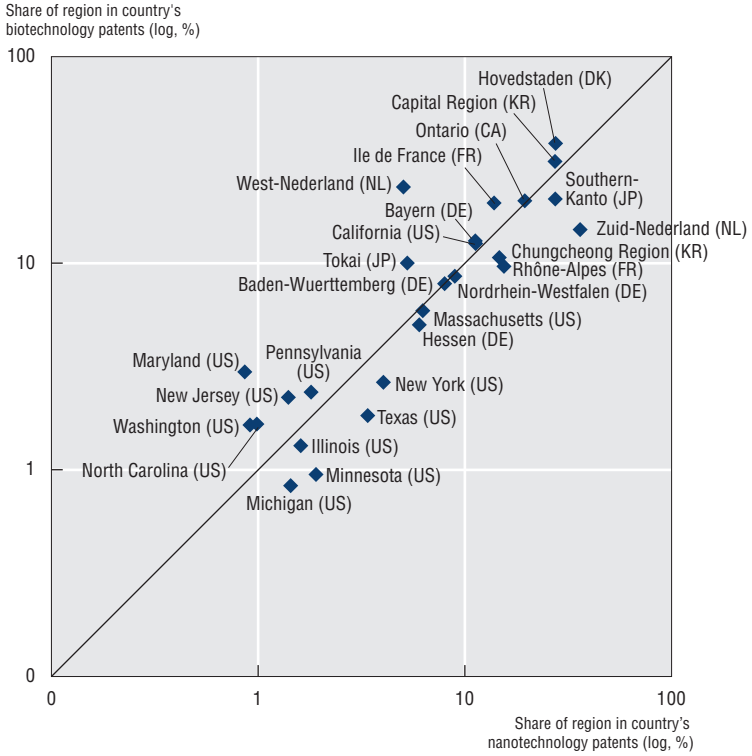


Source: OECD, REGPAT Database, January 2010. See chapter notes.

StatLink http://dx.doi.org/10.1787/835177142766

Innovation hot spots in biotechnologies and nanotechnologies, 2005-07

Top 26 patenting regions as a percentage of the country's biotechnology and nanotechnology patents



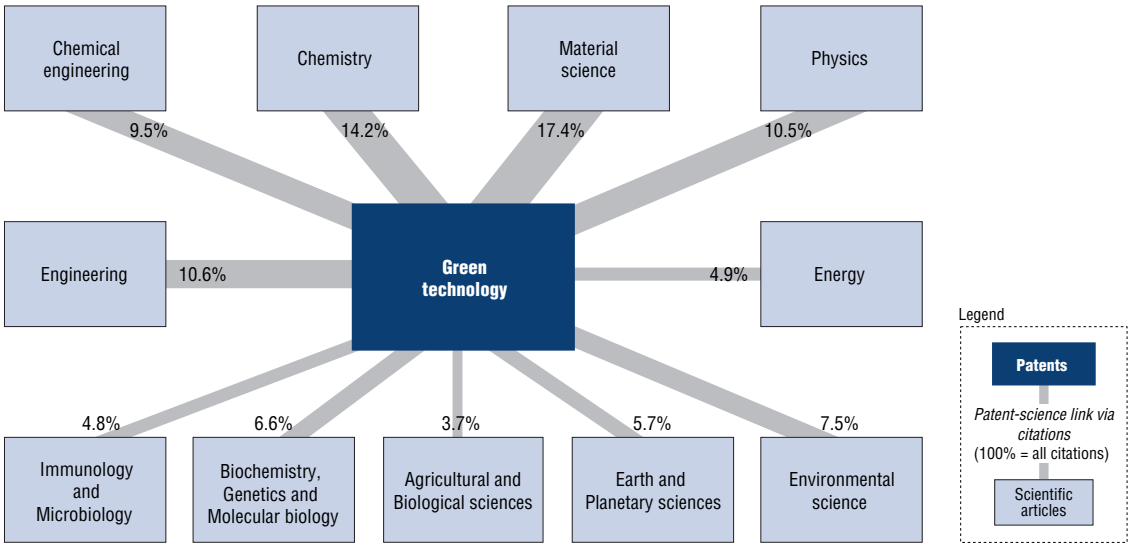
Source: OECD, REGPAT Database, January 2010. See chapter notes.

StatLink http://dx.doi.org/10.1787/835210411417

SCIENCE FOR "GREEN" INNOVATION

What are the links between innovation and the science base? A new indicator uses co-citation analysis and matches environmental patents and scientific publications. It shows that "green" innovations (patents) draw on a broad base of scientific knowledge.

The innovation-science link in "green" technologies, 2000-07



How to read this figure

Environmental technologies draw on scientific knowledge from material science (17.4%), chemistry (14.2%), physics (10.5%), etc. The co-citation links in the figure do not sum to 100% because a residual category "other fields" is not shown.

What is a "green" technology?

The list of environmental patent applications was generated through a new search algorithm developed by the OECD and the European Patent Office (EPO). Fields covered include: renewable energy; fuel cells and energy storage; alternative-fuelled vehicles; energy efficiency in the electricity, manufacturing and building sectors; and "clean" coal (including carbon capture and storage).

What is a patent-science link?

Analysis of the link between patents and scientific literature is based on the "non-patent literature" (NPL) listed as relevant references in patent documents. The NPL was matched with the scientific literature database (Scopus) which makes it possible to determine whether or not the NPL is a scientific article and to obtain bibliographical information unrecorded in the NPL.

Source: OECD calculations, based on Scopus Custom Data, Elsevier, July 2009; OECD, Patent Database, January 2010; and EPO, Worldwide Patent Statistical Database, September 2009.

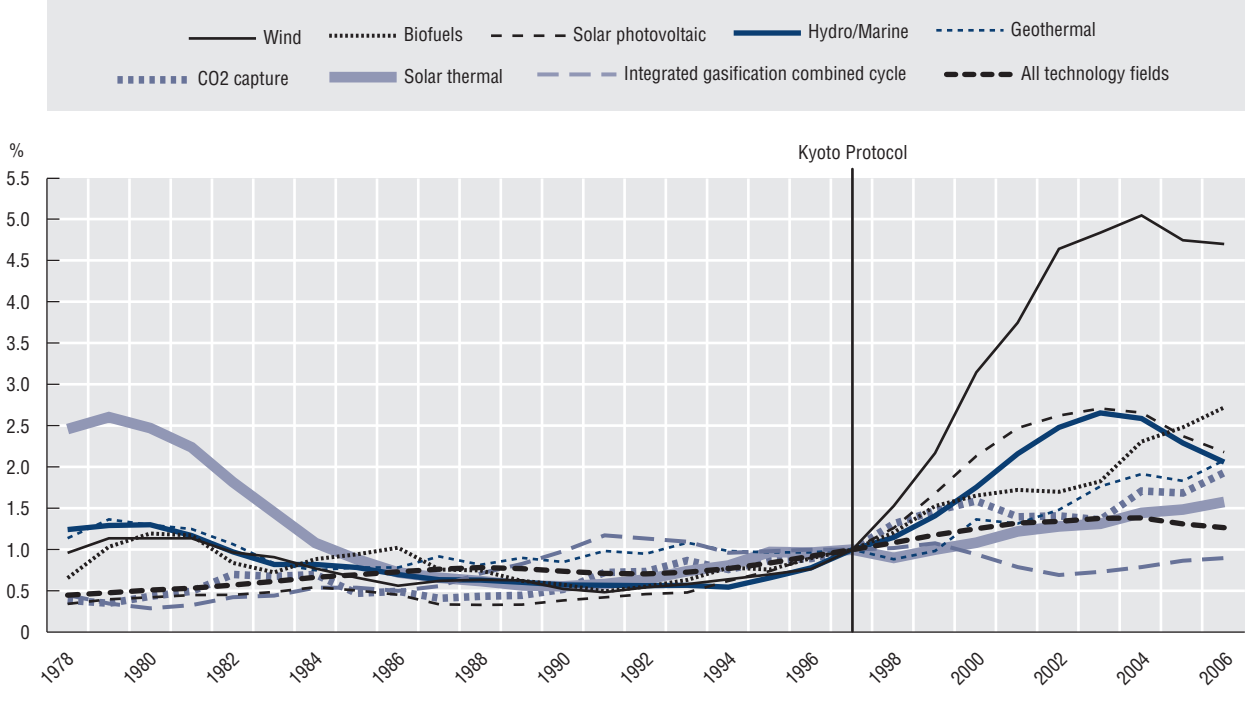
StatLink http://dx.doi.org/10.1787/835220245863

THE CLIMATE CHALLENGE

Despite limited progress in Copenhagen, investment in technological innovation for climate change mitigation is likely to increase as many OECD countries implement binding national policies. However, reaching agreement on emission cuts at the international level would certainly provide a significant spur to innovation.

Trends in technological innovation for climate change mitigation, 1978-2006

"Claimed priorities" (patent counts) in climate mitigation technologies worldwide (three-year moving average, indexed on 1997 = 1.0, Annex I signatories)



Source: OECD calculations based on EPO, Worldwide Patent Statistical Database, September 2009. See chapter notes.

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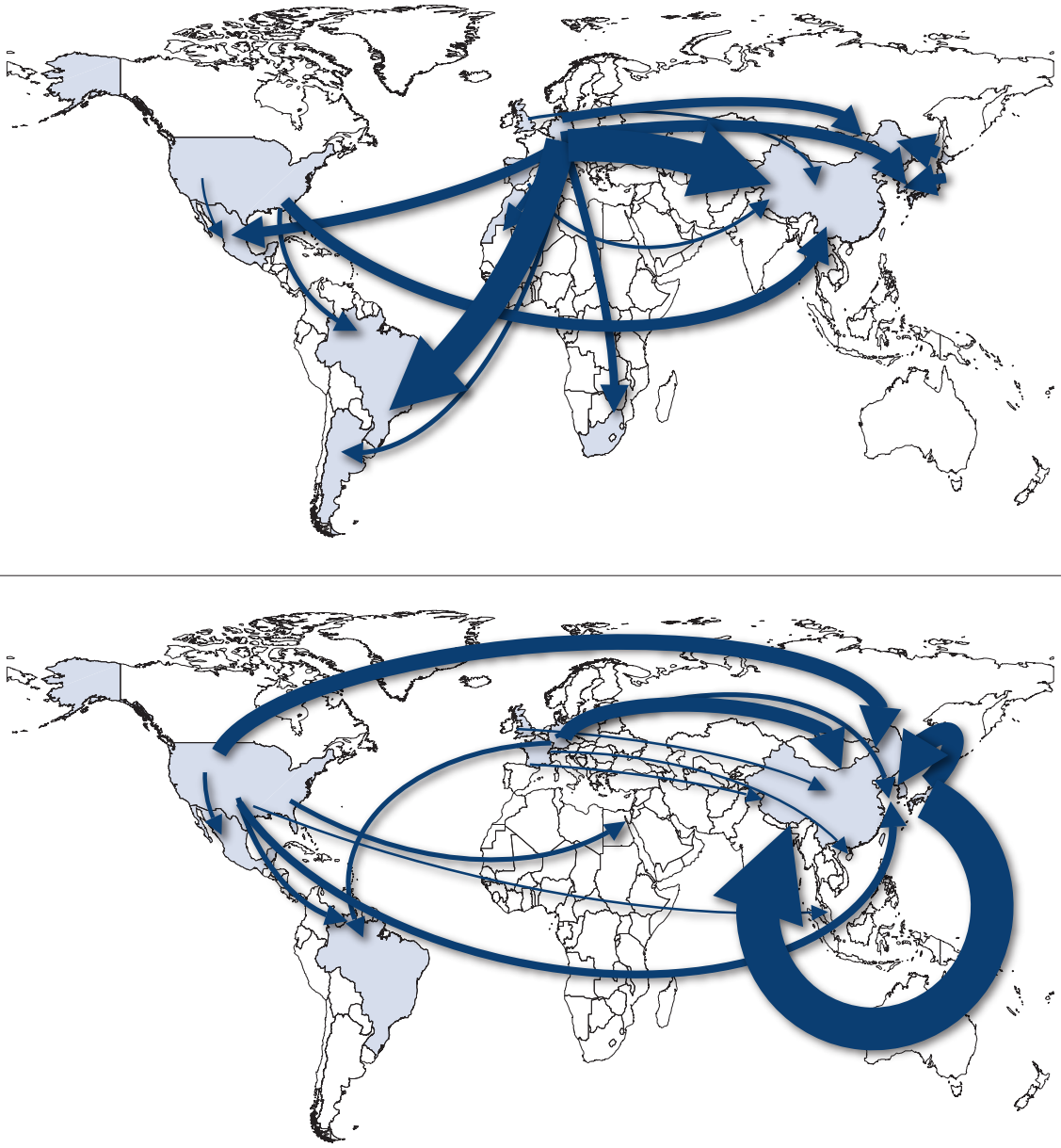
TECHNOLOGY TRANSFERS FOR THE ENVIRONMENT

Innovation mostly occurs in OECD countries, but some transfer to developing countries will be needed to address environmental problems.

Transfer of wind (top) and solar photovoltaic (bottom) technologies, 1990-2007

Transfers from Annex I to non-Annex I signatories, measured using duplicate patent applications



How to read this figure

The figures present data on the extent of transfer (measured in terms of duplicate patent applications) from Annex I to non-Annex I signatories of Kyoto Protocol for two key technologies – wind power and solar photovoltaics. The direction and thickness of the arrows reflect the relation between the country in which a patent application was first filed and subsequent duplicate filings in other countries. Patenting is costly in terms of the preparation of the application and the administrative costs and fees associated with the approval procedure. As such, inventors are unlikely to apply for patent protection in a second (or "duplicate") country unless they are relatively certain of the potential market for the technology in that country. On this basis it is possible to see how widely innovations are diffused in the global economy and learn which countries are the sources and recipients of such innovations. See *www.oecd.org/environment/innovation*.

Source: OECD (forthcoming), *The Invention and Transfer of Environmental Technologies*, OECD, Paris.

Notes

Cyprus

The following note is included at the request of 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 recognizes 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 »".

The following note is included at the request of all the European Union Member States of the OECD and the European Commission:

"The Republic of Cyprus is recognized 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".

Israel

"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."

"It should be noted that statistical data on Israeli patents and trademarks are supplied by the patent and trademark offices of the relevant countries."

Decomposition of growth in GDP per capita, 2001-08

- Based on GDP in USD, constant prices, converted using 2000 PPPs.

Labour productivity growth: adding the contribution of intangible assets, 1995-2006

- Estimates refer to the total economy for Canada and Japan; the market sector for Australia, France, Germany, Italy, Spain, Sweden and the United Kingdom; the non-financial business sector for Finland; and the non-farm business sector for the United States.
- Japanese estimates do not take account of the contribution of labour quality.
- Data for the United States from Corrado, C., D. Sichel and C. Hulten (2009), data for Sweden from Edquist H. (2009); data for Japan from Fukao K., T. Miyagawa, K. Mukai, Y. Shinoda and K. Tonogi (2009); data for Australia from Barnes P. and A. Mc Clure (2009); data for the United Kingdom from Marrano G. M, J.E. Haskel and G. Wallis (2009); data for Austria, the Czech Republic, Denmark, France, Germany, Greece, Italy, Spain and the Slovak Republic from Van Ark B. , J. X. Hao, C. Corrado and C. Hulten (2009).

Investment in fixed and intangible assets as a share of GDP, 2006

- Estimates refer to the total economy for Canada and Japan; the market sector for Australia, France, Germany, Italy, Spain, Sweden and the United Kingdom; the non-financial business sector for Finland; and the non-farm business sector for the United States.
- Data on intangible assets for the United States provided by C. Corrado; data for Japan provided by T. Miyagawa; data for Sweden provided by H. Edquist; data for Germany, Italy, Spain and the United Kingdom provided by J. Haskel, A. Pesole and members of the COINVEST project; data for Austria, Denmark and the Czech Republic provided by J. Hao and B. van Ark; data on intangible and tangible investment for Australia provided by P. Barnes; for Canada by N. Belhocine. Data on tangible investment for France are based on INSEE data. For other countries figures for tangible investment are OECD calculations based on EU KLEMS Database and OECD, Annual National Accounts Database.

New-to-market product innovators, 2004-06

- For Spain, R&D activity refers to 2006 only.
- The industries included are: Mining and quarrying; Manufacturing; Electricity, gas and water; Wholesale trade; Transport and storage; Communications; Financial intermediation; Computer and related activities; Architectural and engineering activities; and Technical testing and analysis.
- For Australia (2006-07), Business Characteristics Survey 2006-07; Canada (2002-04, manufacturing), Survey of Innovation 2005; Iceland (2002-04), CIS-4; Japan (1999-2001), J-NIS 2003; Korea (2005-07, manufacturing), Korean Innovation Survey 2008; Mexico (2006-07), Research and Technological Development Survey 2008; New Zealand (2006-07), Business Operations Survey 2007; South Africa (2002-04), South African Innovation Survey 2005.

Source: OECD, Working Party of National Experts in Science and Technology (NESTI) Innovation microdata project based on CIS-2006, June 2009 and national data sources.

Patents and trademarks per capita, 2005-07

- Triadic patent families refer to patents filed at the European Patent Office (EPO), the US Patent and Trademark Office (USPTO) and the Japan Patent Office (JPO) that protect the same invention. Counts are presented according to the priority date and the residence of the inventors.
- Cross-border trademark counts correspond to the number of applications filed at USPTO except for Australia, Canada, Mexico, New Zealand and the United States. For these countries counts are based on the Office for Harmonization in the Internal Market (OHIM), German PTO and JPO distributions.

Service-related trademarks, 2008

- Service-related trademarks correspond to the applications designating at least one service class.
- The country is the country of the applicant's address.
- The shares of services correspond to the applications at USPTO, except for the United States for which applications at OHIM are used.
- Trademarks are registered at the national level in patent and trademark offices. It is also possible to register a Community trademark valid throughout the European Community at OHIM. Trademarks are registered for one or several classes of products, the fees increasing with the number of classes designated. The International Classification of Goods and Services for the purposes of registration of marks contains 34 good and 11 service classes. Trademarks can cover only goods, only services, or a combination of the two.

Comparing cycles: United States gross domestic product and trademark applications at the USPTO, 1999-2010

- Good (respectively service) trademarks represent trademark applications designating only goods (respectively service) classes; finance, insurance and real estate trademarks represent trademark applications designating class 036 of the International Classification of Goods and Services.
- The United States' GDP is based on the series of seasonally adjusted GDP, expenditure approach, in volume (chained volume estimates) contained in the OECD Quarterly National Accounts dataset.
- Raw GDP and trademark applications series were treated using the OECD's Composite Leading Indicators methodology. Monthly data were used for trademark applications and quarterly data for GDP, converted to a monthly frequency via linear interpolation and aligned with the mid-quarter month. This treatment removes seasonal patterns and trends (using the Hodrick-Prescott filter) in order to extract the cyclical pattern. The cyclical pattern presented on the graph is expressed as a percentage deviation from long-term trends. Considering the filters applied, the remaining cycles are those with a period of between 18 months and 10 years. The analysis was performed on series from January 1990 to March 2010 for trademark applications and to December 2009 for GDP. For more information on the methodology, see OECD (2008), *OECD System of Composite Leading Indicators*, OECD, Paris, *www.oecd.org/dataoecd/26/39/41629509.pdf*.
- Trademark series are pro-cyclical, and trademark cycles generally precede GDP cycles (from 1990, five out of seven GDP peaks and troughs were reflected in trademark series, with a mean lead of around six months for service trademarks and eight months for goods trademarks). Trademarks, especially service trademarks, tend to be more significantly affected by the cycle than GDP.
- There is an additional peak for the trademark series which does not correspond to the economic activity around 2004. It corresponds to the accession of the United States to the Madrid Agreement in November 2003, which facilitated the filing procedure for foreign applications.

Complementary innovation strategies in manufacturing, 2004-06

- For Australia (2006-07), Business Characteristics Survey 2006-07; Canada (2002-04, manufacturing), Survey of Innovation 2005; Iceland (2002-04), CIS-4; Japan (1999-2001), J-NIS 2003; Korea (2005-07, manufacturing), Korean Innovation Survey 2008; New Zealand (2006-07), Business Operations Survey 2007; South Africa (2002-04), South African Innovation Survey 2005.

Source: OECD, Working Party of National Experts in Science and Technology (NESTI) Innovation microdata project based on CIS-2006, June 2009 and national data sources.

Complementary innovation strategies in services, 2004-06

- The industries included are: Wholesale trade; Transport and storage; Communications; Financial intermediation; Computer and related activities; Architectural and engineering activities; and Technical testing and analysis.
- For Australia (2006-07), Business Characteristics Survey 2006-07; Iceland (2002-04), CIS-4; Japan (1999-2001), J-NIS 2003; New Zealand (2006-07), Business Operations Survey 2007; South Africa (2002-04), South African Innovation Survey 2005.

Source: OECD, Working Party of National Experts in Science and Technology (NESTI) Innovation microdata project based on CIS-2006, June 2009 and national data sources.

Firms with national/international collaboration on innovation, 2004-06

- The industries included are: Mining and quarrying; Manufacturing; Electricity, gas and water; Wholesale trade; Transport and storage; Communications; Financial intermediation; Computer and related activities; Architectural and engineering activities; and Technical testing and analysis.
- For Australia (2006-07), Business Characteristics Survey 2006-07; Canada (2002-04, manufacturing), Survey of Innovation 2005; Iceland (2002-04), CIS-4; Japan (1999-2001), J-NIS 2003; Korea (2005-07, manufacturing), Korean Innovation Survey 2008; New Zealand (2006-07), Business Operations Survey 2007; South Africa (2002-04), South African Innovation Survey 2005.

Source: OECD, Working Party of National Experts in Science and Technology (NESTI) Innovation microdata project based on CIS-2006, June 2009 and national data sources.

Collaboration on innovation, 2004-06

- For Spain, R&D activity refers to the year 2006 only.
- The industries included are: Mining and quarrying; Manufacturing; Electricity, gas and water; Wholesale trade; Transport and storage; Communications; Financial intermediation; Computer and related activities; Architectural and engineering activities; and Technical testing and analysis.
- For Australia (2006-07), Business Characteristics Survey 2006-07; Canada (2002-04, manufacturing), Survey of Innovation 2005; Iceland (2002-04), CIS-4; Japan (1999-2001), J-NIS 2003; Korea (2005-07, manufacturing), Korean Innovation Survey 2008; New Zealand (2006-07), Business Operations Survey 2007; South Africa (2002-04), South African Innovation Survey 2005.

Source: OECD, Working Party of National Experts in Science and Technology (NESTI) Innovation microdata project based on CIS-2006, June 2009 and national data sources.

Scientific articles and co-authorship, 1998 and 2008

- When articles (or patents) have multiple authors (or inventors) from different countries, these articles (patents) are either partly attributed to each country mentioned (fractional count) or fully attributed to every relevant country (simple count), thus generating multiple counting at an aggregate level. In general, fractional counting procedures are used to compute counts by countries, but the alternative is sometimes preferable, as with indicators on international co-operation.

Trends in co-operation on scientific articles, 1985-2007

- The data are based on research articles in natural and medical sciences and engineering.

Scientific collaboration with BRIC countries, 1998 and 2008

- Only countries with more than 500 publications, and/or EU27 and OECD countries are tabulated. North America: United States, Canada and Mexico. Europe: Austria, Belarus, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovenia, Slovak Republic, Spain, Sweden, Switzerland, United Kingdom and Ukraine. Far East and Oceania: Australia, Indonesia, Japan, Korea, Malaysia, New Zealand Singapore, and Thailand.

Innovation hot spots in renewable energy, 2005-07

- Data relate to patent applications filed under the Patent Co-operation Treaty (PCT) for renewable energy technologies. Patent counts are based on the priority date, the inventor's region of residence and fractional counts. The regional breakdown used is based on OECD's Territorial Level 2.

Innovation hot spots in biotechnologies and nanotechnologies, 2005-07

- Data relate to patent applications filed under the Patent Co-operation Treaty (PCT) in biotechnology and in nanotechnology. Patent counts are based on the priority date, the inventor's region of residence and fractional counts. The regional breakdown used is based on OECD's Territorial Level 2.

Trends in technological innovation for climate change mitigation, 1978-2006

- Patents in technologies relating to climate change mitigation were identified using search algorithms developed by the OECD and the EPO. See OECD (2009), "Environmental policy framework conditions, innovation and technology transfer", ENV/EPOC/WPNEP(2009)2/FINAL for the methodology.
- Annex I Kyoto Protocol signatories: Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Croatia, the Czech Republic, Denmark, Estonia, the European Union, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Monaco, the Netherlands, New Zealand, Norway, Poland, Portugal, Romania, the Russian Federation, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, the United Kingdom and the United States.

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Chapter 2

EMPOWERING PEOPLE TO INNOVATE

People are at the heart of the innovation process. A first set of indicators focuses on the role education systems play in building competencies for innovation and on how this human capital is actually deployed on the labour market. These indicators position countries with respect to the performance of students from a young age and throughout the educational system, with a special focus on those with scientific skills, science and engineering degrees and doctoral holders, who are specifically trained for research. Additional indicators look beyond the education systems to labour market outcomes and skills mismatches. These indicators are only a selection of the very rich set of OECD indicators of performance and policy levers in the area of education and employment.

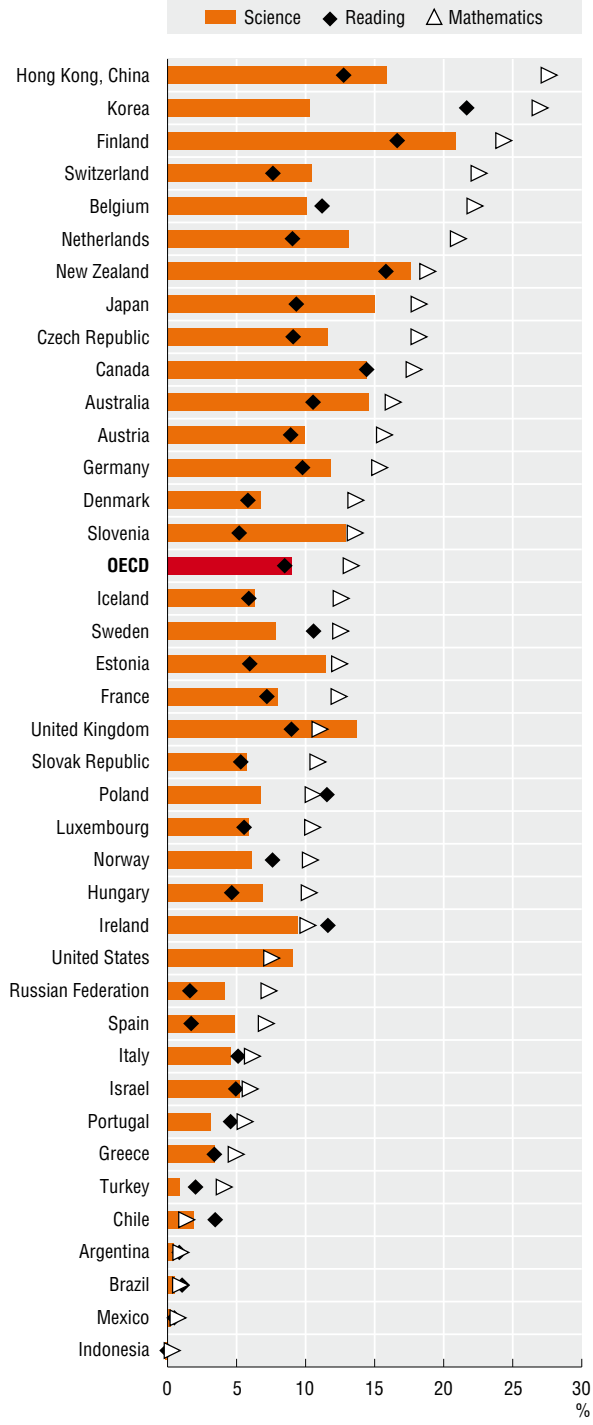
Enabling people throughout the economy and society to participate in innovation will provide new ideas, knowledge and capabilities, and enhance the influence of market demand on innovation. A second set of indicators tries to deal with dimensions which are much harder to measure: the mobility of students and workers (and the tacit knowledge they bring with them); entrepreneurial talent (something that is hard to measure but is often considered critical for turning ideas into value); the role of consumers in innovation (as they can drive demand for specific technologies and create markets large enough for innovations to be developed). Here, the indicators selected are imperfect proxies but point to the need for better measurement using surveys of households or individuals. Finally the whole question of how individuals' talents can be tapped and leveraged for innovation cannot be addressed through existing measures. A "Gap page" lays out the need for such metrics, the challenges, and the existing international efforts that go in the direction of addressing these gaps.

2.1 • Basic scientific skills 44
2.2 • Tertiary education 46
2.3 • Doctorate holders 48
2.4 • Skills mismatch 50
2.5 • International mobility 52
2.6 • Entrepreneurial talent 54
2.7 • Gap page – Innovative workplace and skills for innovation 56
2.8 • Consumers' demand for innovation 58

Education systems play a broad role in supporting innovation because knowledge-based societies rely on a highly qualified and flexible labour force in all sectors of the economy and society. Innovation requires the capacity to continually learn and upgrade skills.

Reading, mathematics and science proficiency at age 15, 2006

Percentage of top performers



Source: OECD, PISA 2006 Database.

StatLink http://dx.doi.org/10.1787/835310061550

DID YOU KNOW?

More than half of the 15-year-olds in the OECD countries have used a computer for more than five years, but 12% of students have never used a computer at school.

(OECD, PISA 2006.)

While basic competencies are generally considered important for absorbing new technologies, high-level competencies are critical for the creation of new knowledge and technologies. Emphasis is increasingly placed on capabilities for adapting and combining multidisciplinary knowledge and performing complex problem solving. The acquisition of such skills starts at a very early age.

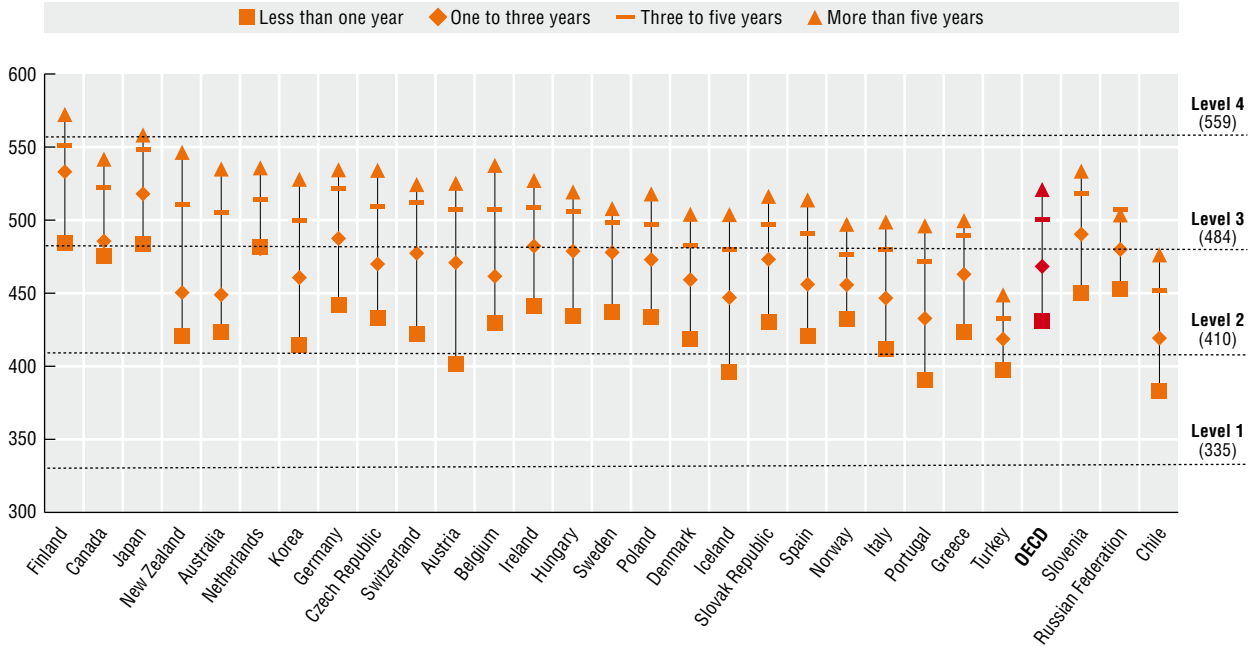
A focus on top-performing students allows for a better understanding of proficiency patterns among 15-year olds. Data from the OECD's Programme for International Student Assessment (PISA) show that in almost all OECD countries, the share of top performers was higher in mathematics than in science and reading. However, the variability in the proportion of top performers across countries suggests differences in countries' potential capacities to staff future knowledge-driven industries with home-grown talent.

Results from PISA 2006 also show an association between how long students have been using computers and their performance in science. On average, 15-year-olds with more than five years of experience with computers raise their average PISA score in science by 90 score points compared to those who have used computers for less than one year. This gap corresponds to more than one proficiency level in the PISA science test.

Definitions

Top performers in science are students proficient at Levels 5 and 6 in the PISA 2006 science assessment (*i.e.* they have obtained scores higher than 633.33 points). The other levels in science performance are: Level 4 (score of 558.7), Level 3 (score of 484.1), Level 2 (score of 409.5) and Level 1 (score of 334.9). *Top performers in reading* are students proficient at Level 5 in the PISA 2006 reading assessment (*i.e.* with scores higher than 625.61). *Top performers in mathematics* are students proficient at Levels 5 and 6 in the PISA 2006 mathematics assessment (*i.e.* with scores higher than 606.99).

Length of time students have been using a computer and mean PISA science score, 2006



How to read this figure

In Finland, 15-year-old students who had more than five years of experience with computers had an average score of 574 points. This is 88 points higher than those who have used a computer for less than a year.

Source: OECD (2010), *Are the New Millennium Learners Making the Grade? Technology Use and Educational Performance in PISA 2006*, OECD, Paris. See chapter notes.

StatLink http://dx.doi.org/10.1787/835310061550

Measurability

The achievement scores are based on assessments administered as part of the Programme for International Student Assessment (PISA) undertaken by the OECD. The most recent available PISA data were collected during the 2006 school year. Around 400 000 students were randomly selected and represented about 20 million 15-year-olds in the schools of the 57 participating countries, including all 30 OECD member countries and 27 partner countries and economies.

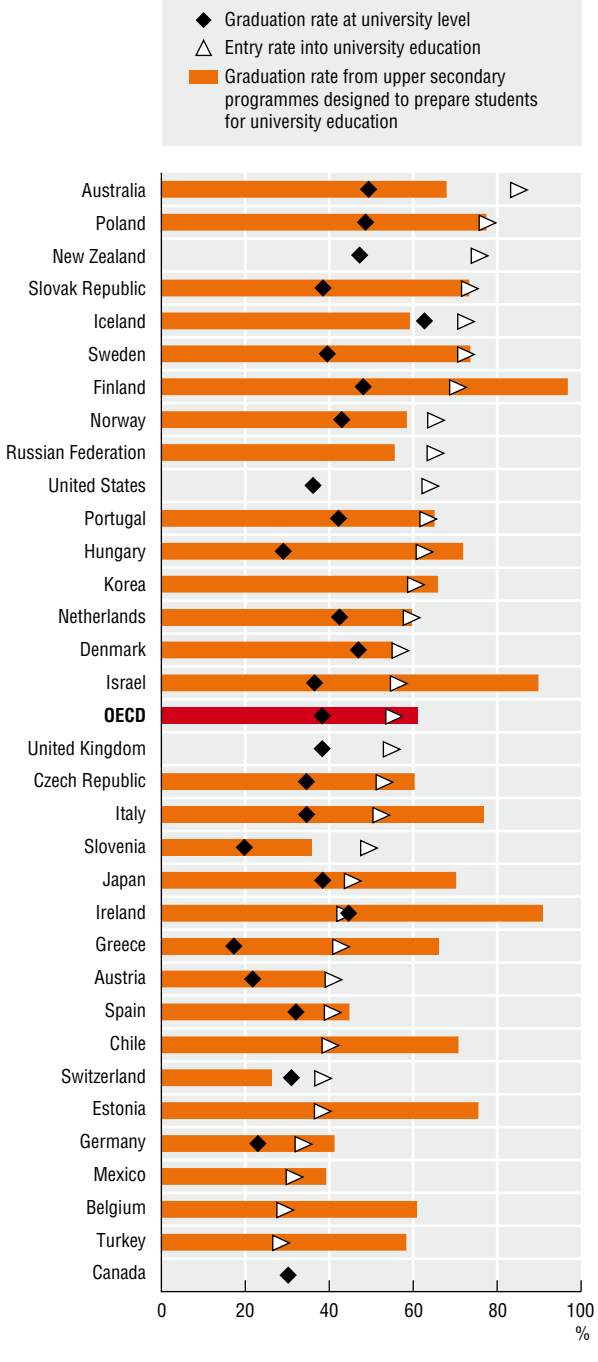
The target population is students aged from 15 years and 3 (completed) months to 16 years and 2 (completed) months at the beginning of the testing period and who were enrolled in an educational institution at the secondary level, irrespective of the grade level or type of institution, and irrespective of whether they participated in school full-time or part-time. Although the main focus of PISA 2006 was science, the survey also covered reading and mathematics. The PISA 2006 survey also, for the first time, sought information on students' attitudes to science by including questions on attitudes within the test itself, rather than only through a complementary questionnaire.

PISA 2006 also gave countries the option to administer a short questionnaire on students' familiarity with information and communication technology (ICT). This questionnaire made it possible to gain more detail on students' access to computers than the main questionnaire. The ICT questionnaire focused on how familiar students were with computers rather than on ICT in general. Students were asked how often they used computers, where and how they learned to use computers and the Internet, and how confident they were in performing certain computer tasks. As a result, a more nuanced picture of students' access to, and use of, ICT can be drawn for the 25 OECD countries and 14 partner countries and economies that completed the ICT questionnaire. To complement the information on ICT, an additional questionnaire was sent to school principals about the use of ICT in their schools and the extent to which a lack of ICT hinders instruction.

High graduation rates at university level indicate a country's capacity to develop a highly skilled labour force. Increasing the number of students who enter and successfully complete a university programme requires efficient and flexible higher education systems. The cost and duration of studies and the lack of bridges between university and work may prompt students to leave their studies before graduation to enter the labour market.

Transition from upper secondary education to graduation at the university level, 2007

Graduation and entry rates



Source: OECD (2009a), *Education at a Glance 2009: OECD Indicators*, OECD, Paris. See chapter notes.

StatLink http://dx.doi.org/10.1787/835354553320

DID YOU KNOW?

In OECD member countries, four out of ten young people are expected to obtain a university degree during their lifetime.

(OECD, *Education at a Glance 2009*.)

Differences between upper secondary and tertiary education graduation/entry rates are due to many factors: the arrival of international students and pathways from vocational programmes inflate university entries, while access restrictions, military service or time spent working deflate entries.

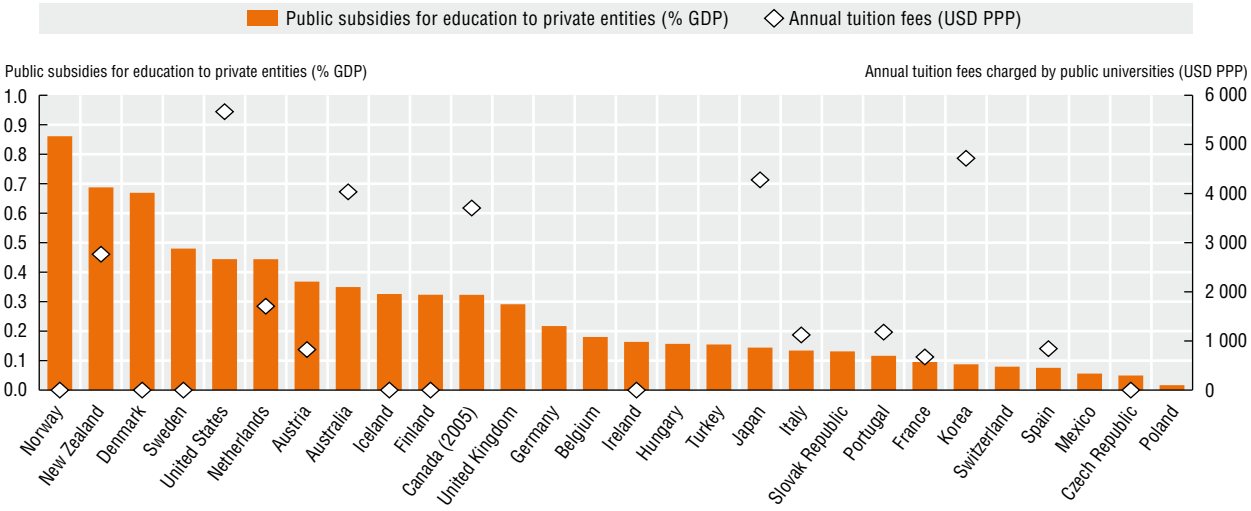
Entry rates are affected by tuition fees. Public subsidies that cover education costs and serve as a substitute for work income may encourage participation in education, particularly among low-income students. Public universities in the Nordic countries do not charge tuition fees, and both the level of public aid and the university entry rate are high.

Overall economic returns are a key driver of individuals' decisions to invest in education beyond compulsory schooling. Very high private returns suggest that education should be expanded by increasing access and making loans more readily available, rather than by lowering the costs of education. Low returns indicate insufficient incentives for individuals to invest in education, either because education is not rewarded in the labour market, or because costs, in terms of tuition fees, foregone earnings and taxation, are relatively high.

Definitions

University education is tertiary-A education. *Graduation rates* are the estimated percentage of an age cohort that will complete the corresponding level of education during their lifetime. *Entry rates* represent the estimated percentage of an age cohort that will enter a university programme for the first time during their lifetime. *Tuition fees* are annual fees charged to students by public tertiary-A institutions. *Public subsidies* to households include grants/scholarships, student loans, family or child allowances contingent on student status, public subsidies in cash or in kind and interest-related subsidies for private loans. The *net present value* approach compares the discounted cash flows of costs (tuition fees and foregone earnings) and benefits (higher levels of earnings) from tertiary education (ISCED 5/6).

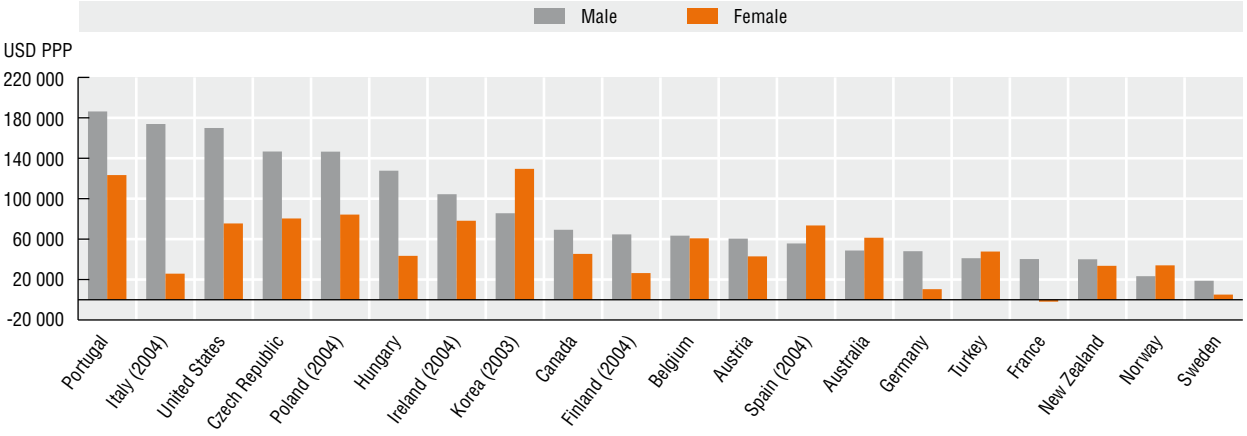
Annual tuition fees charged by public universities and public subsidies to private entities, 2007



Source: OECD (2009a), *Education at a Glance 2009: OECD Indicators*, OECD, Paris. See chapter notes.

StatLink http://dx.doi.org/10.1787/835354553320

Private net present value for an individual obtaining tertiary education as part of initial education, 2005



Source: OECD (2009a), *Education at a Glance 2009: OECD Indicators*, OECD, Paris. See chapter notes.

StatLink http://dx.doi.org/10.1787/835354553320

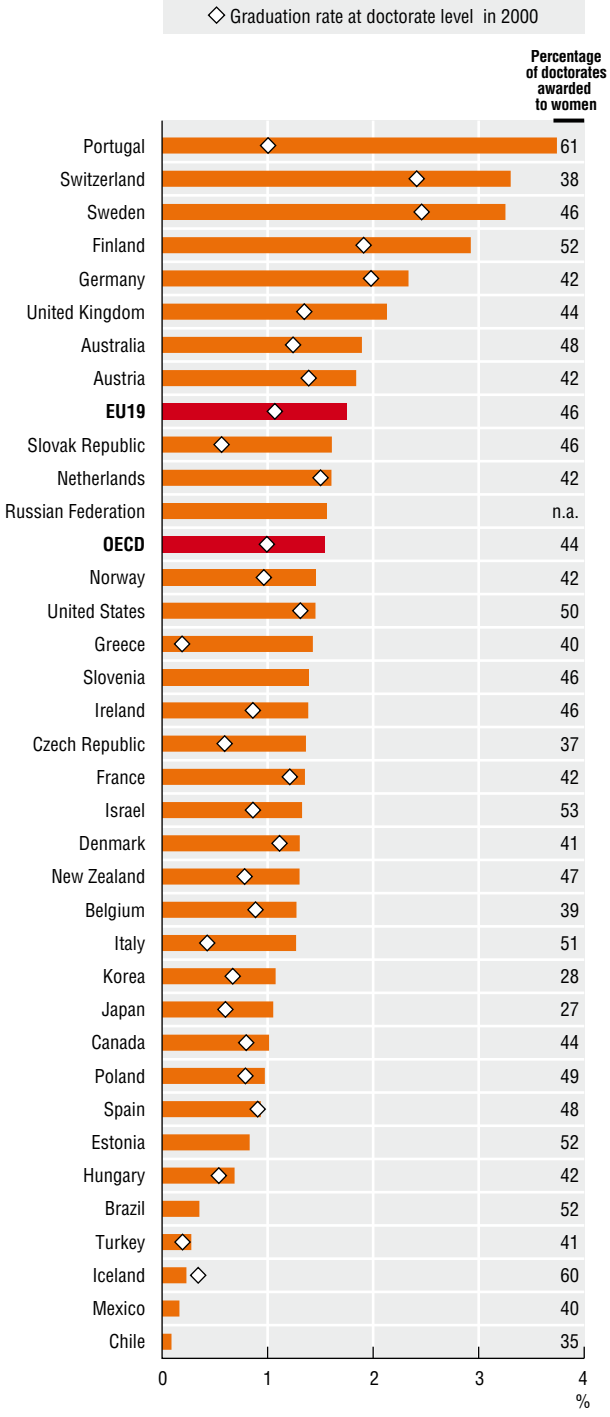
Measurability

In the calculation of private net present value, private investment costs include after-tax foregone earnings adjusted for the probability of finding a job (unemployment rate) and direct private expenditures on education. On the benefit side, the age-earning profiles are used to calculate the earnings differential between different educational groups (below upper secondary education; upper secondary or post-secondary non-tertiary education; and tertiary education). These gross earnings differentials are adjusted for differences in income taxes and social contributions as well as social transfers to arrive at net earnings differentials. The cash flows are further adjusted for the probability of finding a job (unemployment rates). These calculations are done separately for males and females to account for differences in earnings differentials and unemployment rates. From a policy perspective, awareness of economic incentives is crucial to understanding the flow of individuals through the education system. However, developing estimates of returns to education has some broad conceptual limitations and involves a number of restrictive assumptions for international comparability, see Chapter A8 in OECD (2009a), *Education at a Glance 2009: OECD Indicators*, OECD, Paris.

Doctoral graduates have attained the highest education level and are key players in research and innovation. They have been specifically trained to conduct research and are considered the best qualified to create and diffuse knowledge.

Graduation rates at doctorate level, 2007

As a percentage of the relevant age cohort



Source: OECD (2009a), *Education at a Glance 2009: OECD Indicators*, OECD, Paris.

StatLink http://dx.doi.org/10.1787/835355261387

DID YOU KNOW?

In 2007, Brazil, China, India and the Russian Federation, taken together, trained half as many doctoral graduates as OECD countries, taken together.

(OECD Science, Technology and Industry Scoreboard 2009.)

A small but growing proportion of the population obtains an advanced research programme degree. Since 2000, the number of OECD-area doctorates increased by 5% to reach more than 210 000 new doctorate holders in 2007. The higher participation of women at the doctoral level explains in large part the overall increase in doctorates awarded in the last decade.

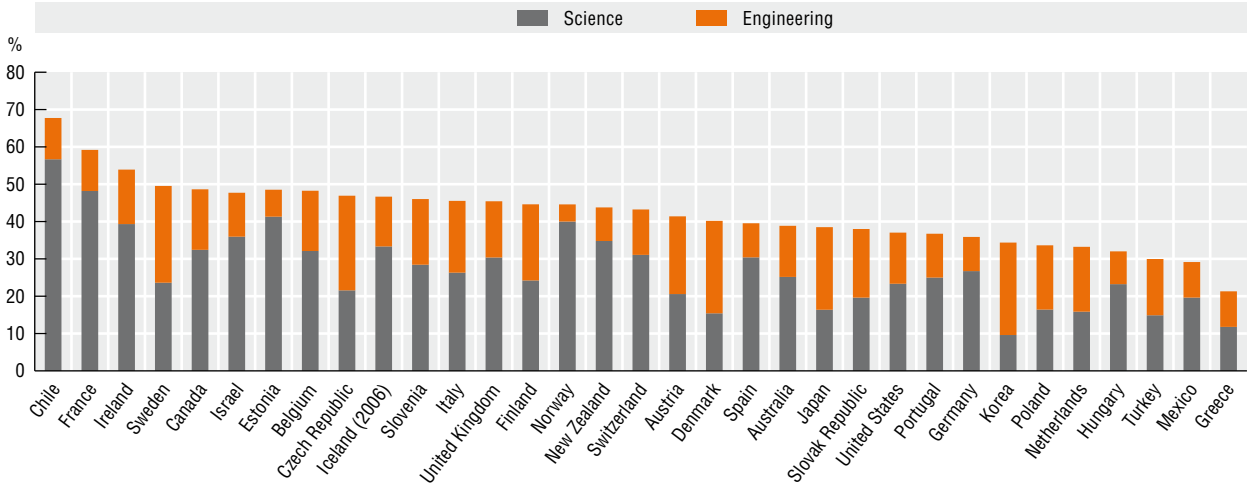
While the absolute number of science and engineering (S&E) doctorates increased significantly in all OECD countries over the last decade, the relative share of S&E doctorates has fallen in several countries. This is a serious concern for many countries given the important role played by science in today's knowledge-based economies.

Definitions

Doctoral graduates have attained the second stage of university education and obtain a degree at ISCED Level 6. They have successfully completed an advanced research programme and gained an advanced research qualification, *e.g.* Ph.D. *Science degrees* include: life sciences; physical sciences; mathematics and statistics; and computing. Engineering degrees comprise: engineering and engineering trades; manufacturing and processing; and architecture and building. *Graduation rates* represent the estimated percentage of an age cohort that will complete the corresponding level of education during their lifetime.

Science and engineering graduates at the doctoral level, 2007

As a percentage of all new degrees at the doctoral level



Source: OECD, Education Database, February 2010.

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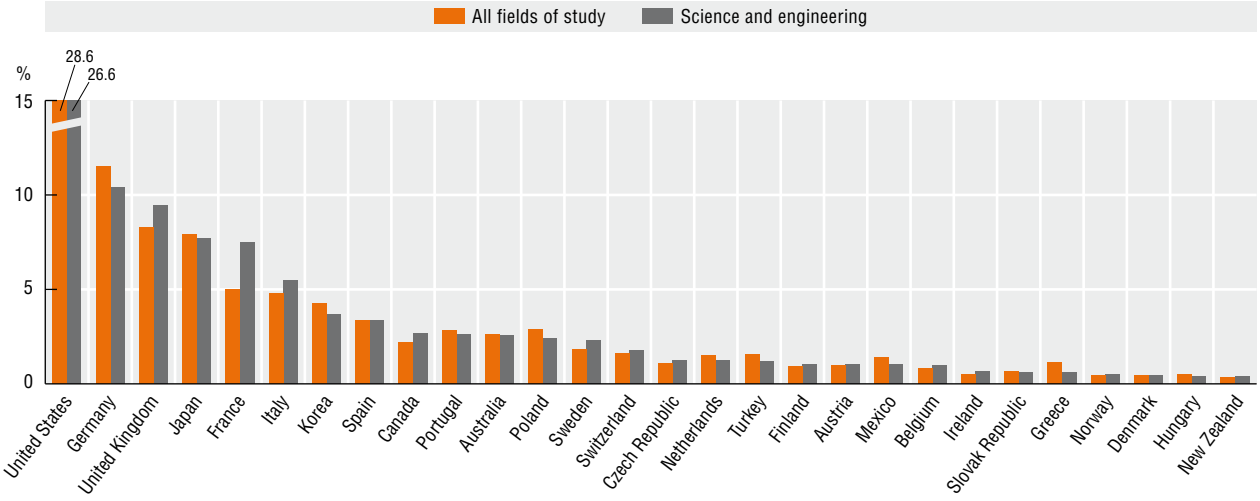
New graduates at doctorate level, by country of graduation, 2007

As a percentage of total OECD new graduates at doctorate level



Source: OECD, Education Database, February 2010.

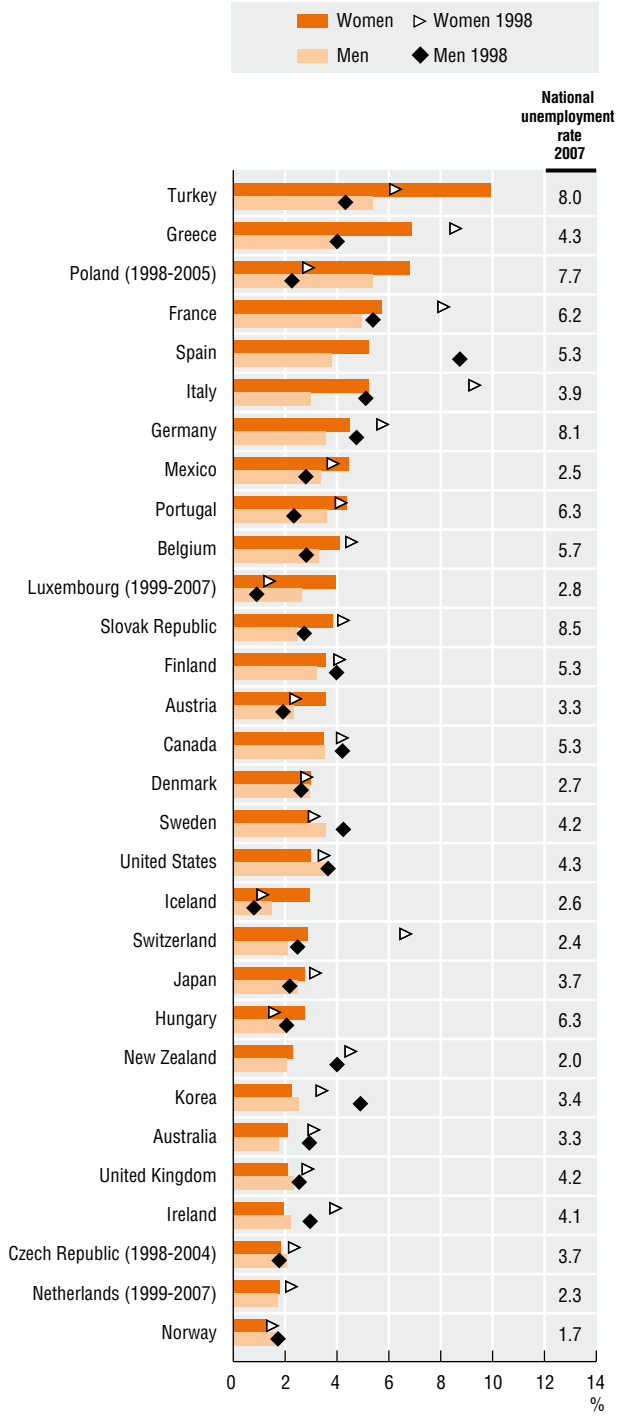
StatLink http://dx.doi.org/10.1787/835355261387

Measurability

Graduation rates for tertiary programmes, including advanced research programmes, are calculated as net graduation rates (*i.e.* as the sum of age-specific graduation rates). Net graduation rates represent the estimated percentage of the age cohort that will complete tertiary education (based on current patterns of graduation). Gross graduation rates are used for countries that are unable to provide such detailed data. In order to calculate gross graduation rates, countries identify the age at which graduation typically occurs. The number of graduates, regardless of their age, is divided by the population at the typical graduation age. In many countries, defining a typical age of graduation is difficult because graduates are dispersed over a wide range of ages.

Getting people to the labour market is crucial to foster innovation, economic growth and social well-being. Ensuring the right balance between specific labour market needs and generic competencies is a challenge faced today by higher education institutions around the world.

Unemployment rate of university graduates, 2007



Source: OECD (2009b), *OECD Science, Technology and Industry Scoreboard 2009*, OECD, Paris.

StatLink http://dx.doi.org/10.1787/835373004272

DID YOU KNOW?

On average across OECD countries, about 25% of people without a university degree are employed as managers, professionals or technicians.

(OECD, Educational Attainment Database, 2009.)

Unemployment rates decrease as educational attainment increases for both males and females, but differences by gender exist. In most countries, the unemployment rate of females with university degrees is higher than that of men with the same educational level. In some countries it is even higher than the national unemployment rate.

Transition to full employment can take several years and the match between educational attainment and occupation is not perfect. Unemployment rates of doctoral graduates in the humanities are generally higher than those in other fields.

An analysis of the skill composition of employment based on occupation and educational attainment shows a difference between the supply of and demand for highly skilled employees in most countries.

The attractiveness of research positions and careers is critical for innovation. Doctoral graduates are satisfied with their situation, but less so in terms of salaries, benefits, job security or opportunities for advancement. Dissatisfaction appears more prominent among women. Data on their earnings reveal that in most countries for which information is available, doctoral graduates are better paid when they do not work as researchers, especially outside the enterprise sector.

Definitions

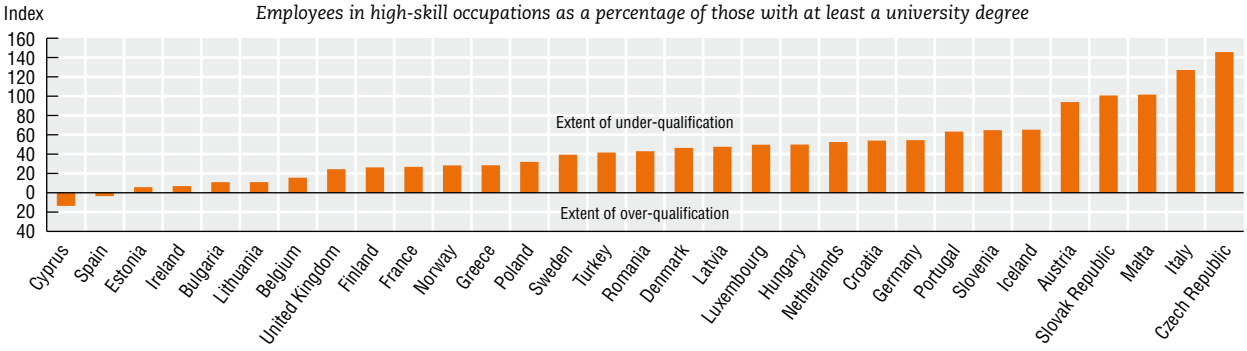
Skilled occupations are those designated by the UN "International Standard Classification of Occupations" (ISCO-88) as ISCO1 (legislators, senior officials and managers), ISCO2 (professionals) and ISCO3 (technicians and associate professionals).

The index of occupations and educational attainment at the country level is computed as follows:

$$\left| \left[\left(\frac{\textit{Number of high skilled_occupation definition}}{\textit{Number of high skilled_education definition}} \right) \times 100 \right] - 100 \right|$$

Supply of and demand for highly skilled employees, 2009

Employees in high-skill occupations as a percentage of those with at least a university degree



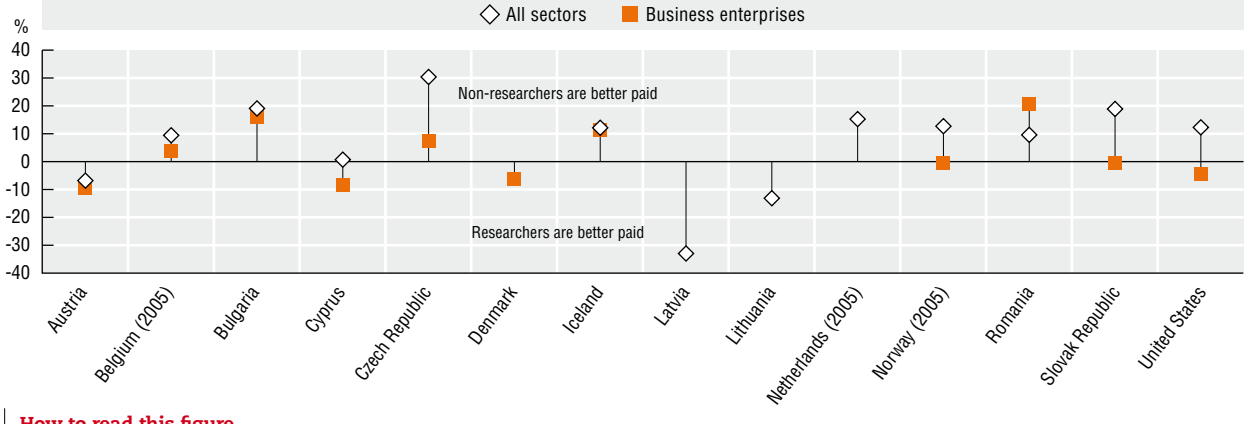
How to read this figure

In the Slovak Republic, there are two times (100%) more highly skilled individuals when defined on the basis of their job rather than their educational attainment.

Source: OECD, ANSKILL Database, December 2009.

StatLink http://dx.doi.org/10.1787/835373004272

Percentage difference in median gross annual earnings between doctorate holders working as researchers and those not working as researchers, 2006



How to read this figure

In the United States, doctorate holders earn 12% more when they do not work as researchers, except in the business sector, where as researchers they earn 4% more than non-researchers.

Source: OECD/UIS/Eurostat CDH data collection 2009.

StatLink http://dx.doi.org/10.1787/835373004272

Measurability

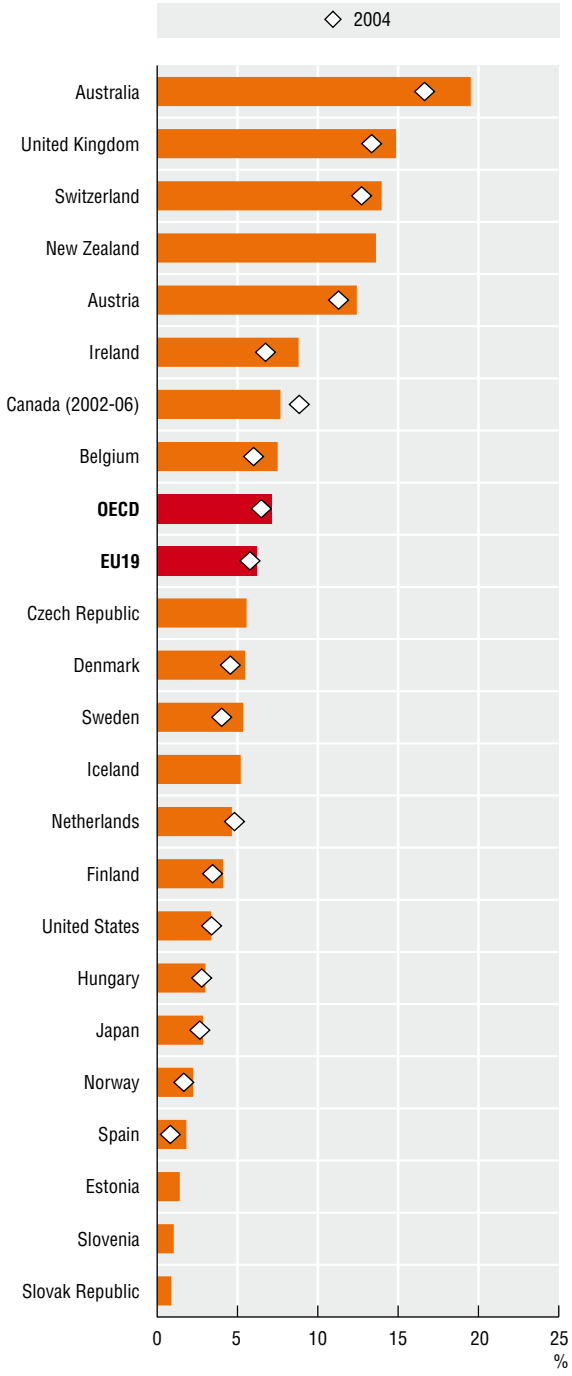
As early as 1995 the OECD and Eurostat released a *Manual on the Measurement of Human Resources Devoted to S&T* (HRST), the "Canberra Manual". HRST are measured on two dimensions: occupations (ISCO2 and ISCO3) and level of educational attainment (ISCED5 and ISCED6). On this basis, the OECD developed a new database, ANSKILL. This database aims to add an industry-level "skill" dimension to the STAN Database for Structural Analysis. It covers European countries, Australia, Canada, Japan and the United States. The major comparability issue relates to the industry breakdown.

The need to focus on more specific sub-populations is further addressed through the OECD/UNESCO Institute for Statistics/Eurostat project on Careers of Doctorate Holders (CDH). This project aims at better understanding this population's labour market, career paths and mobility. Efforts are being made to better measure specific aspects of the career patterns of doctorate holders. For instance, improved definitions and means of measuring two new important phenomena, postdoctoral positions and types of mobility (*e.g.* inter-sectoral and international mobility), are being established with the help of experienced institutions (*e.g.* the US National Science Foundation). These improvements will be included in the 2010 CDH data collection.

Mobility – and in particular international mobility – of skilled human resources plays an important role in innovation. It contributes to the creation and diffusion of knowledge, particularly tacit knowledge, which is more effectively shared within a common social and geographical context. Coherent and efficient migration regimes help making the most of brain circulation.

International students, 2007

As a percentage of all tertiary enrolments



Source: OECD (2009a), *Education at a Glance 2009: OECD Indicators*, OECD, Paris. See chapter notes.

StatLink http://dx.doi.org/10.1787/835412110164

DID YOU KNOW?

More than 65% of foreign tertiary students in the United States come from Asia.

(OECD, Education Database, 2010.)

One way for students to expand their knowledge of cultures and languages, and better equip themselves in an increasingly globalised labour market, is to pursue their higher-level education in countries other than their own. Some countries, particularly in the European Union, have established policies and schemes that promote such mobility to foster intercultural contacts and to help build social networks.

The proportion of international students in tertiary enrolments provides a good indication of the magnitude of student mobility in different countries. The indicator can be broken down by level and field of education and can be used to highlight programmes that attract students from abroad.

Young people are also more likely to move between jobs than older professionals. Job-to-job mobility is particularly strong in the Nordic countries, probably as a consequence of an active labour market policy combined with social safety nets.

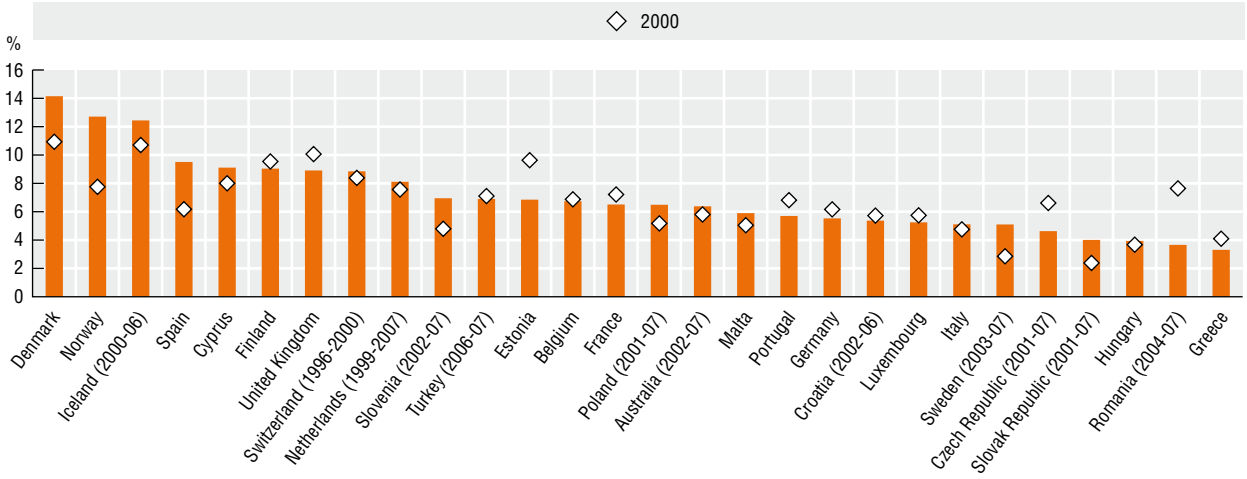
New data on doctorate holders reveal that in European countries 15% to 30% have experienced mobility over the past ten years. International mobility of professionals is driven by a variety of motives ranging from personal and family considerations to academic and job-related reasons.

Definitions

International students are those who travel to a country different from their own for the purpose of tertiary study. Depending on country-specific immigration legislation and data constraints, the definition is based either on the student's country of residence or on the student's country of prior education. *Job-to-job mobility* is defined as the movement of an individual between one job and another from one year to the next. It does not include inflows into the labour market from a situation of unemployment or inactivity. The rates are established by using information on when the current job began and the working status of the person one year before the survey. *Mobile doctorate holders* are those who have stayed abroad and returned to their home country for professional or personal reasons.

Job-to-job mobility of human resources in science and technology (HRST), employed 25-to-64-year-olds, 2007

As a percentage of total employed HRST, 25-to-64-year-olds

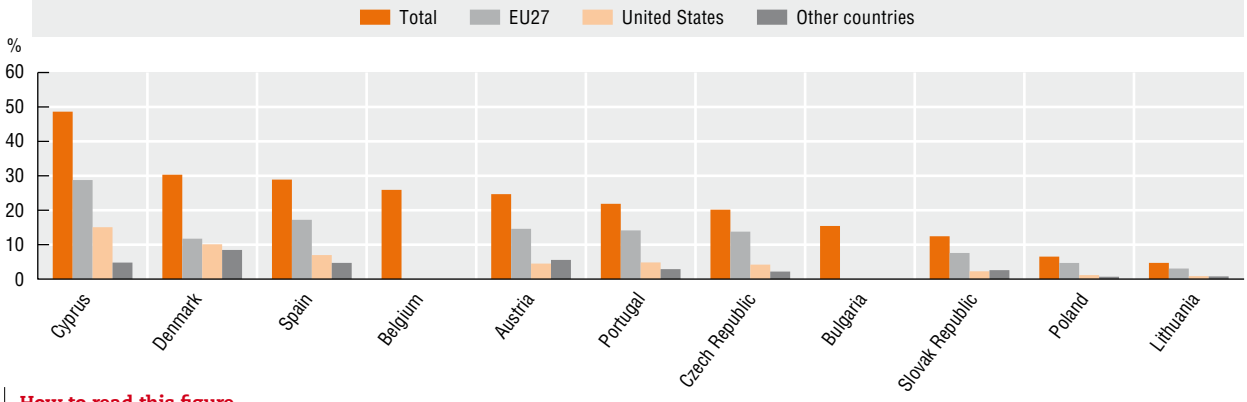


Source: Eurostat, based on European Labour Force Surveys, October 2009.

StatLink http://dx.doi.org/10.1787/835412110164

International mobility of doctorate holders, by main destination, 2006

Percentage of national citizens with a doctorate having lived/stayed abroad in the past ten years



How to read this figure

30% of doctorate holders currently based in Denmark had stayed abroad in the last ten years. The breakdown of their last destination is: 12% in Europe, 10% in the United States and 8% in other countries.

Source: OECD/UIS/Eurostat CDH data collection 2009.

StatLink http://dx.doi.org/10.1787/835412110164

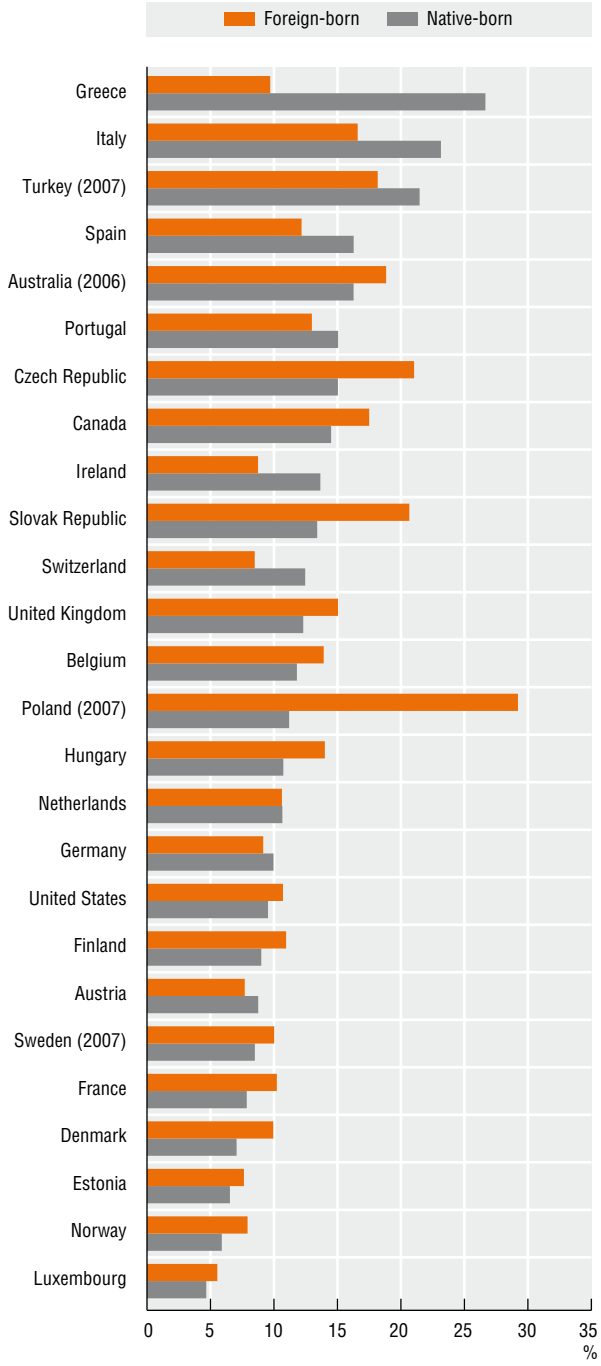
Measurability

The measurement of mobility poses a real challenge to statisticians, mainly because of the difficulty of tracking a moving target. Mobility can occur between jobs in the same enterprise, the same industry or the same sector of the economy, between different sectors (*e.g.* from a university to an enterprise), or between countries. International mobility is often approximated by measures of stocks (*e.g.* foreign citizens or foreign-born) and not of flows (change of situation or move to another country). A further complication is the difficulty of differentiating temporary mobility from migration. The OECD has made good progress in recent years in developing better statistics on international mobility and migration, notably of international students, using the results of the 2000 worldwide cycle of censuses. The Careers of Doctorate Holders (CDH) project has introduced new ways of capturing mobility by introducing, on the one hand, a new definition of "internationally mobile doctorate holders" and, on the other, a series of questions on national origin, the list of countries in which doctorate holders have studied, worked or carried out research, and the reasons for mobility. The first results, shown above, are promising, but need to be consolidated with the next data collection.

Entrepreneurship provides an expanded set of employment opportunities, wider skill development and greater opportunities to innovate. Entrepreneurship education plays a key role by raising awareness about entrepreneurship as a potential career path and developing skills for starting and growing companies.

Self-employed, by place of birth, 15-to-64-year-olds, 2008

As a percentage of total employment



Source: OECD (forthcoming), *International Migration Outlook: SOPEMI 2010*. See chapter notes.

StatLink http://dx.doi.org/10.1787/835542183283

DID YOU KNOW?

25% of US high-technology companies started during 1995-2005 had at least one immigrant founder, and 50% in Silicon Valley.

(Wadhwa *et al.*, 2007.)

Entrepreneurship empowers people to take their future into their own hands, whether through self-employment or by creating a firm that employs other people. A country's entrepreneurial activity therefore ranges from self-employment to the creation of high-growth firms.

Self-employment is only part of a country's total entrepreneurial activity, but it is a significant segment of the economy in most countries. In several countries the foreign-born are more likely to be self-employed than the native-born. This correlates with several studies demonstrating the significant role played by immigrants in entrepreneurial ventures.

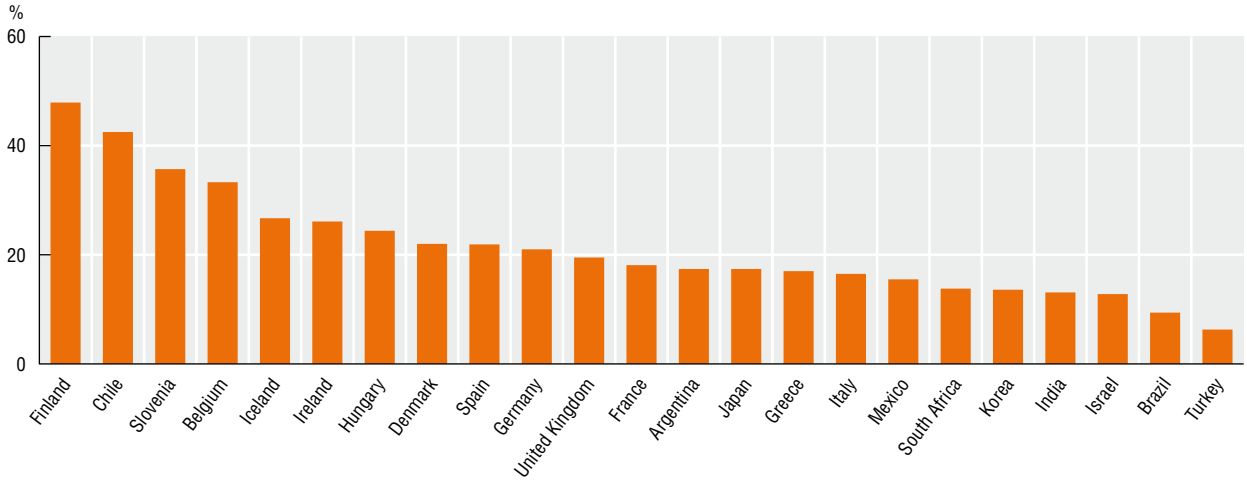
Entrepreneurship education is critical for raising awareness about starting and growing a business and providing the skills, attitudes and behaviours to do so. Entrepreneurship education is growing significantly in countries across the world. Previously a specialised training programme, it is increasingly integrated in required courses at all levels of education.

Despite this recent growth, in most countries less than a quarter of the population aged 18 to 64 indicated having participated in training for starting a business. This indicates the need for further progress in this area. There is also a need for more training in the management and growth of young enterprises.

Definitions

Self-employed persons are defined as those who work in their own business, professional practice or farm for the purpose of earning a profit. They may or may not have employees. A country's foreign-born population includes all persons who have that country as their usual residence and who were born in another country. *Training in starting a business* includes all voluntary or compulsory training/courses during or after school.

Percentage of the population aged 18 to 64 years old who received any type of training in starting a business, during or after school, 2008



Source: Bosma, N., Z.J. Acs, E. Autio, A. Coduras and J. Levie (2009), *Global Entrepreneurship Monitor: 2008 Executive Report*, Global Entrepreneurship Research Association (GERA).

StatLink http://dx.doi.org/10.1787/835542183283

Measurability

While several proxies have been used to determine the level of entrepreneurship in countries, more work needs to be done to develop metrics that provide a more complete picture of entrepreneurial activity (beyond self-employment or other measures currently used).

The Labour Force Survey divides the population of working age (15 years and more) into three mutually exclusive groups: persons in employment, unemployed persons and inactive persons. Self-employment is a subcategory of persons in employment; the self-employed work in their own business and want to make profit. The concepts and definitions used in the Labour Force Survey are based on the guidelines of the International Labour Organisation and guarantee broad availability and comparability across countries.

The Global Entrepreneurship Monitor (GEM) surveyed 54 developed and developing countries in 2008. GEM takes a broad view of entrepreneurship and focuses on the role of the individual in the entrepreneurial process. The survey asks about personal assessments, attitudes and perceptions, in addition to intentions of starting a business in the near future. Given the importance of entrepreneurship education, specific questions on this topic were included in the 2008 GEM study.

Data on entrepreneurship education is difficult to compare as the data are usually collected at the local or regional level and focus on specific programmes rather than on measures which can be compared internationally. However, in the past ten years, interest in this area has grown and more national and international studies are being conducted, particularly in the United States and Europe. While data on activity (number of courses, number of students reached, number of faculty, etc.) can be obtained and are increasingly available, data on outcomes is limited (World Economic Forum, 2009) as few educational institutions (except in the United States) track their alumni and therefore are unable to measure the impact of the programmes on later career choices. There is a need to co-ordinate these local and national efforts so that more of the existing data collected can be shared internationally.

For any organisation, an important source of continuing productivity growth is effective management of the organisation of work and ensuring that the talents of individuals are being tapped. Innovative capabilities are strengthened in work places which provide a fertile environment for innovation. Better measures are needed of the skills required and of ways in which the workplace promotes such skills.

Why do we need indicators ?

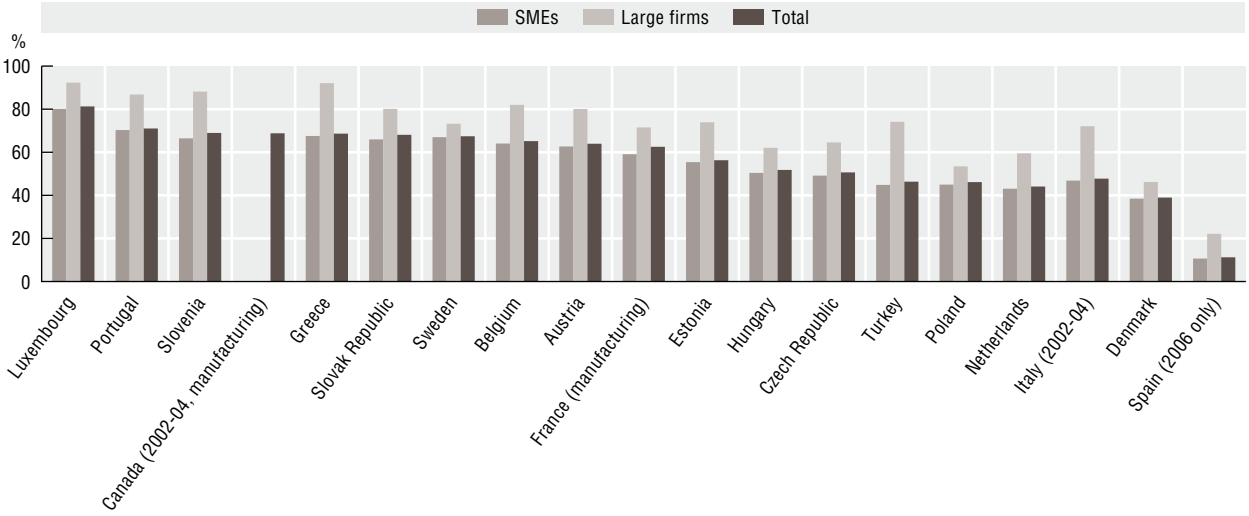
The importance of work-based learning highlights the fact that skills acquisition is a lifelong process. In addition to formal education through the primary, secondary and tertiary levels, the learning that takes place on the job is a crucial component of skilled workers' toolkits and helps shape innovation outcomes. A recent OECD firm-level study of nine countries shows that one of the main strategies of innovative companies is to accompany spending on new machinery with training of their workforce (OECD [2009c], *Innovation in Firms: A Microeconomic Perspective*).

The skills and competencies required for innovation are broad. Incremental innovation and the improvement of organisational efficiency and routines, for example, can come from a range of workers, not just managers, researchers or external consultants, and can rely on different skills and competencies. Moreover, new organisational methods or marketing innovations require specialised skill sets well beyond traditional science and engineering training. The pace and changing nature of innovation, as well as changes in countries' industrial structures, mean that people need to upgrade their skills throughout their adult lives.

Training is only one of several instruments a firm can use to leverage its human capital potential. Interaction and learning within firms enables employees to share information, challenge existing patterns, and experiment and collaborate to improve products and processes. The potential role of learning and interaction within organisations has been highlighted as a way to strengthen firm performance in the post-crisis environment. However, these concepts remain difficult to quantify and better measurement instruments are needed.

Firms engaged in innovation-related training activities, by size, 2004-06

As a percentage of total innovative firms



How to read this figure

There is a wide variation across countries regarding the prevalence of innovation-related training activities at the firm level. In Luxembourg and Portugal, more than 70% of innovative firms engage in such activities, but in several other countries, the share is less than 50%. In all countries, SMEs are less likely than larger firms to engage in innovation-related training activities.

Source: Eurostat CIS-2006 (CIS-4 for Italy) and for Canada: Statistics Canada, 2005 Survey of Innovation.

StatLink *http://dx.doi.org/10.1787/835552812202*

Definitions

Training for innovation is defined as internal or external training specifically for the development and/or introduction of new or significantly improved products or processes. *SMEs* are firms with less than 250 employees.

What are the challenges?

Developing a harmonised set of indicators to measure organisational change and innovative workplaces

Organisational studies have long analysed the interaction between work organisation, skills and technology (Toner, 2009). Concepts such as job rotation, incentives to participate actively in innovation, and measures to monitor, evaluate, capture and diffuse improvements across work teams, are often used to describe new organisational practices and have been tested in a number of surveys (*e.g.* the European Working Conditions Survey, EWCS). Studies that have looked at the relation between new organisational practices and innovation have usually found it to be positive (Greenan and Lorenz, 2009). To improve understanding of these relations it is necessary to harmonise definitions and collect comparable indicators of organisational changes and innovative workplaces. Better measures of workplace skills are required, and there is scope to more fully exploit available matched firm-worker data to analyse the relation between skills, innovation and performance (Nås and Ekeland, 2009).

Define and measure skills for innovation

The skills and competencies required for innovation are broad. What measures can be used to capture the range of skills innovators need? Can such skills be in fact defined? A first challenge is to develop a conceptual framework to better guide and prioritise the measurement of skills for innovation. This entails distinguishing and defining the relations among concepts of creativity, entrepreneurship and innovation and linking measurement to clearly defined policy objectives. Once the target of measurement is defined, the appropriate survey vehicle must be chosen (see below).

Options for international action

The MEADOW Guidelines on organisational change and its economic and social impacts (2010)
www.meadow-project.eu/

The MEADOW (MEAsuring the Dynamics of Organisations and Work) Guidelines propose a measurement framework for collecting and interpreting internationally harmonised data on organisational change and its economic and social impacts for both private- and public-sector organisations. The objective is to provide evidence for European policy initiatives aimed at increasing the flexibility and adaptability of organisations and employees while simultaneously improving the quality of jobs during economic booms as well as downturns. The MEADOW Guidelines propose a survey that links the interview of an employer with interviews of his or her employees. This is the richest survey setting for measuring organisational change and its impacts on the workplace. Some aspects, such as the way existing organisational arrangements or processes of change are experienced and felt by employees, can only be captured with accuracy by interviewing the employees concerned. Other aspects, including general information about the organisation's choice of policies and practices affecting the internal division of labour or relations with external suppliers or subcontractors are best measured at the employer level. Linked surveys can also provide different and complementary information on the same organisational characteristics or processes. The MEADOW Guidelines are the result of a Co-ordinating Action funded by the European Commission which brought together a multidisciplinary consortium of 14 partners from 9 European countries.

A way forward would be to explore the potential of this survey to study organisational change linked to the introduction of new processes and organisational and management practices.

The OECD PIAAC (Programme for the International Assessment for Adult Competencies) Survey
www.oecd.org/els/employment/piaac/

Certain forms of work organisation demand particular skills of employees, but they are not always easy to measure. According to results from the OECD's PIAAC pilot study, workers who participated in quality-improvement circles appeared to need higher reading and numeracy skills and stronger communication skills, while team-working was associated with greater internal communication skills. The full PIAAC survey, to be carried out in 2011, will cover Canada, Chile, Japan, Korea, the Russian Federation and United States, in addition to EU countries. It will allow for investigating the links between key cognitive skills and a range of variables, with a particular focus on skills of individuals and their actual use at work place. A way forward to measure skills for innovation at the workplace would be to explore the possibility of adding a "PIAAC-type" component/module to innovation surveys and thus link skills at the workplace to innovation outcomes.

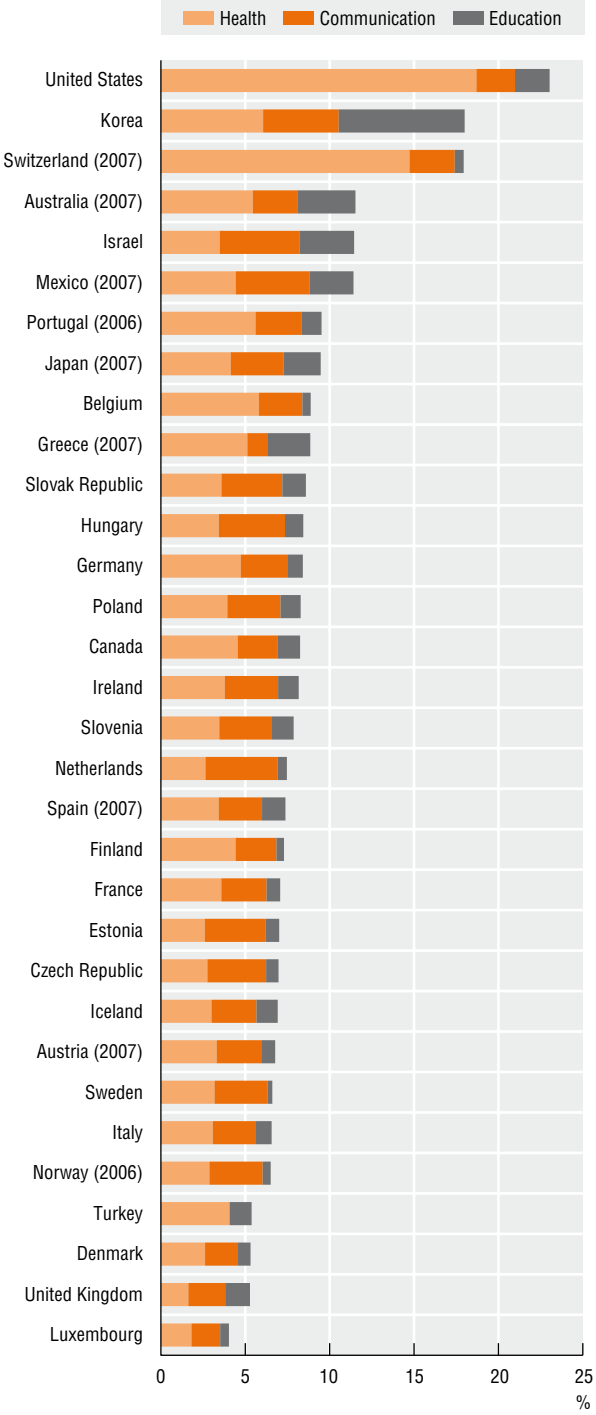
The Eurostat Community Innovation Survey (CIS)

The next CIS-2010 will contain a short *ad hoc* module (about four questions) on "Creativity and Skills for Innovation". The questions are currently under development.

Enabled by new technologies, users and consumers play a growing role in the innovation process and can directly influence innovation and encourage the development of new technologies.

Final consumption expenditure of households, by selected category, 2008

As a percentage of total final consumption expenditures



Source: OECD, National Accounts Database, February 2010.

StatLink http://dx.doi.org/10.1787/835570672184

DID YOU KNOW?

In ten OECD countries, mobile outpaced fixed lines as the main telecommunication revenue stream.

(OECD Communications Outlook 2009.)

Health, communication and education are three important areas in which technological or organisational innovation will help to improve the goods or services delivered to the population. In these areas in particular, users and consumers can play an active role by testing new ideas and providing feedback to service providers (firms and governments) to help orient the innovation effort.

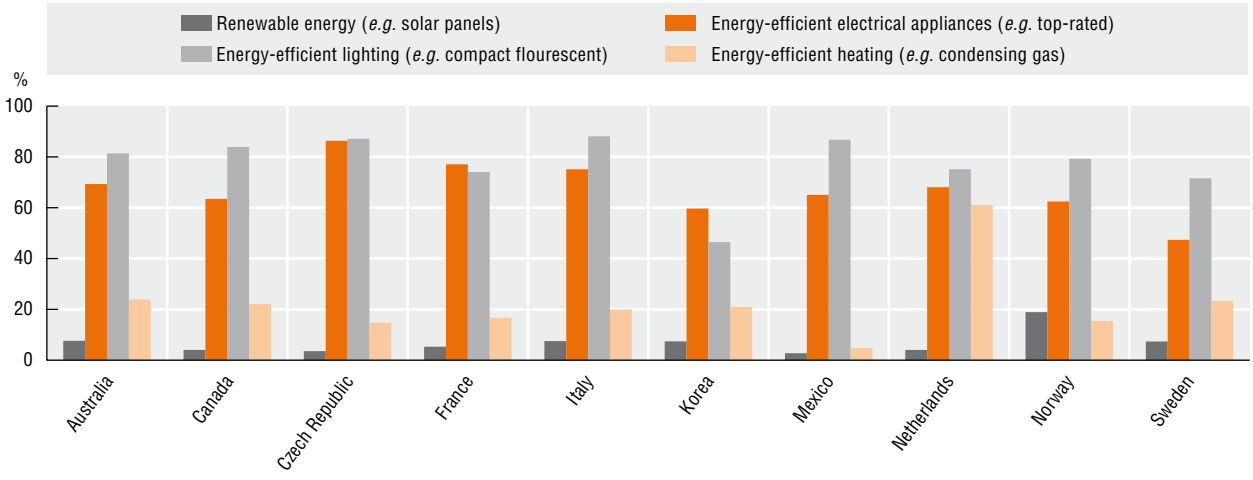
Spurred by high consumer demand and rapid technological advances, information and communication technology (ICT) plays a large part in the everyday life of many OECD consumers. Although communication-related expenditures represent a small percentage of the household budget (2.6% in 2008), its share has grown steadily over the last two decades.

Consumer demand for environmentally friendly goods and services (*e.g.* energy-efficient appliances, alternative-fuelled vehicles, non-toxic cleaning products) is likely to play an important role in the development of a new generation of "green" goods and services. Empirical work at the OECD indicates that exploiting such demand depends on price incentives and information-based measures to help consumers make informed choices based on their underlying demand for improved environmental quality.

Definitions

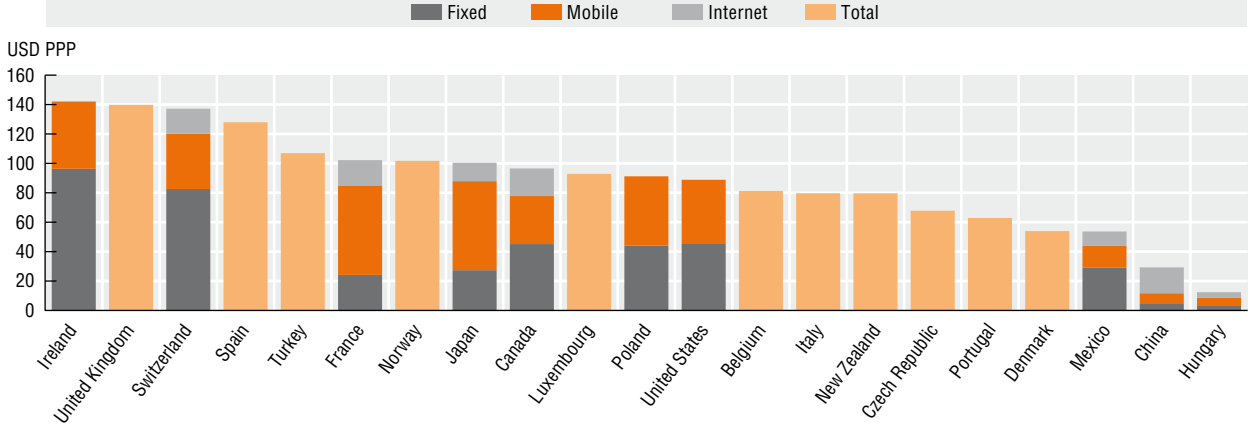
The *final consumption expenditure* of households or demand from households (along with public consumption and investment) is part of a country's domestic demand and one of the constituents of GDP. The data are compiled in the National Accounts. Final consumption expenditure of households is divided into 12 categories, including health, communication and education.

Percentage of households having invested in environmentally friendly products in the last ten years, 2008



Source: OECD (forthcoming), *Environmental Policy and Household Behaviour: A Survey of OECD Countries*, OECD, Paris.
StatLink http://dx.doi.org/10.1787/835570672184

Monthly household expenditures on communication services, by type of access, 2007



Source: OECD (2009d), *OECD Communications Outlook 2009*, OECD, Paris.
StatLink http://dx.doi.org/10.1787/835570672184

Measurability

Adoption of new environmentally friendly products is key to encouraging demand for "green" innovation. Unfortunately, household-level data on the adoption of such innovations for a cross-section of OECD countries is not available since standard commodity classifications do not offer a sufficient level of disaggregation. Moreover, much of the data required to assess the determinants of household behaviour – including the use of such innovations – are not reflected directly in consumer expenditure patterns. In order to fill this gap, the OECD collected data from 10 000 households on issues such as waste generation, energy and water use, personal transport and consumption of organic food. Work scheduled for 2011-12 focuses on the adoption of eco-innovations.

National surveys were used to compare monthly spending by households on communication services with a breakdown (for some countries) by type of access. Unfortunately, these surveys are not always easy to compare since they use different questionnaires, definitions and methodologies. Countries such as Ireland, Poland and the United States do not include Internet services in their data. As the question of spending on ICT becomes more important, national surveys tend to become more detailed so that recent questionnaires are more internationally comparable than older ones.

Notes

Cyprus

The following note is included at the request of 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 recognizes 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 »".

The following note is included at the request of all the European Union Member States of the OECD and the European Commission:

"The Republic of Cyprus is recognized 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".

Israel

"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."

"It should be noted that statistical data on Israeli patents and trademarks are supplied by the patent and trademark offices of the relevant countries."

2.1. BASIC SCIENTIFIC SKILLS

Length of time students have been using a computer and mean PISA science score, 2006

- Countries are ranked in descending order of mean PISA science scores.

2.2. TERTIARY EDUCATION

Transition from upper secondary education to graduation at the university level, 2007

- Year of reference for upper secondary graduation rates is 2006 for Australia.
- Includes ISCED 4A programmes in Austria ("Berufsbildende Höhere Schulen").

Annual tuition fees charged by public universities and public subsidies to private entities, 2007

- Some levels of education are included with others for Japan and the Slovak Republic.
- Public institutions only for Turkey, Switzerland and Poland.

Private net present value for an individual obtaining tertiary education as part of initial education, 2005

- Cash flows (components) are discounted by 5% interest rate.
- Assuming that foregone earnings for all individuals refer to the minimum wage, except for the Czech Republic, Hungary, Poland and Portugal, which report full-time earnings.

2.5. INTERNATIONAL MOBILITY

International students, 2007

- For the purpose of measuring student mobility, international students are defined on the basis of their country of residence in Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Estonia, Hungary, Japan, New Zealand, Norway, the Slovak Republic, Slovenia, Spain, Sweden, the United Kingdom and the United States. For the remaining countries international students are defined on the basis of their country of prior education (Finland, Iceland, Ireland and Switzerland).
- Excludes data on social advancement education in Belgium.
- Percentage in total tertiary education underestimated for the Netherlands, Canada and Switzerland because certain programmes are excluded.
- Excludes private institutions in Canada.

2.6. ENTREPRENEURIAL TALENT

Self-employed, by place of birth, 15-to-64-year-olds, 2008

- Self-employed excludes agriculture. For Canada, persons still in education are excluded.

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Chapter 3

UNLEASHING INNOVATION IN FIRMS

A dynamic business sector is a main source of and channel for innovation. Indicators of firms' birth and death rates reflect this dynamism. However, work is needed to improve the quality and timeliness of business registers and their international comparability. Policy areas for particular attention are the financing of innovative efforts, and the fostering of the start-up and growth of new firms via the appropriate regulatory framework. A few indicators are selected to reflect the cost of investment, the availability of venture capital and business angels networks, as well as regulatory and taxation indicators that are likely to affect entreprenurial activities. Indicators covering the interface between entrepreneurship and innovation are not yet well established. The focus here is on young dynamic firms and an experimental indicator obtained by the matching of patent filings with company data is proposed.

3.1 • Entry and exit 64

3.2 • Mobilising private funding 66

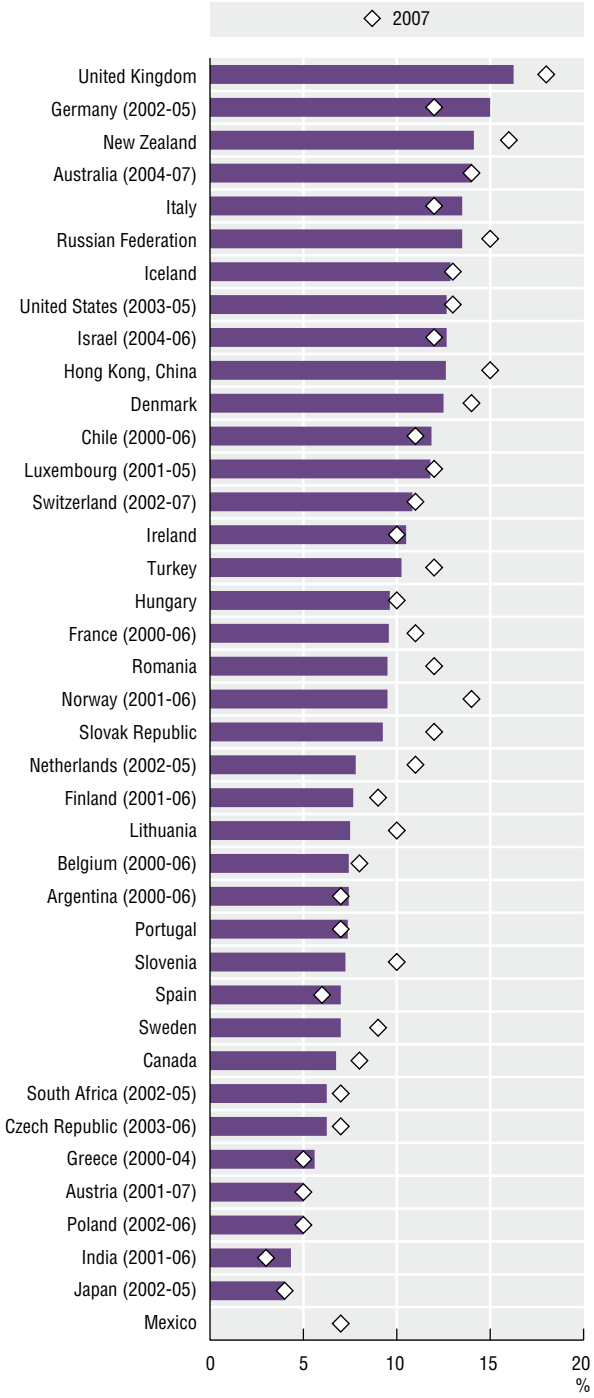
3.3 • Policy environment 68

3.4 • Young and innovative firms 70

The contribution of enterprises to innovation is crucial, and a dynamic business sector is a key source and channel of technological and non-technological innovation. New companies frequently exploit technological or commercial opportunities which have been neglected by more established companies and bring them to market.

Entry rate, average 2000-07

Number of newly registered corporations as a percentage of all registered corporations



Source: World Bank, Entrepreneurship Database WBGES08 (2008).

StatLink http://dx.doi.org/10.1787/835584771745

DID YOU KNOW?

In the United States growth of employment in surviving firms after the first seven years is at least twice that of European firms.

(Bartelsman, Scarpetta and Schivardi, 2005.)

Entry rates provide information on the dynamism of the business sector.

Employer indicators are more relevant for international comparisons than indicators covering all enterprises, as the latter are sensitive to the coverage of business registers.

Employer enterprise birth and death rates reflect the process of creative destruction. An efficient process of firm entry and exit makes an important contribution to aggregate employment and productivity growth: market selection leads to the death of less productive firms and the success of more productive ones.

A breakdown by industry shows that there is more creative destruction in services than in manufacturing, with a net entry of services enterprises in most countries. The picture is less clear in manufacturing as relatively lower birth and death rates result in net entry of manufacturing enterprises in some countries and a net exit in others.

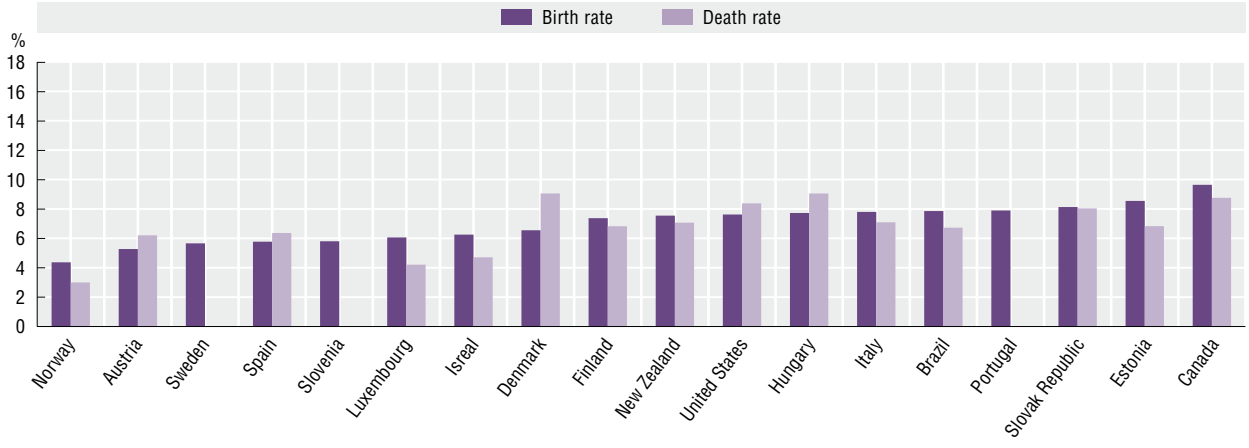
Definitions

Entry rates in the World Bank Database are calculated as the number of newly registered corporations divided by the number of total registered corporations.

The *employer enterprise birth and death rates* in the OECD Structural and Demographic Business Statistics Database (SDBS) are calculated as the number of births and deaths of employer enterprises, respectively, as a percentage of the population of active enterprises with at least one employee.

Employer enterprise birth rate (2006) and death rate (2005) in the manufacturing sector

As a percentage of the population of active enterprises with at least one employee

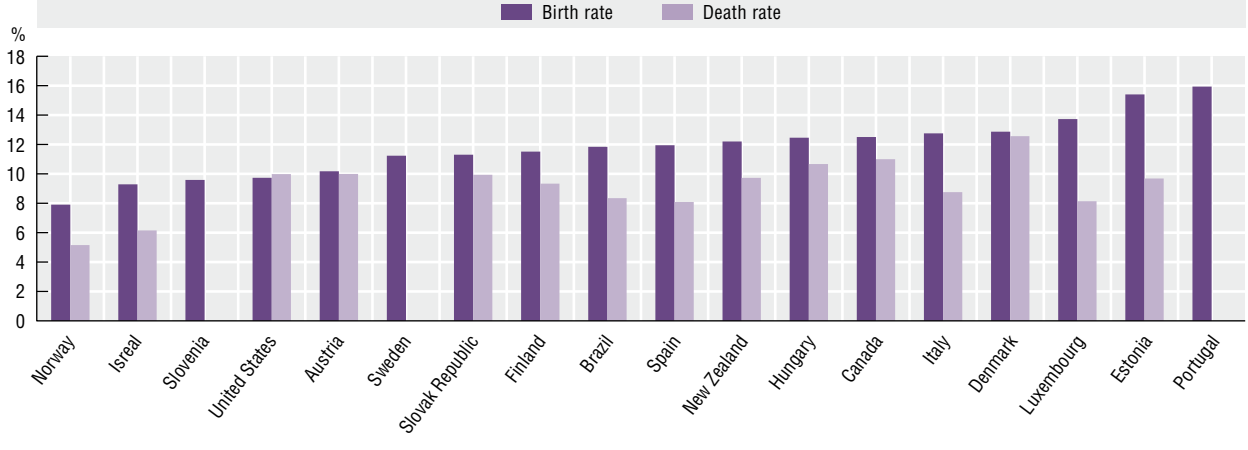


Source: OECD, Structural and Demographic Business Statistics Database, November 2009. See chapter notes.

StatLink http://dx.doi.org/10.1787/835584771745

Employer enterprise birth rate (2006) and death rate (2005) in the services sector

As a percentage of the population of active enterprises with at least one employee



Source: OECD, Structural and Demographic Business Statistics Database, November 2009. See chapter notes.

StatLink http://dx.doi.org/10.1787/835584771745

Measurability

The World Bank definition of entrepreneurship is a legal one, and entry rates are based on the number of limited liability corporations, or their equivalent in other legal systems, collected from business registers and other sources (including private ones) in the surveyed countries.

The OECD, instead, defines an employer enterprise birth as the birth of an enterprise with at least one employee. This employer-based indicator, developed in the framework of the OECD-Eurostat Entrepreneurship Indicators Programme and included in the OECD Structural and Demographic Business Statistics Database (SDBS), distinguishes between start-ups without employees (self-proprietor/self-employed businesses) and the creation of new businesses with employees. The latter typically have a greater growth potential and economic significance. The data are collected only through official sources, *e.g.* national statistical offices, and thus ensure the international comparability of the data, which is not affected by differences in coverage of business registers. While the OECD measure of employer enterprise births is currently available for a smaller set of countries than the World Bank's indicator of entry rate, the Entrepreneurship Indicators Programme will progressively cover more OECD member and non-member economies.

Private funding, whether in the form of debt or equity, plays a key role in fuelling innovation. However, significant amount of funding has dried up owing to the recent economic crisis, particularly for seed and start-up companies.

Long-term interest rates, 2008

Per cent per annum

Source: OECD, Main Economic Indicators Database, October 2009.

StatLink http://dx.doi.org/10.1787/835656441446

DID YOU KNOW?

In 2009, US venture capital investment was USD 17.7 billion, while US business angels investment was USD 17.6 billion.

(NVCA/PwC, 2010; and Sohl 2010.)

New and innovative small firms can obtain both debt and equity financing. The cost of financing investment had been decreasing, but following the financial crisis access to finance has become particularly difficult for entrepreneurs and young firms.

For entrepreneurial firms, especially young, technology-based firms with high growth potential, venture capital is an important source of funding at the seed, start-up and growth phases. Venture capital differs significantly among countries and is very sensitive to market cycles in terms both of the amounts invested and the stages of investment. Under some conditions, venture capital funds may invest in the later stages, leaving gaps at the pre-seed and seed stages where profit expectations are less clear and risks are much higher.

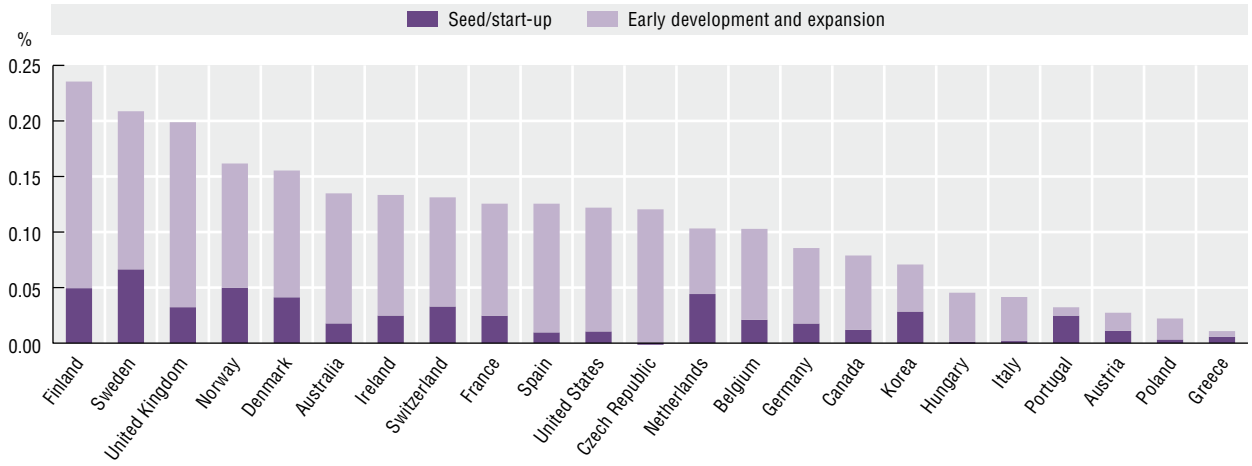
When entrepreneurs need other external sources of seed capital, business angels, often successful entrepreneurs or experienced business people, have become an increasingly important source of equity capital. Financing at this stage often comes informally from founders, friends and family; and formally from venture capital investors or business angels. Private-sector financing is becoming more organised. The United States has the most developed market but activity in Europe and other regions is growing.

Definitions

Debt financing (*e.g.* loans from individuals, banks or other financial institutions; sale of bonds, notes or other debt instruments) involves the acquisition of resources with an obligation to repay. *Venture capital* is private equity provided by specialised firms acting as intermediaries between primary sources of finance (insurance, pension funds, banks, etc.) and private companies whose shares are not freely traded on any stock market. A *business angel* is a private investor who generally provides finance and business expertise to a company in return for an equity share in the firm. Some business angels form syndicates or networks in order to take on larger deals and spread risk.

Venture capital investment, 2008

As a percentage of GDP

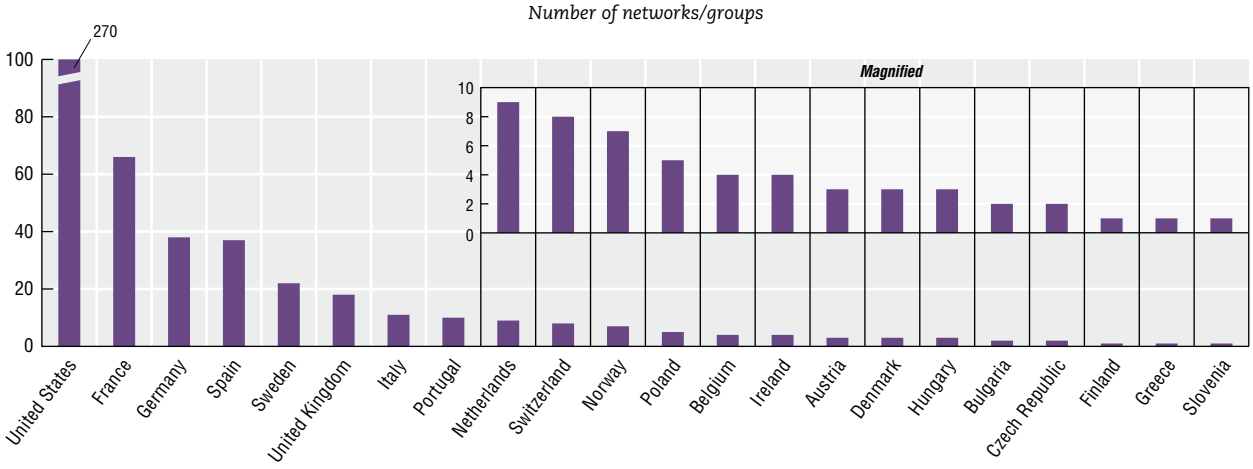


Source: OECD (2009a), *Measuring Entrepreneurship: A Collection of Indicators*, OECD, Paris, based on the OECD, Entrepreneurship Financing Database. See chapter notes.

StatLink http://dx.doi.org/10.1787/835656441446

Business angels, 2007

Number of networks/groups



Source: OECD (2009a), *Measuring Entrepreneurship: A Collection of Indicators*, OECD, Paris, based on the OECD, Entrepreneurship Financing Database. See chapter notes.

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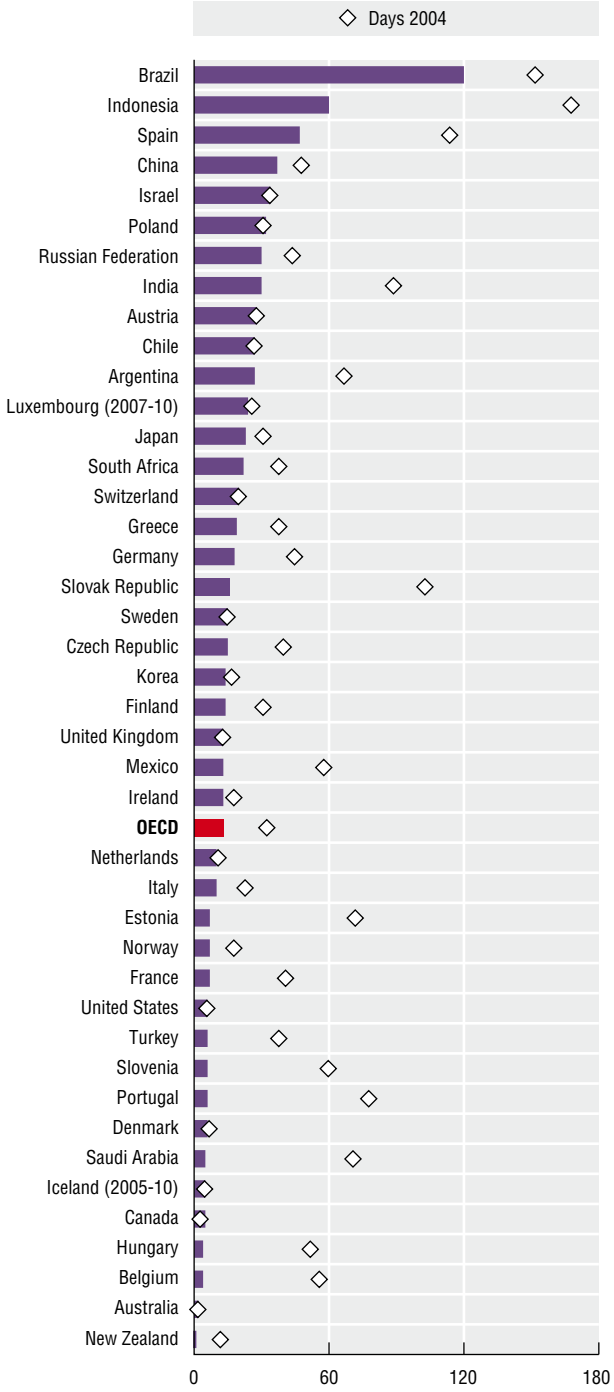
Measurability

National and regional venture capital associations collect data on venture capital from their members. Until recently, venture capital data were not fully comparable internationally, owing to differences in definitions and classification methods. However, given recent changes in methodology, data have become more comparable: inward and outward flows are treated in the same way across countries and the comparability of industry classifications has improved (OECD [2009a], *Measuring Entrepreneurship: A Collection of Indicators*).

National and regional angel capital associations are beginning to collect data on the informal angel investment sector. The US Angel Capital Association (ACA) and the European Business Angel Network (EBAN) work to expand the set of angel investment statistics beyond those currently available. Angel investment is growing in Asia and other regions, although data are not yet collected in a manner that allows for cross-country and regional comparisons.

While entry and growth of new firms is important, so is their adaptability to changes in the economy and their ability to exit when necessary. New enterprises drive a large number of obsolete firms out of the market and often do not survive very long themselves. A policy environment that fosters the start-up and growth of new firms is essential for innovation to flourish.

Days needed to start a business, 2010



Source: International Bank for Reconstruction and Development/ World Bank (2009), *Doing Business 2010*, United States.

StatLink http://dx.doi.org/10.1787/835713671578

DID YOU KNOW?

Since 2004, 254 reforms have made start-ups easier in 134 economies. Yet on average worldwide, it still takes 8 procedures and 36 days to start a business.

(*Doing Business*, 2010.)

Cutting red tape to improve the quality of regulations is important for facilitating business creation. The decrease in the number of days needed to open a business shows significant progress in this direction.

A high-quality regulatory framework is important to allow businesses to enter the market and grow. In this respect, most OECD countries have lowered barriers to entrepreneurship during the last decade.

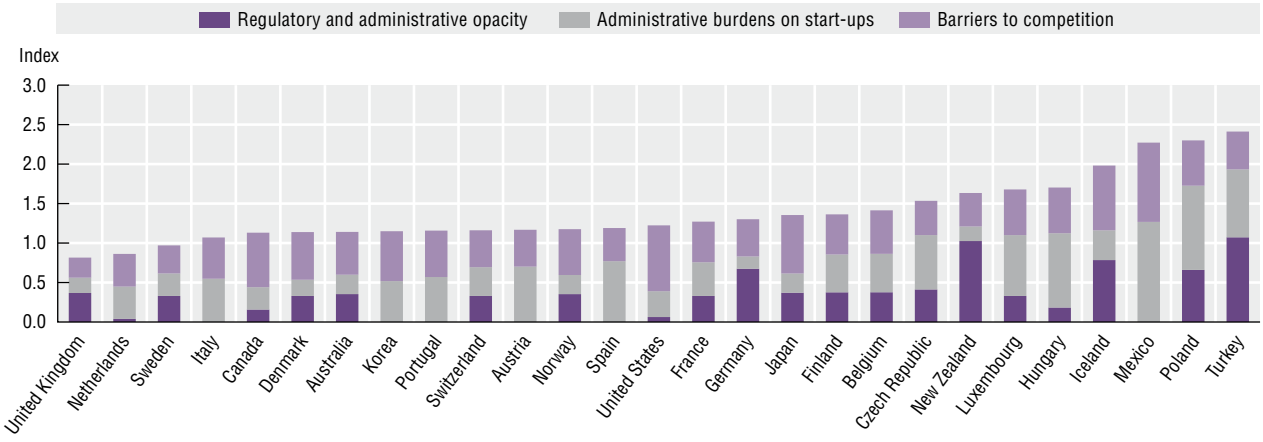
In addition, individuals' decisions to start a business are affected by taxes and tax policy: general taxes (personal income, corporate and capital gain tax rates, social security contributions) and targeted tax policies (tax incentives targeted to start-ups, young firms and SMEs). OECD analysis finds that reducing top marginal personal income tax rates raises productivity in industries with potentially high rates of enterprise creation.

Definitions

The *barriers to entrepreneurship* indicator measures regulations affecting entrepreneurship on a scale of zero to six; lower values suggest lower barriers. The index is composed of barriers to competition (legal barriers, antitrust exemptions, barriers in network sectors and in retail and professional services); regulatory and administrative opacity (licences, permits, simplicity of procedures); and administrative burdens for creating new firms. The *marginal tax rate* covers employees' and employers' social security contributions and personal income tax. The *corporate income tax rate* is the statutory tax rate applicable to incorporated businesses. It combines the central and sub-central (statutory) corporate income tax rate. *Days needed to start a business* is the median duration indicated by incorporation lawyers as necessary to complete the procedures.

Barriers to entrepreneurship, 2008

Scale from 0 to 6 from least to most restrictive

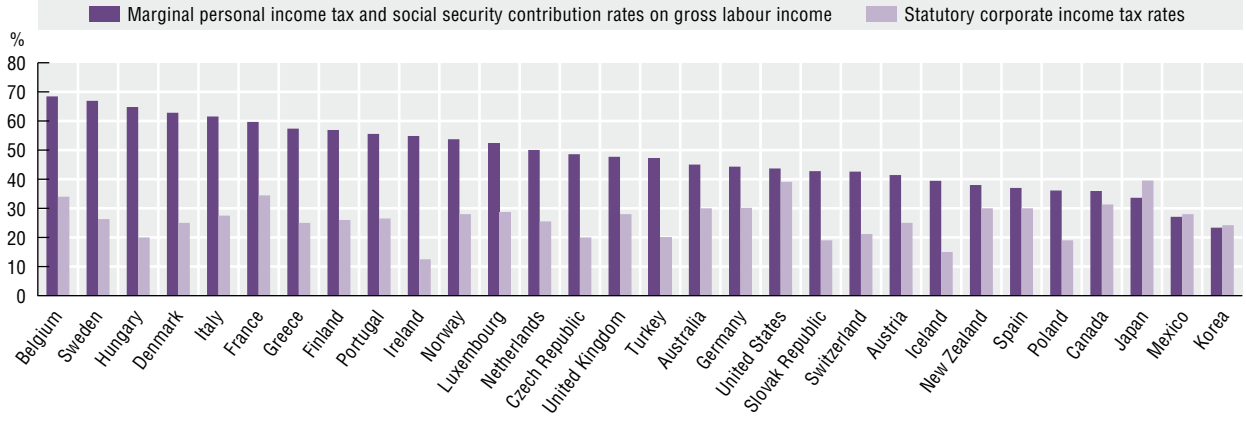


Source: OECD, Product Market Regulation Database, December 2009.

StatLink http://dx.doi.org/10.1787/835713671578

Taxation on personal income and corporate income, 2009

Marginal personal income tax and social security contribution rates on gross labour income and statutory corporate income tax rates



Source: OECD (2010), *Taxing Wages 2008-2009: 2009 Edition*, OECD, Paris. See chapter notes.

StatLink http://dx.doi.org/10.1787/835713671578

Measurability

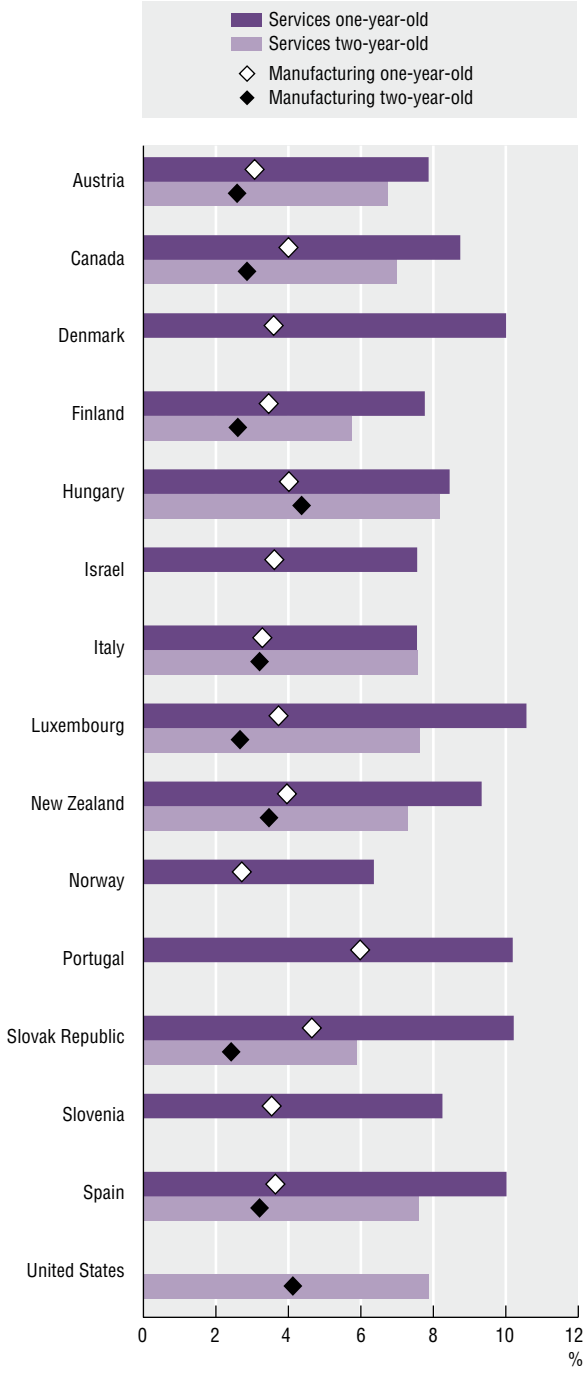
Product market regulations (PMR) indicators are quantitative indicators derived from qualitative information on laws and regulations that may affect competition. The qualitative information mainly comes from answers to a questionnaire by national administrations, the results of which are subject to peer review, which guarantees a high level of comparability across countries. Higher-level (composite) indicators, such as the barrier to entrepreneurship indicator, are calculated as weighted averages of their lower-level indicators using equal weights for aggregation. See OECD (2009b), *Economic Policy Reforms: Going for Growth 2009*, Chapter 7 and Annex 7.A1.

Personal income taxes and the differential between the treatment of self-employment income and wage income affect individuals' decision to start a business. Corporate taxes determine the after-tax returns on investment and therefore drive firms' investment decisions and potential entrepreneurs' decision on whether to start investing. Personal income tax rates on gross wage income are calculated using the OECD Taxing Wages framework, which allows for broad international comparability across countries. However, the difficulty of calculating comparable tax rates remains a significant burden for cross-country studies on the impact of taxation on entrepreneurship.

Entrepreneurship is not about firm size. It concerns a process that results in growth, creativity and innovation. Young dynamic firms fuel innovation by developing new or improving existing goods, services or processes.

One- and two-year-old employer enterprises in manufacturing and in services, 2006

As a percentage of the total population of employer enterprises



Source: OECD, Structural and Demographic Business Statistics Database, November 2009. See chapter notes.

StatLink http://dx.doi.org/10.1787/835714365117

DID YOU KNOW?

Companies less than five years old created nearly two-thirds of net new jobs in the United States in 2007.

(Kauffman Foundation, 2009, based on US Census data.)

An economy's share of young firms may indicate its dynamism. Younger firms are more prevalent in services than in manufacturing. There may be less turbulence in manufacturing, where older incumbents have acquired a strong competitive position over the years. It would be useful to have post-entry data on the performance of young businesses across countries to compare differences in their survival rates and determinants of growth across countries.

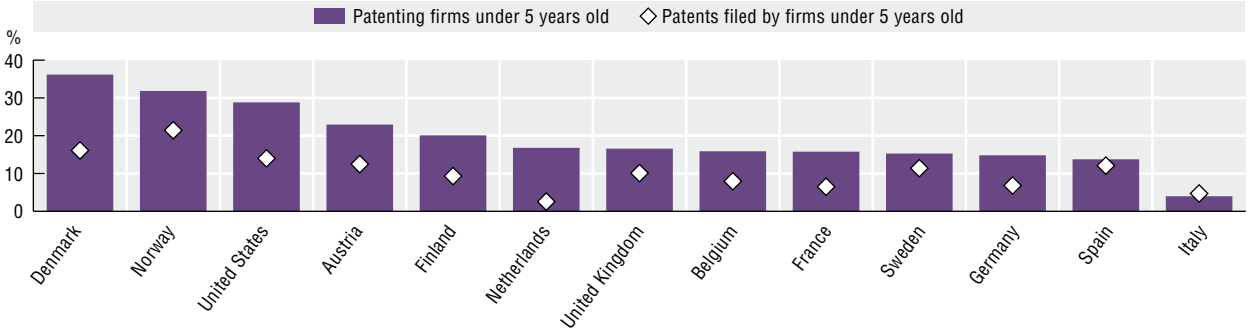
The presence of young firms among patent applicants underlines the inventive dynamics of firms early in their development. It shows their desire to develop new activities and products; this may affect their survival and relative growth. An experimental indicator obtained by the matching of patent filings with businesses listed in the ORBIS database is presented on the right page. This allows looking at the age distribution of patenting firms. This preliminary exercise successfully matches between 70 to 90 percent of total PCT filings depending on the country. In Austria, Denmark, Norway, Spain, Sweden, the United Kingdom and the United States, young firms filed 10% to over 20% of all PCT patents filed in 2005-07.

Definitions

The share of *n*-year-old employer firms for a particular year *t* refers to the number of *n*-year survival enterprises as a percentage of the total enterprise population in year *t*. The number of *n*-year survival enterprises for a particular year *t* is the number of enterprises with at least one employee for the first time in year *t-n* which have not exited in year *t*. This definition excludes cases in which enterprises merge or are taken over by an existing enterprise in year *t-n*.

Patenting activity of young firms, 2005-07

Share of young patenting firms and share of PCT patent filings by young firms



How to read this figure

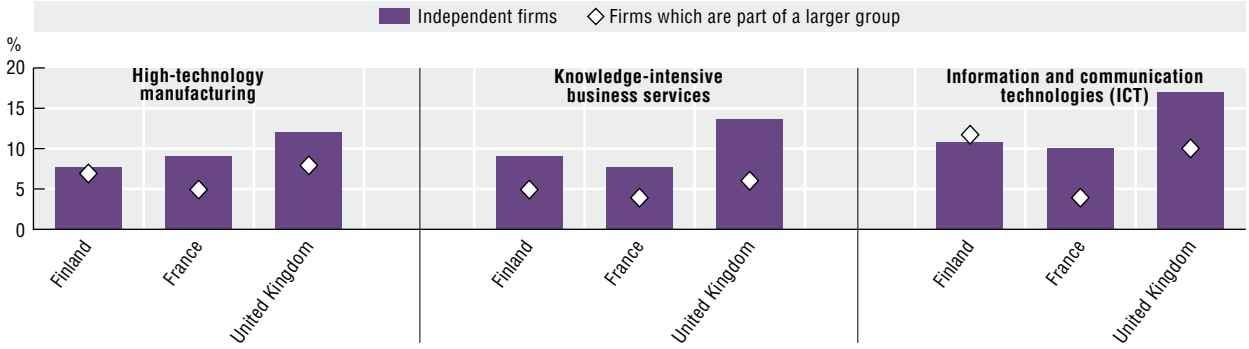
In Denmark, Norway, United States and Austria young firms represent over 20 per cent of patenting firms and they account for over 10 percent of all PCT filings in their respective countries. In other economies, such as Italy or the Netherlands, most of the PCT patent filings are by firms older than 5 years. These estimates are based on a preliminary matching of patent and business data.

Source: OECD, HAN Database, October 2009 and ORBIS© Database, Bureau Van Dijk Electronic Publishing, August 2008. See chapter notes.

StatLink http://dx.doi.org/10.1787/835714365117

Patenting and survival – within a two-year window, 2006

Survival rate differential between patenting and non-patenting firms (independent and part of a larger group)



How to read this figure

Firms that applied for a patent in 2004 had a higher survival rate after two years (2006) than firms that did not apply for a patent. For French firms in the ICT sector that are not part of a group, patenting firms had a 10% higher chance to survive than non-patenting independent firms in the same sector.

Source: OECD, Innovation and entrepreneurship microdata project, 2009. See chapter notes.

StatLink http://dx.doi.org/10.1787/835714365117

Measurability

Firm age is computed as the time elapsed between the date of incorporation and the priority date (date of first filing for a patent worldwide). To identify young firms among patent applicants, firms identified as PCT patent applicants were matched with the ORBIS© database from Bureau Van Dijk Electronic Publishing. The names of applicants as they appear in the patent were linked with those of firms listed in business registers. The exercise was first performed on European and US patentees listed in EPO and PCT patent applications. Coverage is being extended to other countries and other patent offices (the Japan Patent Office, the US Patent and Trademark Office). Ideally, this exercise should match national business registers with patent data. A pilot study was carried out as part of the OECD microdata project on entrepreneurship and innovation and covers Finland, France and the United Kingdom. It compared survival rates of firms that patented and those that did not (the patenting year is 2004, with survival observed in 2006). The data are broken down for independent firms and firms that are part of a group. The range of countries covered will be extended and more sophisticated indicators developed, *e.g.* the growth trajectory of patenting and non-patenting firms.

Notes

Cyprus

The following note is included at the request of 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 recognizes 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 »".

The following note is included at the request of all the European Union Member States of the OECD and the European Commission:

"The Republic of Cyprus is recognized 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".

Israel

"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."

"It should be noted that statistical data on Israeli patents and trademarks are supplied by the patent and trademark offices of the relevant countries."

3.1 ENTRY AND EXIT

Employer enterprise birth rate (2006) and death rate (2005) in the manufacturing sector

- Manufacturing refers to: Mining and quarrying; Manufacturing; Electricity, gas and water.
- For Canada, employer enterprises with fewer than 250 employees.

Employer enterprise birth rate (2006) and death rate (2005) in the services sector

- Services refers to: Wholesale and retail trade; Hotels and restaurants; Transport, storage and communications; Financial intermediation; real estate, renting and business activities.
- For Canada, employer enterprises with fewer than 250 employees.

3.2 MOBILISING PRIVATE FUNDING

Venture capital investment 2008

- The OECD defines here venture capital as the sum of "seed/start-up stages" and "early development and expansion stages". The latter includes:
  - For Australia, early expansion, late expansion, turnaround.
  - For Canada, other early stage, expansion, turnaround.
  - For Korea, initial-early stage, middle stage-early (firms 3 to 5 years), middle stage-late (firms 5 to 7 years).
  - For Japan, early stage, expansion.
  - For the United Kingdom, other early stage, expansion.
  - For the United States and Israel, early stage, expansion.
  - For European countries (except the United Kingdom), growth, rescue/turnaround.

Source: OECD, based on data from Thomson Financial, PwC, EVCA, National Venture Capital Associations, Australian Bureau of Statistics and Venture Enterprise Center.

Business angels, 2007

- Estimates for the number of business angel networks.
- In the United States, some angel capital organisations are funds rather than networks. Groups include networks plus funds.

3.3 POLICY ENVIRONMENT

Taxation on personal income and corporate income, 2009

General notes on the chart:

- Marginal tax rate, covering employees' and employers' social security contributions and personal income tax, with respect to a change of gross labour costs. It is given for a single person without dependents, at 167% of the average wage earner/average production worker. It assumes a rise in gross earnings of the principal earner in the household. The outcome may differ if the wage of the spouse goes up, especially if partners are taxed individually.
- The marginal rates are expressed as a percentage of gross wage earnings.
- The corporate income tax shows the basic combined central and sub-central (statutory) corporate income tax rate given by the adjusted central government rate plus the sub-central rate.

Notes on the statutory corporate income tax rate:

- For Australia, New Zealand and the United Kingdom, all with a non-calendar tax year, the rates shown are those in effect as of 1 July, 1 April and 1 April, respectively.
- In Belgium, the effective corporate income tax rate can be substantially reduced by a notional allowance for corporate equity.
- For France, the rates include a surcharge but do not include the local business tax (*Taxe professionnelle*) or the turnover-based solidarity tax (*Contribution de solidarité*).
- For Germany, the rates include the regional trade tax (*Gewerbesteuer*) and the surcharge.
- For Hungary, the rates do not include the turnover-based local business tax, the innovation tax and the credit institutions' surtax.
- For Italy, these rates do not include the regional business tax (*Imposta Regionale sulle Attività Produttive* – IRAP).
- Poland has no sub-central government tax, however local authorities (at each level) participate in a given percentage of the tax revenue.
- For Switzerland, church taxes, which enterprises cannot avoid, are included.
- For the United States, the sub-central rate is a weighted average state corporate marginal income tax rate.
- For the Netherlands it applies to taxable income over EUR 200 000.

Notes on the marginal personal income tax rate:

- For Greece, average wages overestimate actual gross earnings because they include benefits linked to marriage and children which are not available to all families.
- For Turkey, wage figures are based on the old definition of average worker (ISIC D, Rev.3).

3.4 YOUNG AND INNOVATIVE FIRMS

One- and two-year-old employer enterprises in manufacturing and in services, 2006

- Manufacturing refers to: Mining and quarrying; Manufacturing; Electricity, gas and water.
- Services refers to: Wholesale and retail trade; Hotels and restaurants; Transport, storage and communications; Financial intermediation; real estate, renting and business activities.
- For Canada, employer enterprises with fewer than 250 employees.

Patenting activity of young firms, 2005-07

- Data refer to patent applications filed under the Patent Co-operation Treaty (PCT) by firms with a priority in 2005-07. Counts are based on a set of patent applicants successfully matched with business register data.

Patenting and survival – within a two-year window, 2006

- The following list of industries was used to calculate the groupings:
  - *High-technology manufacturing*
    Manufacture of chemicals and chemical products (ISIC Revision 4: 2011); Manufacture of basic metals (2410); Manufacture of fabricated metal products (2599); Manufacture of computer, electronic and optical products (2610, 2620, 2630, 2640, 2651, 2660, 2670); Manufacture of electrical equipment (2710, 2733, 2740, 2790); Manufacture of machinery and equipment, n.e.c. (2811, 2817, 2819, 2822, 2829); Manufacture of motor vehicles, trailers, and semi-rail (2930); Manufacture of other transport equipment (3011, 3030); Other manufacturing (3250, 3290); Repair and installation of machinery and equipment (3312, 3313, 3314, 3315, 3319, 3320); Waste collection, treatment and disposal activities (3812, 3822); and Repair of computer and personal and household goods (9511, 9512, 9521).
  - *Knowledge-intensive business services*
    Mining support service activities (0910, 0990); Repair and installation of machinery and equipment (3312); Publishing activities (5811, 5812, 5813, 5819, 5820); Sound recording and music publishing activities (5920); Telecommunication (6110, 6120); Computer programming, consultancy and related activities (6201, 6202, 6209); Information service activities (6312); Professional, scientific and technical activities (6910, 6920, 7010, 7020, 7110, 7120, 7210, 7220, 7310, 7320, 7410, 7420, 7490); Employment activities (7810, 7820, 7830); and Repair of computers and peripheral equipment (9511).
  - *Information and communication technologies*
    Manufacture of computer, electronic and optical products (2610, 2620, 2630, 2640, 2651, 2670); Manufacture of electrical equipment (2731, 2732, 2790); Manufacture of machinery and equipment, n.e.c. (2817, 2819, 2829); Other manufacturing (3250, 3290); Repair and installation of machinery and equipment (3312, 3313, 3314, 3319, 3320); Wholesale trade (4651, 4652); Publishing activities (5811, 5812, 5813, 5819, 5820); Sound recording and music publishing activities (5920); Programming and broadcasting activities (6010, 6020); Telecommunication (6110, 6120, 6130, 6190); Computer programming, consultancy and related activities (6201, 6202, 6209); Information service activities (6312); Rental and leasing activities (7730); and Repair of computers and peripheral equipment (9511, 9512, 9521).

  For more details on the International Standard Industrial Classification (ISIC, Revision 4), see *www.unstats.un.org/unsd/cr/registry/regdntransfer.asp?f=135*.

Source: OECD, Working Party on Industry Analysis (WPIA) Innovation and Entrepreneurship Microdata Project, 2009.

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Chapter 4

INVESTING IN INNOVATION

Government plays an essential role in fostering public and private investment in innovation. A first set of indicators looks at investment in R&D and innovation performed by the business sector, government and higher education. Traditional input indicators are accompanied by "experimental" indicators, for example on the mix of direct and indirect public support to R&D, as well as measures of public funding "modes" (*e.g.* institutional versus project funding). A second set of indicators examines investment in smart ICT infrastructure at the aggregate level, as well as by business and governments.

Governments not only play a major role in fostering innovation, they actively participate in the innovation process and provide innovative services. Internationally agreed concepts and comparable metrics for studying innovation in the public sector do not yet exist. A "Gap page" highlights the need for such metrics and the scope for international action. There are also major gaps in our understanding of investments to support innovation and related responsibilities at different levels of government. A second "Gap page" addresses issues of measurement at the sub-national level.

4.1 • Firms investing in R&D 76
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4.5 • Information and communication technologies 84
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4.7 • Governments and smart infrastructure 88
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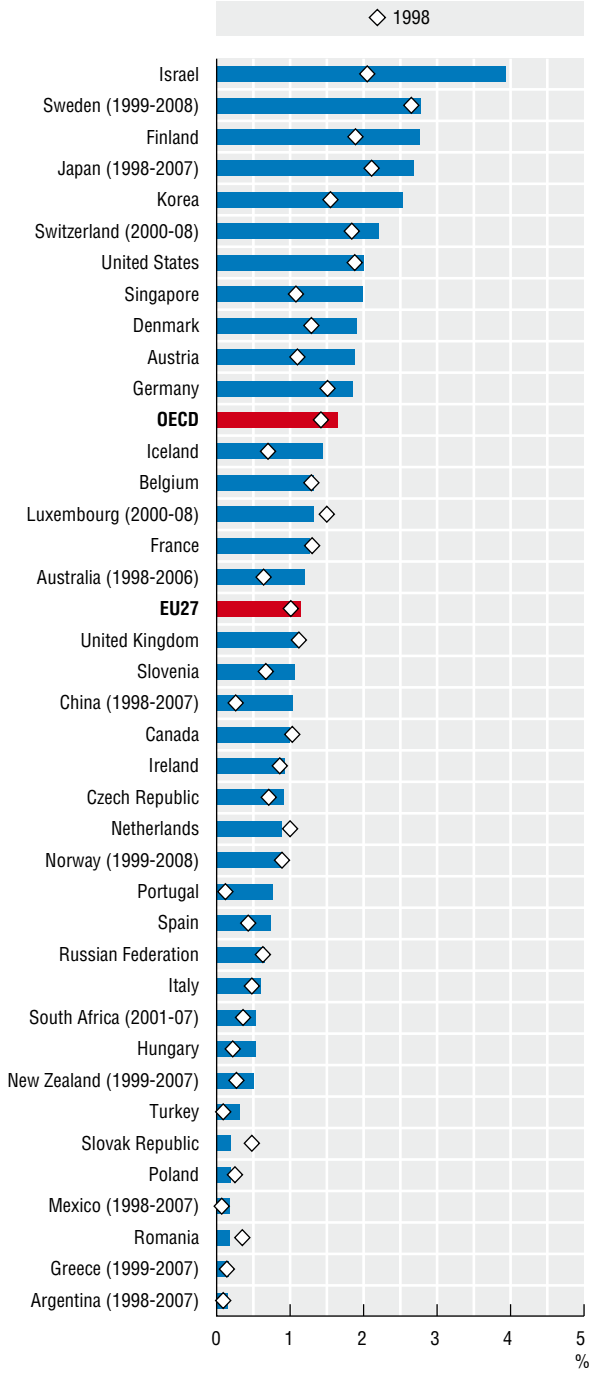
4.9 • Gap page – Multilevel governance of innovation 92

Innovation requires a wide array of public and private investments. However, private investment in R&D and innovation may be below a socially optimal level, mainly because returns are uncertain or the innovator cannot appropriate all the benefits. Governments play an important role in fostering investment in R&D and innovation.

Business enterprise expenditure on R&D, 2008

As a percentage of GDP



Source: OECD, Main Science and Technology Indicators Database, March 2010. See chapter notes.

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DID YOU KNOW?

22 OECD governments provide fiscal incentives to support business R&D.

(OECD, R&D tax incentives project, 2010.)

Business enterprise expenditure on R&D (BERD) is considered important for innovation and economic growth. It has frequently been used to compare countries' private-sector efforts on innovation. For OECD countries, business R&D accounted for 1.65% of GDP in 2008, slightly more than in 1998 (1.45% of GDP).

Governments can choose among various tools to leverage private-sector R&D. They can offer firms direct support *via* grants or procurement or they can use fiscal incentives, such as R&D tax incentives. Direct R&D grants/subsidies target specific projects with high potential social returns; tax credits reduce the marginal cost of R&D activities and allow private firms to choose which projects to fund.

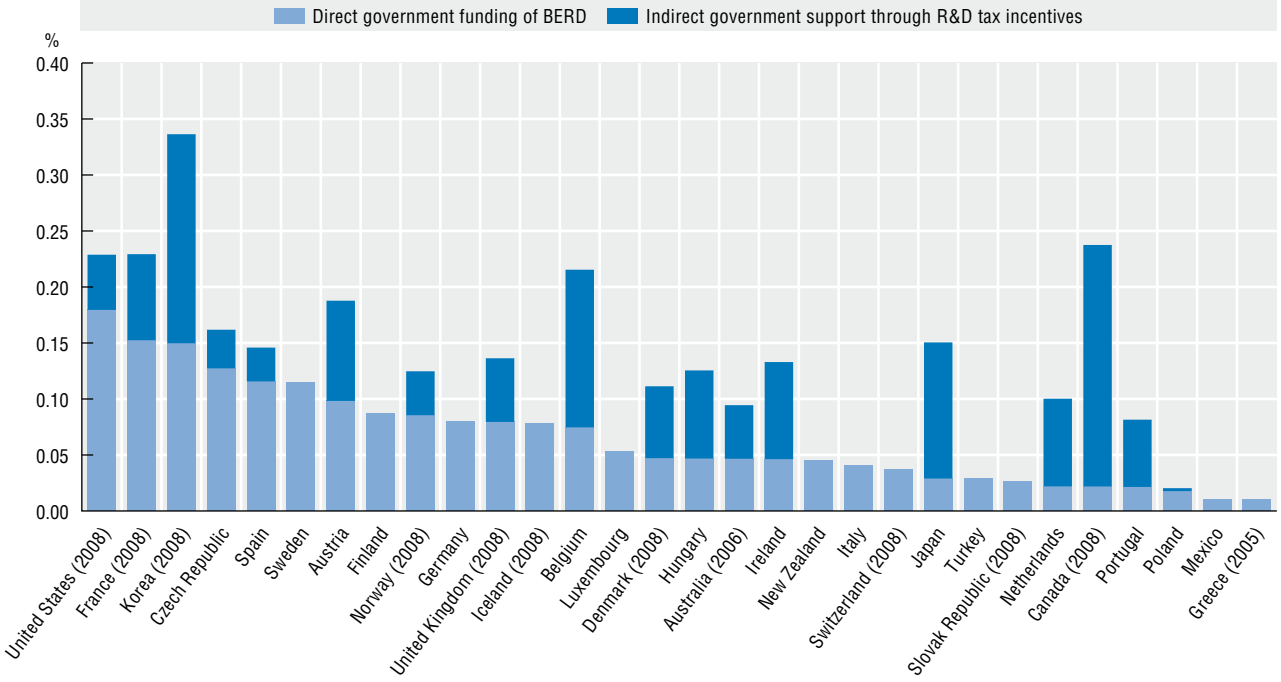
Countries differ in their use of direct and indirect support. The United States (through competitive R&D contracts) and Spain rely more on direct support, while Canada and Japan mostly use indirect support to foster industrial R&D. The optimal balance of direct and indirect R&D support varies from country to country, as each tool addresses different market failures and stimulates different types of R&D. For instance, tax credits mostly encourage short-term applied research, while direct subsidies affect more long-term research. A new indicator of this policy mix has been developed and gives a rather different picture of international comparisons of public support to R&D.

Definitions

Government direct R&D funding includes grants, loans and procurement. *Government indirect R&D funding* includes tax incentives such as R&D tax credits, R&D allowances, reductions in R&D workers' wage taxes and social security contributions, and accelerated depreciation of R&D capital.

Direct and indirect government funding of business R&D and tax incentives for R&D, 2007

As a percentage of GDP



Source: OECD, based on OECD, R&D tax incentives questionnaire, January 2010; and OECD, Main Science and Technology Indicators Database, March 2010. See chapter notes.

StatLink http://dx.doi.org/10.1787/835805814452

Measurability

Direct government funding of R&D is the amount of business R&D funded by the government as reported by firms. It is the sum of different components (contracts, loans, grants/subsidies) with different impacts on the cost of performing R&D. R&D grants and loans decrease the cost of performing R&D, but contracts (usually awarded through competitive bidding) do not directly affect the cost of performing R&D. More information on the different components is needed to better understand the impact of direct R&D support on firms' performance.

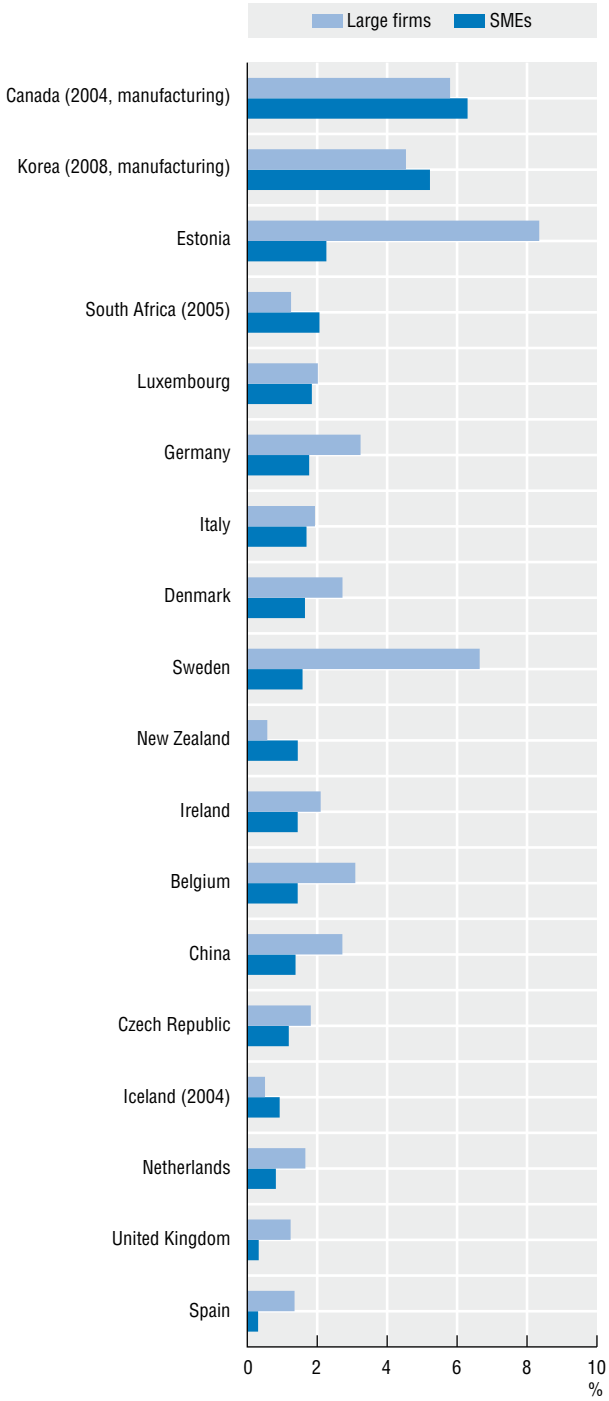
While information on total government direct support is available at both national and international levels, this is usually not the case for R&D-related tax expenditures. Their omission from measures of government-financed R&D leads to incomplete indicators of public R&D support. To gain a more complete view, the OECD developed a questionnaire to collect information on countries' R&D tax incentive schemes and to estimate the cost of such R&D tax incentives.

Countries' R&D schemes differ. Most countries provide fiscal incentives through tax credits or allowances and capital expensing. In Belgium, France, Korea and Spain, additional fiscal incentives are provided through reductions in R&D workers' wage taxes and social security contributions. In some countries, the reported cost of tax incentives differs from the real cost. For instance, Austria has both an R&D tax credit and R&D allowances but only reports the cost of the R&D tax credit. Belgium's tax incentives cover R&D expenditures but also include a deduction for patent income. When possible and to improve international comparability, figures are adjusted to meet the internationally accepted definition of R&D. The OECD is working to compare countries' R&D schemes and methodologies and to assess factors that affect the overall cost (inclusion of sub-national R&D tax credits, differences in firm eligibility, etc.).

Spending on innovation is more than spending on R&D. To develop new products or processes, firms invest in R&D and in other tangible and intangible assets. Governments play a role through programmes that encourage firms to continue investing in innovation-related activities.

Expenditure on innovation, by firm size, 2006

As a percentage of turnover



Source: OECD, Innovation microdata project based on CIS-2006, June 2009 and national data sources. See chapter notes.

StatLink http://dx.doi.org/10.1787/835838585236

DID YOU KNOW?

In most countries, 5-7% of firms' turnover comes from products that are new to the market.

(OECD, Innovation microdata project, 2010.)

Firms invest in innovation to gain market share, reduce costs or, more generally, to become more productive. For many firms, innovation is essential, as consumer demand has become more sophisticated and competition has increased.

On average, firms tend to spend 1-2% of turnover on various innovation-related activities, but this share exceeds 5% for large firms in some countries. R&D usually accounts for around one-half to two-thirds of all innovation expenditure, but the share varies widely by sector and firm size.

In addition to their own resources, many firms benefit from different public support programmes to encourage investment in innovation activities. Between one-tenth and one-third of innovating firms participate in such schemes, with large firms receiving public support more frequently than SMEs.

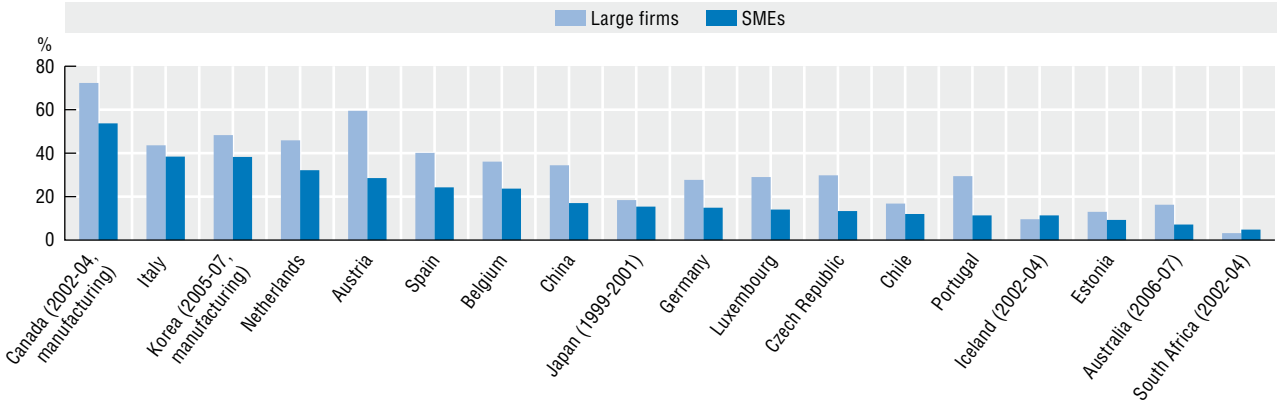
A recent OECD study using innovation surveys for 21 countries showed that firms receiving public support for innovation invest 40% to 70% more than those that do not. Also, higher levels of firms' investment in innovation lead to higher innovation sales and productivity.

Definitions

Expenditure on innovation includes total expenditure incurred by firms for the following activities: intramural R&D; extramural R&D; acquisition of other external knowledge (*e.g.* patents, licences, trademarks); and acquisition of machinery, equipment and software. *SMEs* are firms with fewer than 250 employees. *Public support to innovation* includes financial support via tax credits, grants and loans. *New–to-market product innovations* are new or significantly improved goods or services introduced to the firm's market before its competitors, while *new-to-firm product innovations* are goods and services already available on the market.

Firms receiving public support for innovation, by size, 2004-06

As a percentage of innovating firms



Source: OECD, Innovation microdata project based on CIS-2006, June 2009 and national data sources. See chapter notes.

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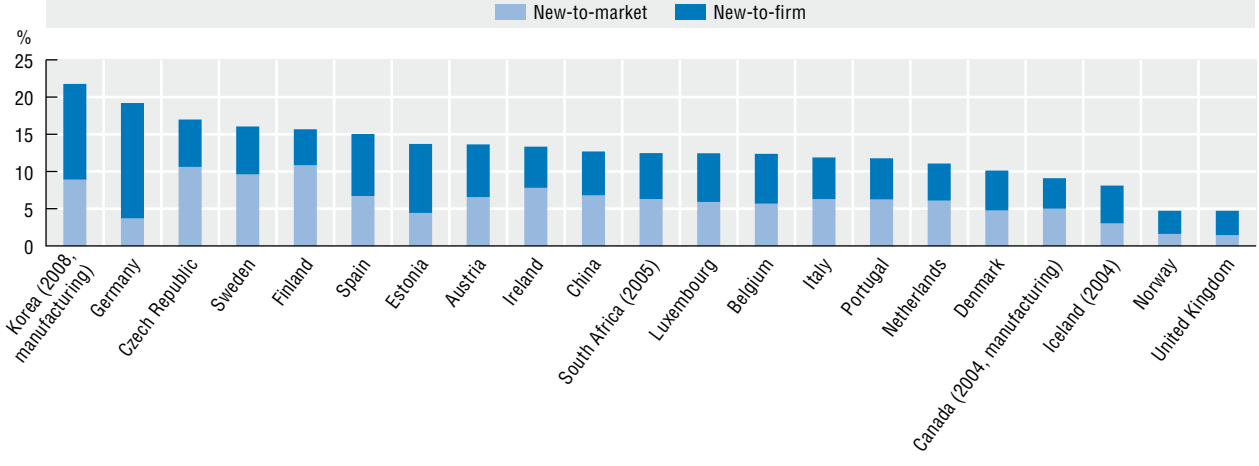
Firms' turnover from product innovation, by type of innovator, 2006

As a percentage of total turnover



Source: OECD, Innovation microdata project based on CIS-2006, June 2009 and national data sources. See chapter notes.

StatLink http://dx.doi.org/10.1787/835838585236

Measurability

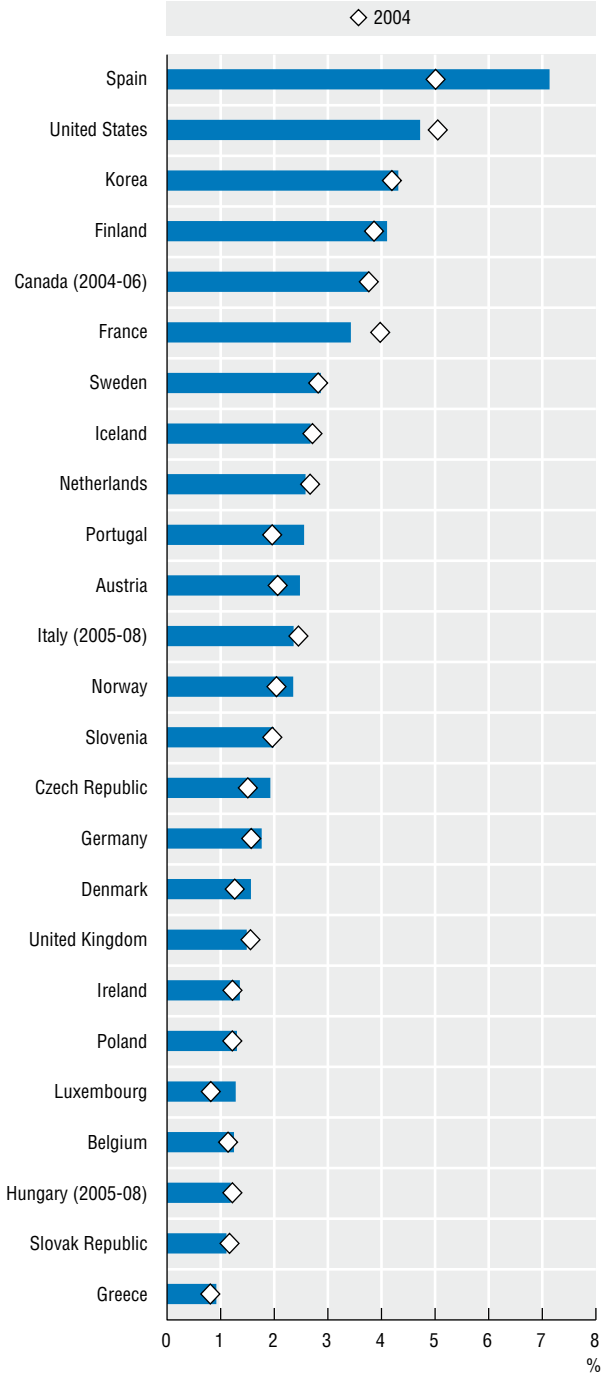
The *Oslo Manual* (OECD and Eurostat, 2005) provides a framework for countries to develop internationally comparable innovation surveys. These surveys collect information on the characteristics of firms that innovate, but much of it is qualitative or based on binary/ordinal scales and measurement challenges remain, such as collecting reliable data on innovation expenditure. Firms may not always be able to distinguish the innovation component of certain expenditures or to report reliable figures for some (non-R&D) activities. The CIS provides a common framework, but national surveys are not always fully comparable, and some important differences remain between the CIS and innovation surveys outside Europe in terms of methodology, scope and data collected. For example, in the CIS expenditures only refer to product and process innovations, while in other surveys, they can include a broader range of activities.

The OECD works to improve harmonisation between surveys as well as to develop new policy-relevant indicators using firm-level data from innovation surveys (OECD [2009a], *Innovation in Firms: A Microeconomic Perspective*). Data linkages with administrative databases or with earlier waves of innovation surveys will be needed to better measure the impact of innovation activities.

Governments perform in-house R&D and also finance R&D in various sectors of the economy. They play many roles in the innovation system, such as providing education, training and skills development, fostering knowledge creation and diffusion, and supporting the R&D efforts of firms.

Government budget appropriations or outlays for R&D, 2007

As a percentage of total government outlays



Source: OECD, Research & Development Database, December 2009; OECD Annual National Accounts Database, March 2010. See chapter notes.

StatLink http://dx.doi.org/10.1787/835870280132

DID YOU KNOW?

OECD countries' stimulus packages for science, R&D and innovation ranged from 0.1% to 0.3% of GDP.

(OECD, Policy Response to the Economic Crisis: Investing in Innovation and Long-Term Growth, 2009.)

Governments invest in R&D for different purposes (national defence, environment, health, etc.). These are usually projects with high social impact but low short-term economic impact or large scientific projects that are too expensive and risky for private-sector investment alone (*e.g.* space research).

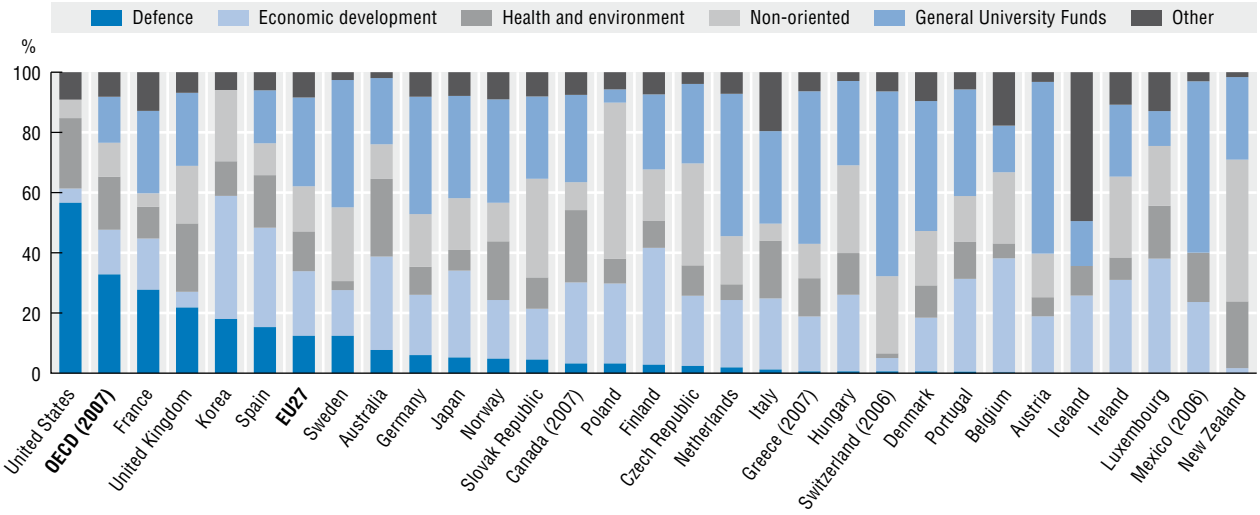
In 2007, OECD central governments invested 1% to 7% of their total budget in R&D activities. Spain had the largest increase in the last few years, with more than 7% of total central government outlays for R&D funding.

Countries vary widely in terms of the importance of funding by socioeconomic objective and by performance sectors. These differences reflect national priorities and differences in countries' national innovation systems. For instance, Poland's high share of public funding to public research organisations and Israel's high share of public funding to the business sector reflect the particularities of each national innovation system.

Definitions

Government budget appropriations or outlays for R&D (GBAORD) are the funds committed by the federal/central government for R&D. It can be broken down by sectors of performance (business enterprise, government, higher education and private non-profit) and by socioeconomic objectives (the main ones are shown on the facing page). *Total government outlays* are current outlays (*e.g.* current consumption, transfer payments, subsidies) and capital outlays. Data refer to the central/federal government only to be consistent with the definition of GBAORD. For countries which include regional and local R&D expenditures in their GBAORD estimates (Belgium, Denmark, Germany, Ireland and United Kingdom), total government outlays include the sub-national aggregates. *General university funds* (GUF) is the estimated R&D content of government block grants to universities (*Frascati Manual*, 2002).

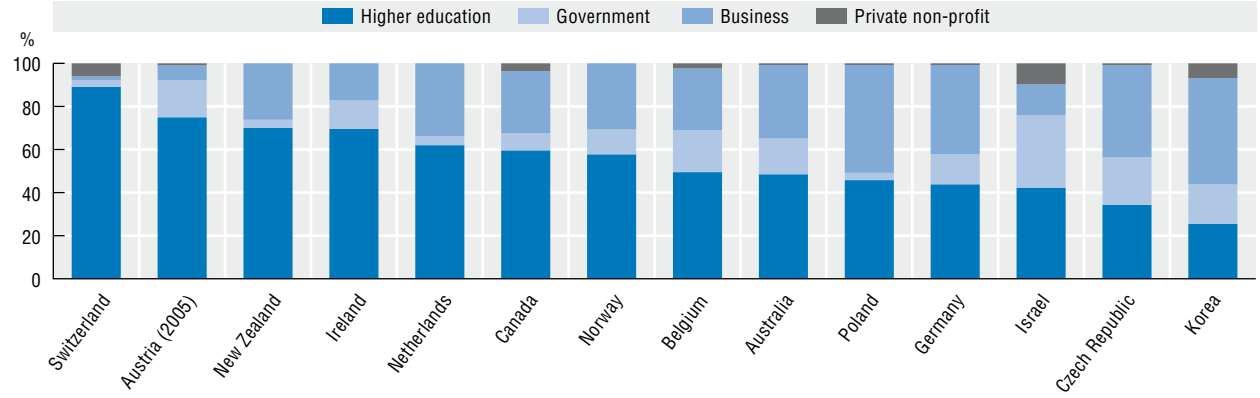
Government budget appropriations or outlays for R&D, by selected socio-economic objectives, 2008



Source: OECD, Research & Development Database, December 2009. See chapter notes.

StatLink http://dx.doi.org/10.1787/835870280132

Government budget appropriations or outlays for R&D, by national sector of performance, 2008



Note: This is an experimental indicator. International comparability is currently limited.
Source: OECD, based on preliminary data from the Microdata project on public R&D funding, 2009. See chapter notes.

StatLink http://dx.doi.org/10.1787/835870280132

Measurability

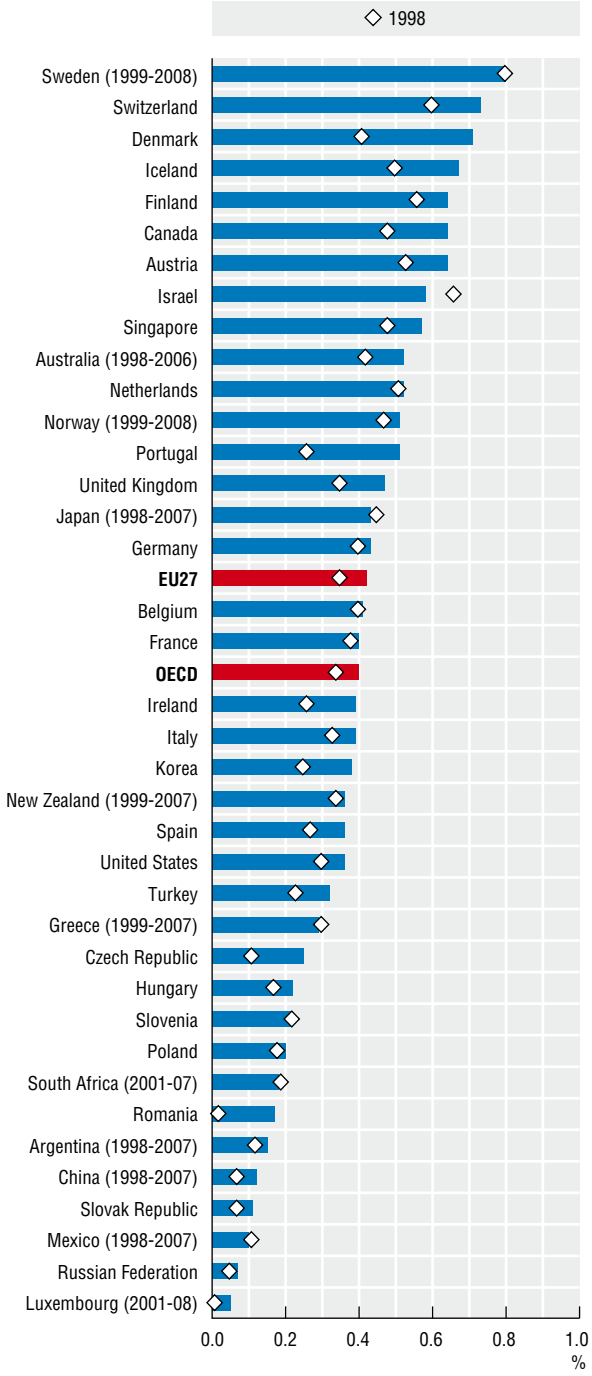
GBAORD (government budget appropriations or outlays for R&D) represents the funds committed for R&D by the federal/central government to be carried out by business enterprise, government, higher education and private non-profit organisations at home or abroad (including international organisations). The data are usually based on budgetary sources and reflect the views of the funding agencies. They are generally considered less internationally comparable than performer-reported data, but they are more timely and reflect current government priorities, as expressed in the breakdown by socioeconomic objectives.

The OECD project on modes of public R&D funding is currently developing new indicators based on the type of instrument (academic, innovation and policy, or thematic instruments) or funding agencies (line ministry, independent agency, etc.). The indicators are still experimental, but NESTI (OECD Working Party of National Experts in Science and Technology Indicators) is working to develop methodological guidelines for refining and institutionalising their collection.

Most basic research is performed in universities and in public research organisations. Public support for such research remains crucial. It is essential for developing new scientific and technological knowledge and the human capital that can lead to innovation to benefit the economy and society.

Higher education expenditure on R&D, 2008

As a percentage of GDP



Source: OECD, Main Science and Technology Indicators Database, March 2010. See chapter notes.

StatLink http://dx.doi.org/10.1787/836005248761

DID YOU KNOW?

On average, more than three-quarters of all basic research in the OECD is performed by governments and universities.

(OECD, Research & Development Database, 2009.)

University spending on R&D accounts for 0.40% of GDP in the OECD area, a share that has increased in most countries over the last decade. This shows the growing importance of universities as providers of useful new knowledge and as trainers of the researchers and other highly skilled workers on which knowledge-based economies rely. In most countries, university basic research accounts for 40% to 70% of all basic research performed in the country.

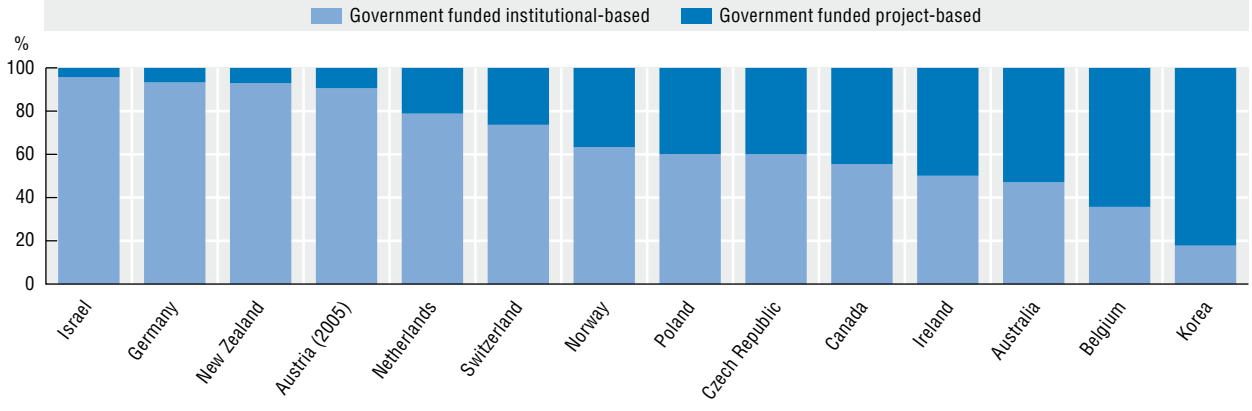
Governments rely on two main modes of direct R&D funding: institutional and project-based. Institutional funding can help ensure stable long-run funding of research, while project-based funding can promote competition within the research system and target strategic areas.

A new indicator has been developed on modes of public funding to the higher education sector (see right-hand page). Government R&D funding modes vary widely and reflect the institutional settings of countries' research systems. In Germany, Israel and New Zealand, institutional funding is the principal mode, while Belgium and Korea rely mainly on project funding. The mix of funding modes can only be changed over the longer run through reforms of the research system.

Definitions

Project funding is defined as funding attributed on the basis of a project submission to a group or individuals for an R&D activity that is limited in scope, budget and time. *Institutional funding* is defined as the general funding of institutions with no direct selection of R&D projects or programmes. *Basic research* is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view. The *public sector* comprises the government and higher-education sectors.

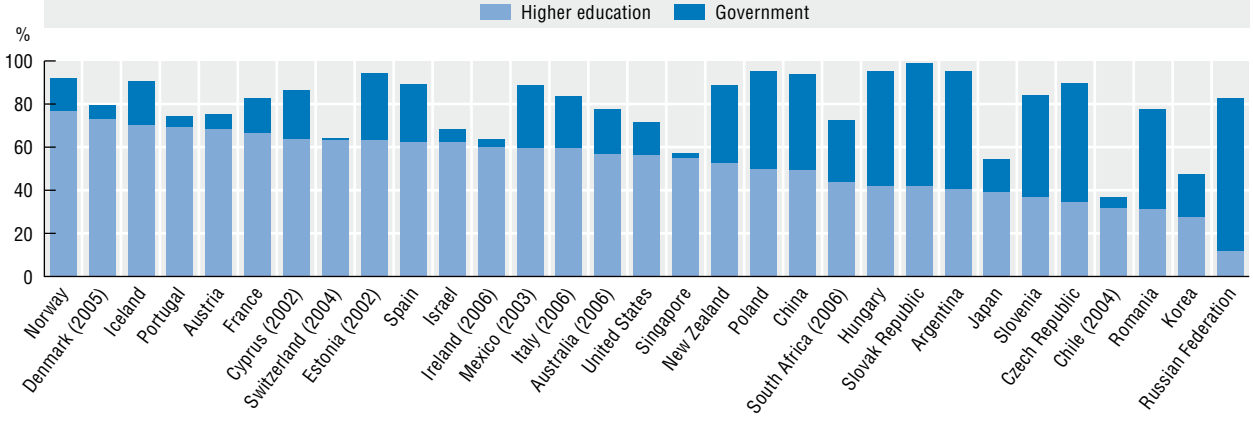
Government funded R&D in higher education, by type of funding, 2008



Note: This is an experimental indicator. International comparability is currently limited.
Source: OECD, based on preliminary data from the Microdata project on public R&D funding, 2009. See chapter notes.
StatLink http://dx.doi.org/10.1787/836005248761

Basic research performed in the public sector, 2007

As a percentage of national basic research



Source: OECD, Research & Development Database, December 2009. See chapter notes.
StatLink http://dx.doi.org/10.1787/836005248761

Measurability

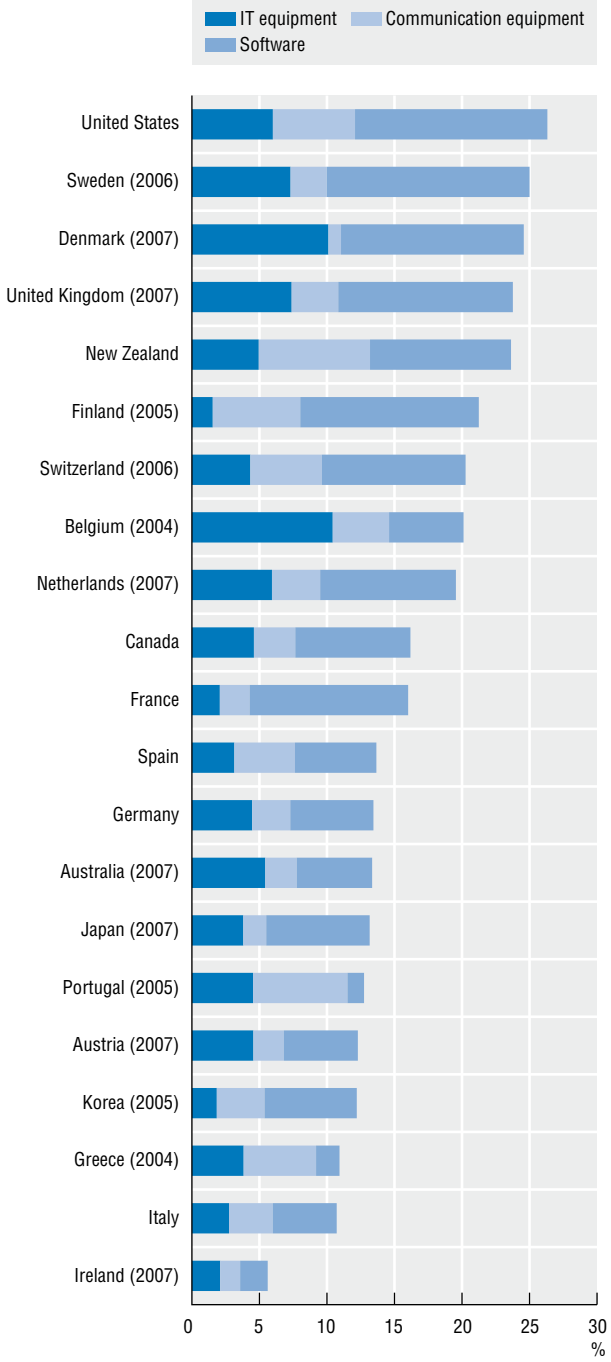
Data on R&D in higher education can be broken down by field of science (natural sciences, engineering, medical sciences, agricultural sciences, social sciences and humanities), by type of costs (current expenditures, capital expenditures), and by source of funds (business enterprise, government, higher education, private non-profit and funds from abroad). Measures of R&D performance in the higher education sector are often estimates by national authorities and evaluation methods are periodically revised. It is necessary to review the design and conduct of higher education R&D surveys to improve the comparability of these indicators.

Project-based funding to higher education includes R&D national contracts from line ministries or government contributions to national funding agencies (*e.g.* research councils). Institution-based funding to higher education includes general university funds (GUF) and other institutional funds. The OECD project on modes of public funding of R&D is developing new indicators by exploiting existing budget data. The project demonstrates the feasibility of collecting these experimental indicators. NESTI (OECD Working Party on National Experts in Science and Technology Indicators) is working to develop methodological guidelines for refining and institutionalising their collection.

Investment in information and communication technology (ICT) is important for a country's economic growth. At the firm level, it provides an essential platform for changing organisational methods and introducing new products and processes.

ICT investment, by asset in OECD countries, 2008

As a percentage of non-residential gross fixed capital formation, total economy



Source: OECD, Productivity Database, April 2010; *www.oecd.org/statistics/productivity*. See chapter notes.

StatLink http://dx.doi.org/10.1787/836006258516

DID YOU KNOW?

Software accounts for 10% of total investment in the OECD area .

(OECD Science, Technology and Industry Scoreboard 2009.)

ICT has the potential to increase innovation by speeding up the diffusion of information, favouring networking among firms, reducing geographic limitations and increasing efficiency in communication.

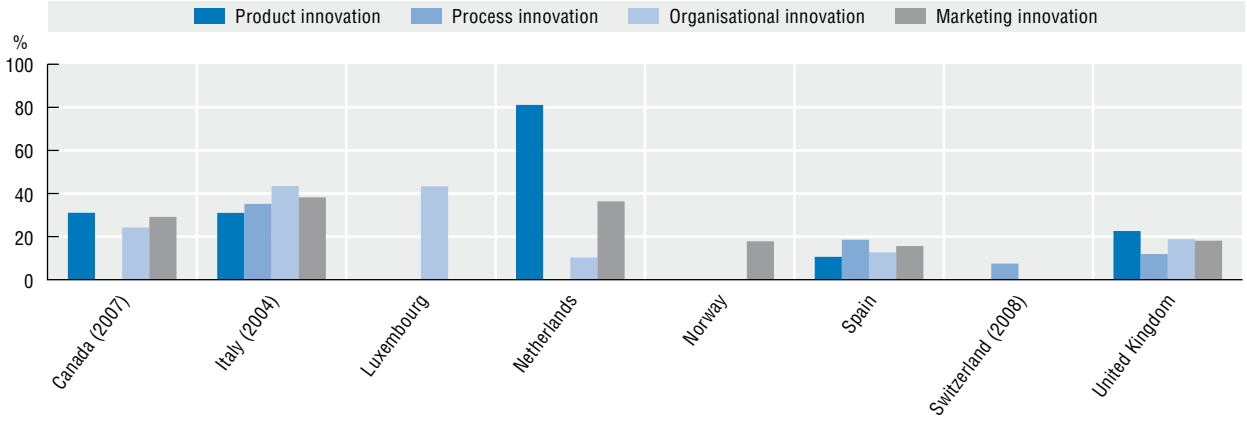
Most national studies show the positive impact of ICT investment on GDP growth, but OECD countries continue to differ markedly in this respect. ICT represents around 25% of total fixed non-residential investment in Denmark, Sweden and the United States but around 10% or less in Ireland, Italy and Greece.

New OECD analysis at firm level shows that ICT enables innovation. The probability to innovate increases with the intensity of ICT use. This is true for both manufacturing and service firms and for different types of innovation, although here too countries differ. Further analysis is needed to assess whether these differences are due to national factors or to statistical differences in the measurement of innovation and ICT use.

Definitions

Expenditure on ICT products is considered investment only if the products can be physically isolated. (*e.g.* ICT embodied in equipment is not considered investment). *ICT use* is measured by two variables: number of website facilities for e-commerce (*i.e.* to sell to customers) and number of automatic links for e-business (*i.e.* to buy from and sell to other firms). The figures report the largest effect linked to ICT use (number of website facilities for e-commerce and automatic links for e-business). Missing bars indicate that the effect of ICT is not statistically significant. Other factors that may affect the probability to innovate (firm size, R&D and skills) are controlled for by the econometric technique used.

Increase in the probability to innovate linked to ICT use, manufacturing, 2006



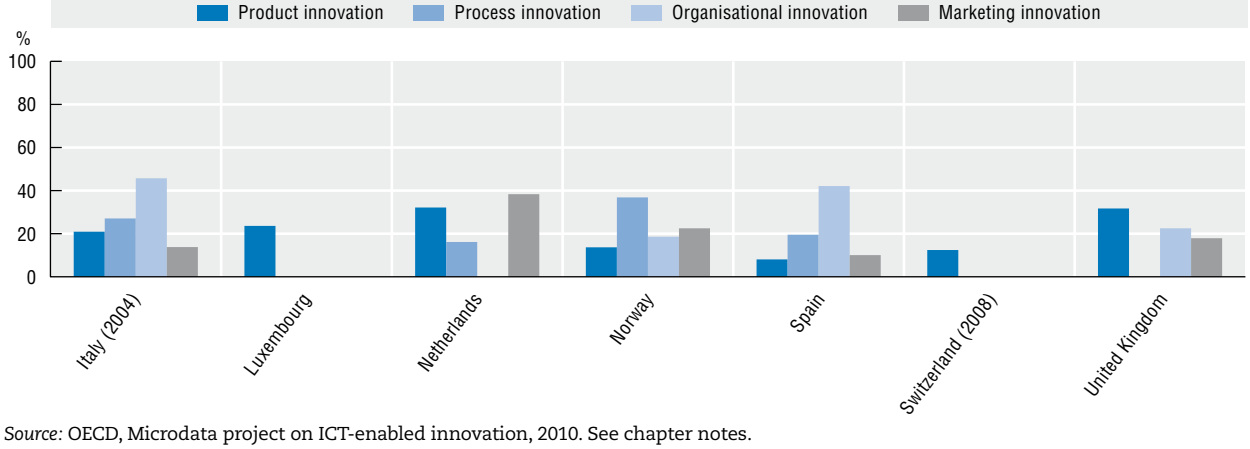
How to read this figure

Canadian manufacturing firms with high ICT use (large number of website facilities for e commerce) are 31% more likely to introduce a product innovation, 24% more likely to introduce an organisational innovation and 29% more likely to introduce a marketing innovation than those not using ICT (website facilities). ICT use does not have any impact on probability of introducing process innovation for Canadian manufacturing firms.

Source: OECD, Microdata project on ICT-enabled innovation, 2010. See chapter notes.

StatLink http://dx.doi.org/10.1787/836006258516

Increase in the probability to innovate linked to ICT use, services, 2006



Source: OECD, Microdata project on ICT-enabled innovation, 2010. See chapter notes.

StatLink http://dx.doi.org/10.1787/836006258516

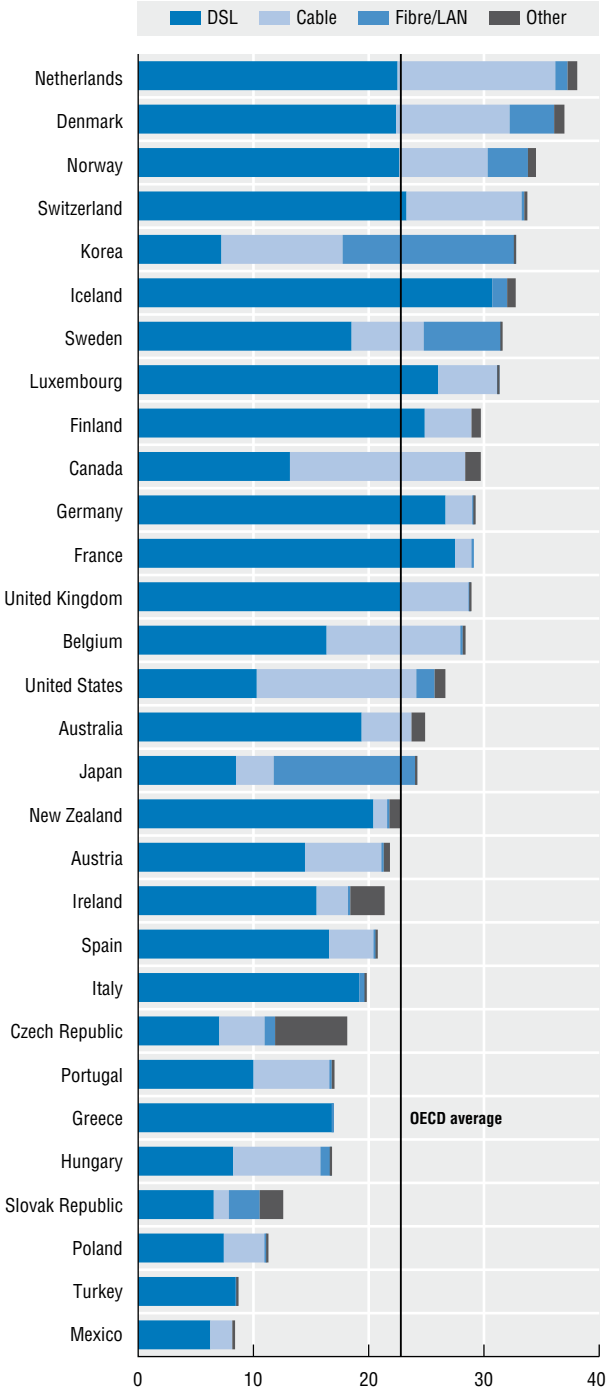
Measurability

Correct measurement of investment in ICT in both nominal and volume terms is crucial for estimating the contribution of ICT to economic growth and performance. Data availability and measurement of ICT investment based on national accounts (SNA 93) vary considerably across OECD countries, especially for investment in software, deflators applied, breakdown by institutional sector and temporal coverage. In the national accounts, expenditure on ICT products is considered investment only if these can be physically isolated (ICT embodied in equipment is considered not investment but intermediate consumption). Thus, ICT investment may be underestimated, depending on how intermediate consumption and investment are treated in a country's accounts.

A new OECD project analyses the effect of ICT use on probability to innovate. It is based on firm-level data from ICT business surveys and innovation surveys in eight OECD countries. Results for a larger set of countries are expected.

Today, high-speed broadband networks support innovation throughout the economy much as electricity and transport networks spurred innovation in the past. Innovations such as smart electrical grids, tele-medicine, intelligent transport networks, interactive learning and cloud computing will require fast communication networks to operate efficiently.

OECD broadband subscribers per 100 inhabitants, by technology, June 2009



Source: OECD, Broadband Statistics, June 2009; *www.oecd.org/sti/ict/broadband.*

StatLink http://dx.doi.org/10.1787/836026204506

DID YOU KNOW?

The transformation of the newspaper, music and video industries indicates how broadband has become the leading delivery system for a wide range of content.

(OECD, Broadband Statistics, 2009.)

High-speed broadband access has changed personal and business practices dramatically. It has enabled broader participation in the innovation process by opening it beyond customers, suppliers, competitors, government laboratories and universities to consumers. It has transformed some sectors by making outsourcing and off-shoring more efficient.

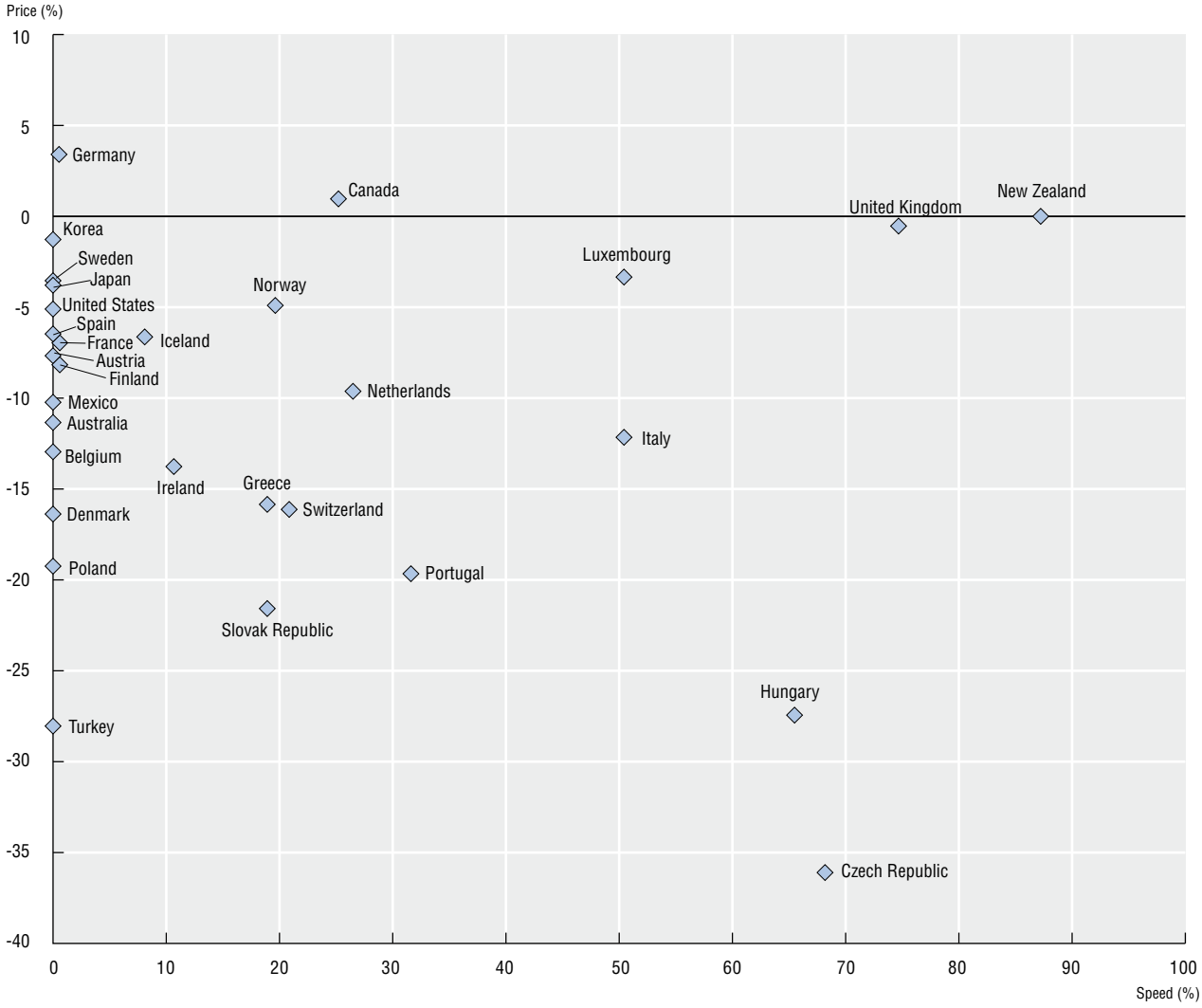
Statistics show that future growth in super-fast broadband is likely to come from fibre-optic networks rather than DSL or cable. Nearly one in ten OECD subscribers currently accesses the Internet over fibre. In Japan and Korea, most access Internet over fibre. Fibre connections are growing fast in Denmark, Norway, Sweden and the United States.

One way to trace the evolution of market broadband prices is to take a representative offer and follow over time its characteristics, such as price, advertised speed and data allowance. From 2005 to 2009, prices generally declined while speeds increased in many OECD countries.

Definitions

Broadband includes all subscriptions to DSL lines, cable modem, fibre-to-the-premises (*e.g.* house, apartment) and fibre-to-the-building subscribers (*e.g.* apartment LAN) which are capable of download speeds of at least 256 kbit/s. *Other* includes fixed wireless technologies (satellite, LMDS, MMDS, WiMAX [fixed] and other fixed-wireless transport technologies) with speeds faster than 256 kbit/s to end users. It does not include 3G mobile technologies and Wi-Fi.

Evolution of a representative DSL broadband subscription over time, 2005-09



How to read this figure

The speed of the Czech DSL offer increased by almost 70% and its price fell by over 35% during the period.

Source: OECD, Broadband Statistics, December 2009; *www.oecd.org/sti/ict/broadband*. See chapter notes.

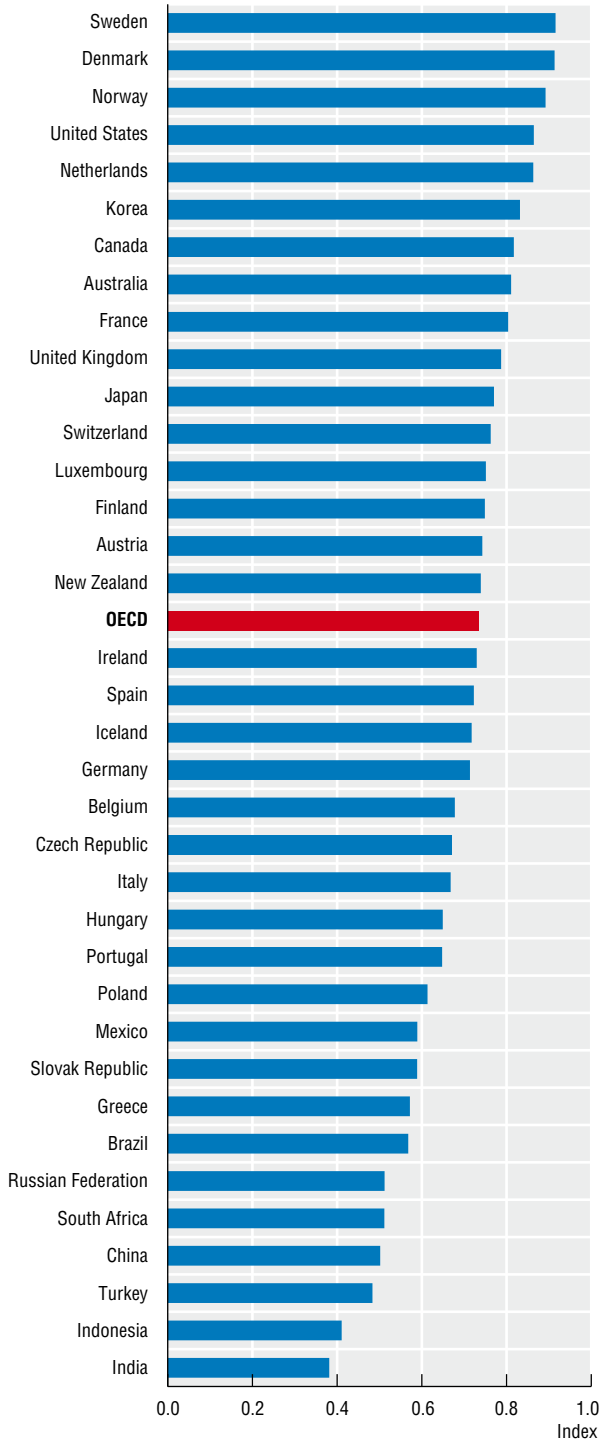
StatLink http://dx.doi.org/10.1787/836026204506

Measurability

The two leading technologies currently used to provide high-speed Internet access are digital subscriber lines (DSL) and cable modem. Other broadband access technologies include fibre-optic lines installed to users' homes or to their buildings. Fixed wireless connections and satellite are also available but represent less than 2% of all broadband subscriptions. The data for broadband subscribers include business and residential connections. Broadband delivered over mobile networks is not included but will continue to evolve as an important platform for connectivity and innovation. The OECD has developed a new measure of wireless broadband connectivity which will help policy makers follow growth in this segment.

Fostering innovation in the public sector at all levels of government enhances the delivery of public services, improves efficiency, coverage and equity, and creates positive externalities in the rest of the economy.

E-government readiness index, 2008



Source: UN (2008), *UN e-Government Survey 2008, From e-Government to Connected Governance*, UN, New York.

StatLink http://dx.doi.org/10.1787/836040668574

DID YOU KNOW?

380 million people used e-voting machines in India during the 2004 legislative elections.

(United Nations Development Programme, 2004.)

A high level of readiness to develop and implement e-government services is a prerequisite for a high-performing, innovative public sector which delivers integrated services for citizens and businesses. E-government readiness is a significant indicator of how prepared a country is to use ICT-enabled public administrations for greater efficiency.

OECD countries' capacity to develop and implement e-government services is generally based on an extensive broadband infrastructure; a repository of electronic information on government laws and policies, including links to archived information and downloadable forms; and a high level of familiarity with ICT among citizens and businesses.

Scandinavian countries lead on the readiness index and generally share similar e-government environments (*e.g.* accessibility and penetration of the electronic infrastructure) and strategies (*e.g.* online provision of services).

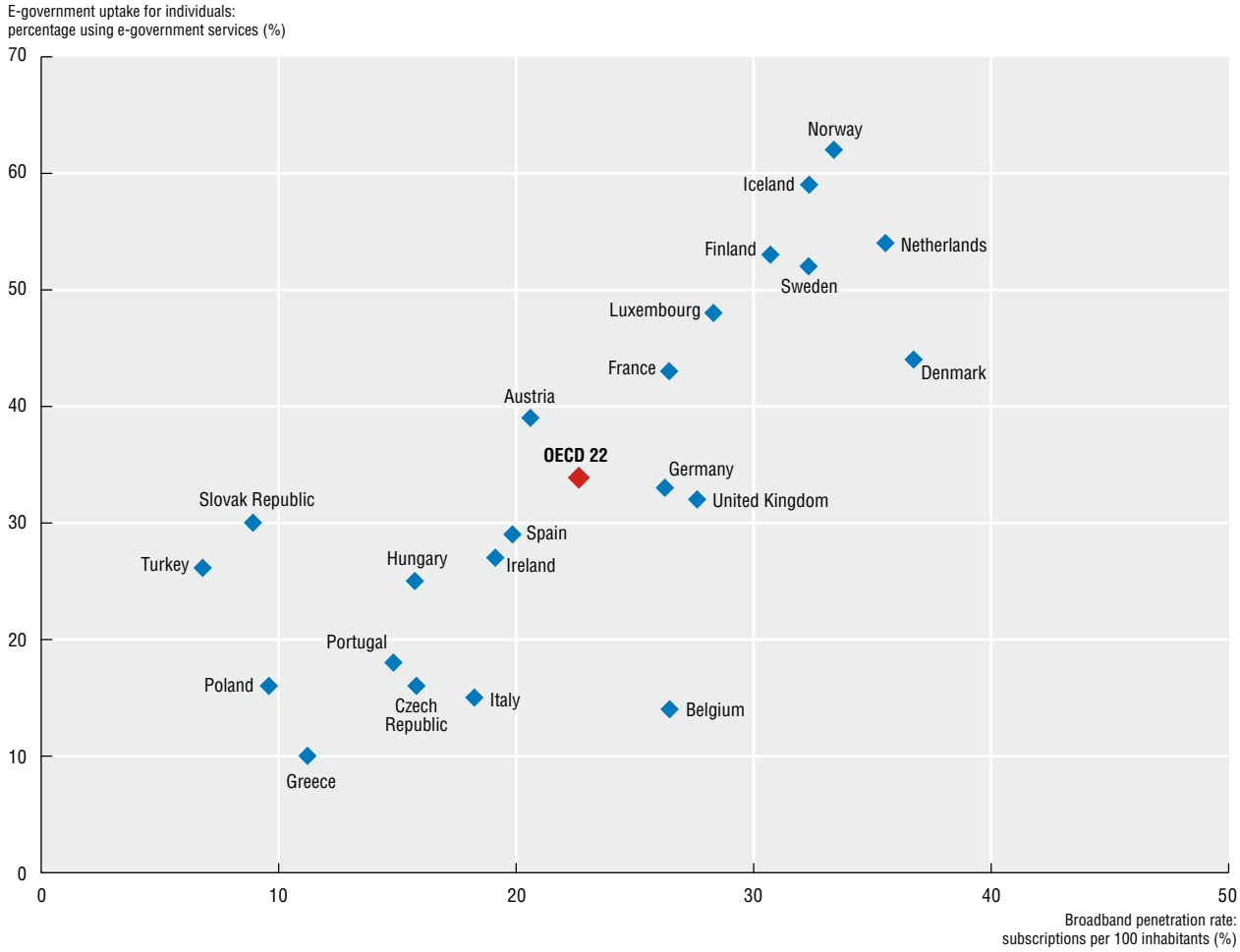
As Internet access is a prerequisite for using e-government services, it is a leading indicator of countries' readiness to harness the potential efficiencies of ICT. One driver for uptake is the penetration of broadband infrastructure in society. The data indicate a strong correlation between the penetration of broadband and the use of e-government services by citizens.

Definitions

The e-government readiness composite index is created by the United Nations and measures the capacity of governments to develop and implement e-government services. The index ranges from 0 (low level of readiness) to 1 (high level). Developed for the UN global e-government survey, the indicator has three sub-indices: web measure, telecommunication infrastructure and human capital.

The e-government take-up by citizens indicator measures the percentage of individuals (aged 16-74) who used the Internet to interact with public authorities in the three months preceding the Eurostat's annual Community Survey on ICT Usage.

Relation between broadband penetration and citizen uptake of e-government services, 2008



Source: OECD (2009d), *Government at a Glance 2009*, OECD, Paris. See chapter notes.

StatLink http://dx.doi.org/10.1787/836040668574

Measurability

OECD countries are transforming government through the use of ICT and ICT-enabled governance structures, new collaboration models (*i.e.* sharing data, processes and portals), and networked or joined up administrations. Transformation of the public sector and e-government are increasingly seen as closely linked policy areas. OECD e-government studies have shown that ICT is increasingly used to support broader public sector efforts to create a more coherent, user-focused and efficient public sector. ICT can change service delivery approaches by creating personalised, high-quality services, thereby increasing user satisfaction and effective service delivery. It facilitates major changes in work organisation and management through back-office coherence and greater efficiency. It increases the transparency of government activities as well as citizen engagement.

However, there is little empirical evidence on these effects. Traditionally, measurement has been limited to input and output indicators, which do not properly capture transformation processes and the outcomes of transformation. To fill this gap, the OECD Directorate for Public Governance and Territorial Development reviewed existing e-government performance indicators. The results of OECD (2009d), *Government at a Glance 2009*, combined with lessons learned from numerous e-government reviews, today form the basis for developing valid and reliable performance indicators mainly focused on service delivery (*e.g.* user take-up and satisfaction, administrative simplification) and organisational indicators (*e.g.* lower administrative burdens, staff satisfaction and skill levels).

Governments are important actors in the innovation process. Not only can they foster innovative activities by firms, they can also develop their own innovations in order to develop more efficient processes and enhance the quality and availability of public services. Even though internationally agreed concepts and metrics for measuring innovation exist for the private sector, there is not as yet a similar framework for the public sector.

Why do we need indicators ?

Innovation is now perceived as encompassing the generation, adoption and diffusion of new ideas. A wide range of indicators have been progressively developed to measure the innovation activities of firms (based on the *Oslo Manual*) but little is known about public-sector innovation dynamics. Many studies have shown (sometimes contrary to public perceptions) that the public sector not only fosters innovation activities in firms but can also be a source of innovation.

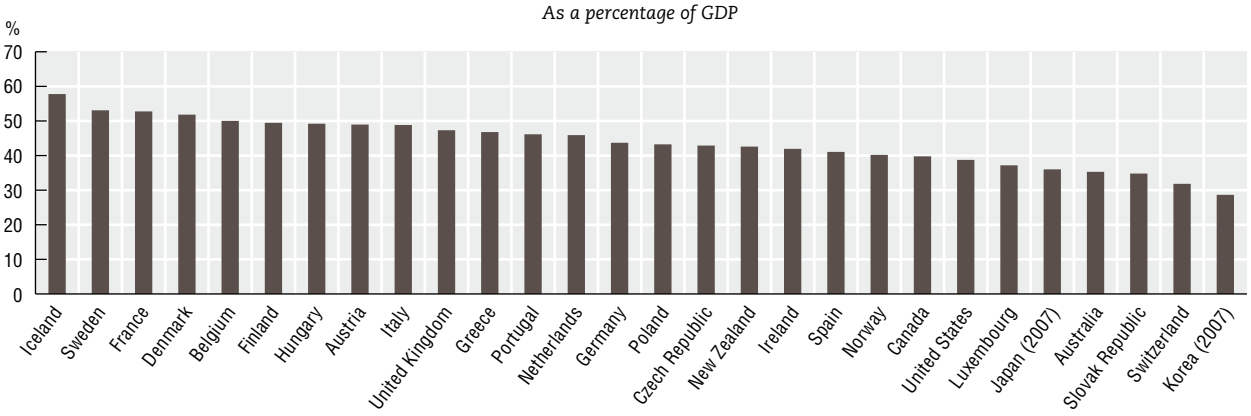
The public sector is an important economic actor, accounting for between one-third and over one-half of GDP in most OECD countries. Innovation is a key tool for achieving its multiple goals (increasing welfare, improving the quality of life of its citizens, ensuring a stable, fair and predictable environment for economic activities) and for addressing global challenges (*e.g.* health, poverty, climate change, food security).

Recent drivers behind innovation in the public sector include rising costs in today's constrained budgetary environment, demand for services due to demographic changes, ongoing pressures to contain costs and improve efficiency, growing demand for accountability, and the need to improve the quality and availability of public services (including education and health).

Measurement efforts should focus not only on monitoring efficiency and costs, but also on providing a broad set of indicators that can shed light on innovation processes in public sector organisations and show how these can help governments meet their goals.

Total expenditure of general government, 2008

As a percentage of GDP



Source: OECD, National Accounts Database, April 2010.

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What are the challenges?

Despite the existence of a framework to measure innovation in firms and years of experience in collecting such data (in Europe through the Community Innovation Survey – CIS), challenges relating to the measurement of public-sector innovation are multiple and non-trivial.

The first is the scope of what is measured: What should be the target population (general government, public sector, public enterprises)? Which types of activities/domains should be included? What are the appropriate statistical units?

Second is how to measure public-sector innovation, and, more specifically, the extent to which the *Oslo Manual* framework, including its definitions and concepts (types, activities, linkages, drivers, objectives, outcomes/impacts, barriers), can be used or adapted. Are the basic concepts and tools relevant to the characteristics of the public sector, in particular its multiple objectives, its complexity and heterogeneity, and its organisational and incentive structures? Can surveys be harmonised across countries given the large differences in the way that public-sector activities are organised across government levels in each country and in the scope of public services?

What types of indicators are needed? A set of "core" measures across all government activities? A more focused (sectoral) approach? Or both?

Before developing large-scale surveys, it is necessary to consider who would be the appropriate respondents for different types of surveys. What should the periodicity be? To what extent can information (*e.g.* expenditure data) be extracted from existing administrative sources?

Ongoing efforts by many national statistical offices to better measure output and productivity in the public sector will also affect the work on public-sector innovation.

Options for international action

Despite the lack of an overall framework, work in this area can build on existing tools for measuring firm innovation and on studies that measure the quality of public services. Various projects are under way both at the OECD and elsewhere to develop a conceptual framework and metrics for public-sector innovation.

The OECD's Working Party of National Experts on Science and Technology Indicators (NESTI) launched a task force in 2009 to examine whether measurement guidelines could be developed. The task force will be preparing a scoping paper in 2010 with measurement priorities and proposals for building a framework.

In addition to publishing a large set of indicators on public sector activities (OECD [2009d], *Government at a Glance 2009*), the OECD's Public Governance and Territorial Development Directorate is undertaking various projects relating to measuring innovation in the public sector including:

- collecting data on the use of co-production in service delivery;
- developing new indicators on the quality of public services ;
- measuring the adoption of new public management practices; and
- expanding data collection on the characteristics of the public-sector workforce.

The OECD Centre for Educational Research and Innovation (CERI) has launched work on measuring innovation in education. Among the options being considered are an adaptation of the *Oslo Manual* concepts to education and the use of various types of tools to measure changes in administrative and pedagogical practices (*e.g.* new CIS-type surveys, employer/employee surveys, extension of existing educational surveys).

Five Nordic countries have launched an initiative to develop a framework for measuring public-sector innovation which includes the testing of a pilot survey during 2010.

OECD efforts will build on this work and on initiatives such as various studies in the United Kingdom (NHS/ Department of Health, National Audit Office, NESTA, Audit Commission) and earlier work in Korea (Government Innovation Index).

There are major gaps in our understanding of investments to support innovation and related responsibilities at different levels of government and of the mechanisms for managing this shared innovation policy competence. The OECD is working to develop indicators in this area.

Why do we need indicators ?

Sub-national governments are active investors. On average, the sub-national level accounts for 64% of an OECD country's public investment. However, data are lacking at sub-national level on innovation investments and programmes.

It is important to capture this regional dimension because regions generally play an active role in innovation policy. They engage public and private actors in networks based on regional characteristics and strengths, and they invest in support for these networks. These efforts lead to positive spillovers.

The level of sub-national spending on innovation can be significant. In Germany, just over 50% of public R&D is managed by sub-national governments (2006). Of public R&D and innovation spending by Spain and its regions, approximately 20% of the 10 billion EUR comes from the regional governments (2007).

In some cases there may be up to four levels of government involved in innovation policy. The policy issue is to manage the overlaps and gaps and to ensure synergies in the inevitable competence-sharing arrangements. To understand these interdependencies, it is necessary to know:

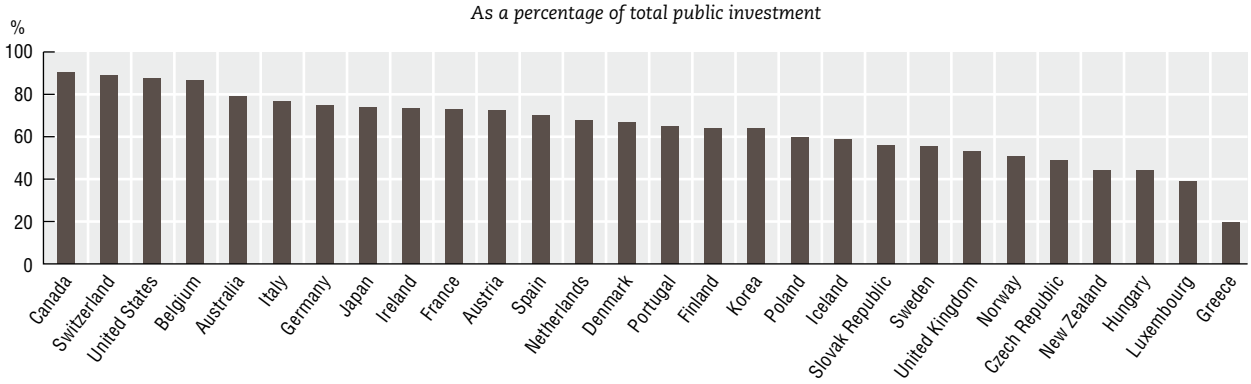
- who does what;
- what the key co-ordination challenges are; and
- how different levels can work together better.

There is also a major gap in understanding regions' innovation policy portfolios. There have been evaluations of individual instruments, but they do not give a sense of the size and orientation of the overall policy portfolio or of its relevance to the region's needs.

It is difficult to identify the incentives that ensure a coherent innovation policy across levels of government. Given a country's responsibility-sharing arrangements, there are several possible co-ordination mechanisms. They include ongoing dialogue, formal consultation processes, agencies for regional development or regional innovation, contracts, and different co-financing arrangements, among others.

Share of sub-national government in public investment, 2007

As a percentage of total public investment



Source: OECD, National Accounts Database, February 2010. See chapter notes.

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What are the challenges?

No agreed categorisation of innovation policy instruments

Some definitions, such as that of research and development (R&D), are generally accepted throughout OECD countries. While there exists a commonly accepted definition of innovation at the firm level, there is no agreed definition of innovation policy instruments. Some countries and regions use a broad policy approach, others a narrower one.

Regional roles in innovation

Various parameters make it difficult to codify the role of regions in a given country, let alone across countries. Even when taking into account different institutional structures (federal, centralised), the domestic allocation of competences for innovation is not always clear. Multi-level governance arrangements differ from one policy area to another and may differ from one region to another in the same country.

Multi-level funding of innovation

Funding for science, technology and innovation flows from various sources, such as sectoral ministries and various levels of government. What share of the funds from each funding source is spent in a region? Some national funding is regionalised. Regions may have their own budgets. For many countries there is also a supra-national level, such as the European Union, which has programmes to promote science, etchnology and innovation.

Indicators at regional level

Developing indicators to depict regional innovation policy portfolios is a task fraught with difficulties: the lack of comparable information at regional level, the huge diversity in approaches and scope of these policies, and the large number of entities to be covered. In the OECD area, there are 335 large sub-national regions. Attempts to quantify policy indicators at regional level are therefore more complex than at national level.

Options for international action

Analyse the new OECD Survey on the Multi-level Level Governance of Science, Technology and Innovation

A recent OECD Survey on the Multi-level Governance of Science, Technology and Innovation provides a first step in collecting data. It includes questions on role-sharing at different levels of government in innovation policy and on how governments co-ordinate policy levels. National and regional governments need to co-design and co-deliver these policies effectively. Another pilot study at the OECD is exploring sub-national spending autonomy in policy fields such as education and transport.

A survey can help to:

Develop taxonomy of policy instruments for supporting regional innovation systems

A classification of policy instruments considered part of innovation policy needs to be developed. While there may not yet be agreement on definitions, such a classification will at least make it possible to compare apples to apples across countries and regions.

Develop indicators on regional competences in innovation policy

Such indicators should capture the multi-dimensional role of regions in different aspects of science and technology (S&T) and innovation policy: setting strategy and objectives; policy development; financing; delivery/ implementation; and evaluation. There are currently no clear measures of regional roles in these policy fields, and no assessments of the relation between different areas of regional competences and the effectiveness of policy outcomes.

Developing quantitative indicators on regional support to R&D and innovation

The OECD and the EU are planning to create innovation policy indicators at national and regional level that can capture the intensity and direction of innovation policies beyond R&D support. Such indicators should also be developed to show the orientation of regional innovation policies. Databases on innovation policies for European regions exist at the national level and are being developed for the regional level, but for regions outside the European Union, the information needs to be obtained in a harmonised way through surveys or other sources.

A quantitative indicator on regional innovation policy intensity is also needed. It should capture efforts made at the regional level to promote innovation. As a first step, regional data on GBAORD (Government budget appropriations or outlays for R&D) should be obtained. The main advantage of this indicator is that the data collected is harmonised. Its disadvantage is that it captures only one aspect of innovation policy.

References: OECD (2010), "Sub-Central Governments and the Economic Crisis: Impact and Policy Responses", Economics Department Working Paper No. 752; OECD (2009e), *Regions Matter: Economic Recovery, Innovation and Sustainable Growth*; OECD (2009f), *OECD Regions at a Glance 2009*; OECD (2009g), *Governing Regional Development Policy: The Use of Performance Indicators;* OECD (2007a), *Linking Regions and Central Governments: Contracts for Regional Development*; OECD (2007b), *Competitive Regional Clusters: National Policy Approaches*.

Notes

Cyprus

The following note is included at the request of 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 recognizes 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 »".

The following note is included at the request of all the European Union Member States of the OECD and the European Commission:

"The Republic of Cyprus is recognized 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".

Israel

"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."

"It should be noted that statistical data on Israeli patents and trademarks are supplied by the patent and trademark offices of the relevant countries."

4.1 FIRMS INVESTING IN R&D

Business enterprise expenditure on R&D, 2008

- Defence excluded (all or mostly) for Israel.
- Excludes most or all capital expenditure for the United States.

Direct and indirect government funding of business R&D and tax incentives for R&D, 2007

- The estimates of R&D tax expenditures do not cover sub-national R&D tax incentives. The Austrian estimate covers the refundable research premium but excludes other R&D allowances. The estimate for the United States covers the research tax credit but excludes the expensing of R&D. For Turkey, a calculation by The Scientific and Technological Research Council of Turkey indicates foregone tax revenue of 593 million Turkish liras (or 0.06% of GDP) in 2008. Italy and Greece offered R&D tax incentives in 2007, but estimates of the related foregone tax revenues are not yet available.

Source: OECD, based on national estimates from the Working Party of National Experts in Science and Technology (NESTI) R&D tax incentives questionnaire, January 2010; and OECD, Main Science and Technology Indicators Database, December 2009.

4.2 FIRMS INVESTING IN INNOVATION

Expenditure on innovation, by firm size, 2006

Source: OECD, Working Party of National Experts in Science and Technology (NESTI) Innovation microdata project based on CIS-2006, June 2009, and national data sources.

Firms receiving public support for innovation, by size, 2004-06

- The industries included are: Mining and quarrying; Manufacturing; Electricity, gas and water; Wholesale trade; Transport and storage; Communications; Financial intermediation; Computer and related activities; Architectural and engineering activities; and Technical testing and analysis.
- For Australia (2006-07), Business Characteristics Survey 2006-07; Canada (2002-04, manufacturing), Survey of Innovation 2005; Iceland (2002-04), CIS-4; Japan (1999-2001), J-NIS 2003; Korea (2005-07, manufacturing), Korean Innovation Survey 2008; New Zealand (2006-07), Business Operations Survey 2007; South Africa (2002-04), South African Innovation Survey 2005.

Source: OECD, Working Party of National Experts in Science and Technology (NESTI) Innovation microdata project based on CIS-2006, June 2009, and national data sources.

Firms' turnover from product innovation, by type of innovator, 2006

Source: OECD, Working Party of National Experts in Science and Technology (NESTI) Innovation microdata project based on CIS-2006, June 2009, and national data sources.

4.3 GOVERNMENT FUNDING OF R&D

Government budget appropriations or outlays for R&D, 2007

- Total government outlays refers to central/federal government only, in order to be consistent with the definition of GBAORD.
- For countries which also include regional and local R&D expenditures in their GBAORD estimates (Belgium, Denmark, Germany, Ireland and the United Kingdom), total government outlays refers to central/federal as well as regional and local government outlays.

Government budget appropriations or outlays for R&D, by selected socio-economic objectives, 2008

- For Japan, military procurement contracts are excluded from defence in government budget appropriations or outlays for R&D (GBAORD). In the United States, general support for universities is the responsibility of state governments; therefore general university funds (GUF) is not included in total GBAORD.

Government budget appropriations or outlays for R&D, by national sector of performance, 2008

Source: OECD, Working Party of National Experts in Science and Technology (NESTI) Project on public R&D funding, 2009.

4.4 HIGHER EDUCATION AND BASIC RESEARCH

Higher education expenditure on R&D, 2008

- Excluding R&D in the social sciences and humanities: Israel (1998 and 2008) and Korea (1998).
- Excludes most or all capital expenditure for the United States.

Government-funded R&D in higher education, by type of funding, 2008

Source: OECD, Working Party of National Experts in Science and Technology (NESTI) Project on public R&D funding, 2009.

Basic research expenditure performed in the public sector, 2007

- Total cost (current and capital) included for all countries except Norway, Estonia, Poland, Spain, Russian Federation and the United States, for which only current costs are included.

4.5 INFORMATION AND COMMUNICATION TECHNOLOGIES

ICT investment, by asset in OECD countries, 2008

- ICT equipment is defined as computer and office equipment and communication equipment; software includes both purchased and own account software. Software investment in Japan is likely to be underestimated, owing to methodological differences.

Increase in the probability to innovate linked to ICT use, manufacturing, 2006

Source: OECD, Working Party on Indicators for the Information Society (WPIIS) Microdata project on ICT-enabled innovation, 2010.

Increase in the probability of innovating linked to ICT use, services, 2006

Source: OECD, Working Party on Indicators for the Information Society (WPIIS) Microdata project on ICT-enabled innovation, 2010.

4.6 FIRMS AND SMART INFRASTRUCTURE

Evolution of a representative DSL broadband subscription over time, 2005-09

- Speeds are those advertised by operators and likely do not correspond to typical throughput.
- See the OECD Broadband Portal for more details on the broadband pricing collection, *www.oecd.org/sti/ict/broadband/prices*.

4.7 GOVERNMENTS AND SMART INFRASTRUCTURE

Relation between broadband penetration and citizen uptake of e-government services, 2008

- Data are provided for 22 OECD member countries monitored by the European Commission. The following OECD member countries are not included in the European Commission data: Australia, Canada, Japan, Korea, Mexico, New Zealand, Switzerland and the United States.

4.9 GAP PAGE – MULTI-LEVEL GOVERNANCE OF INNOVATION

Share of sub-national government in public investment, 2007

- This figure uses gross fixed capital formation as the measure of public investment.

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Chapter 5

REAPING RETURNS FROM INNOVATION

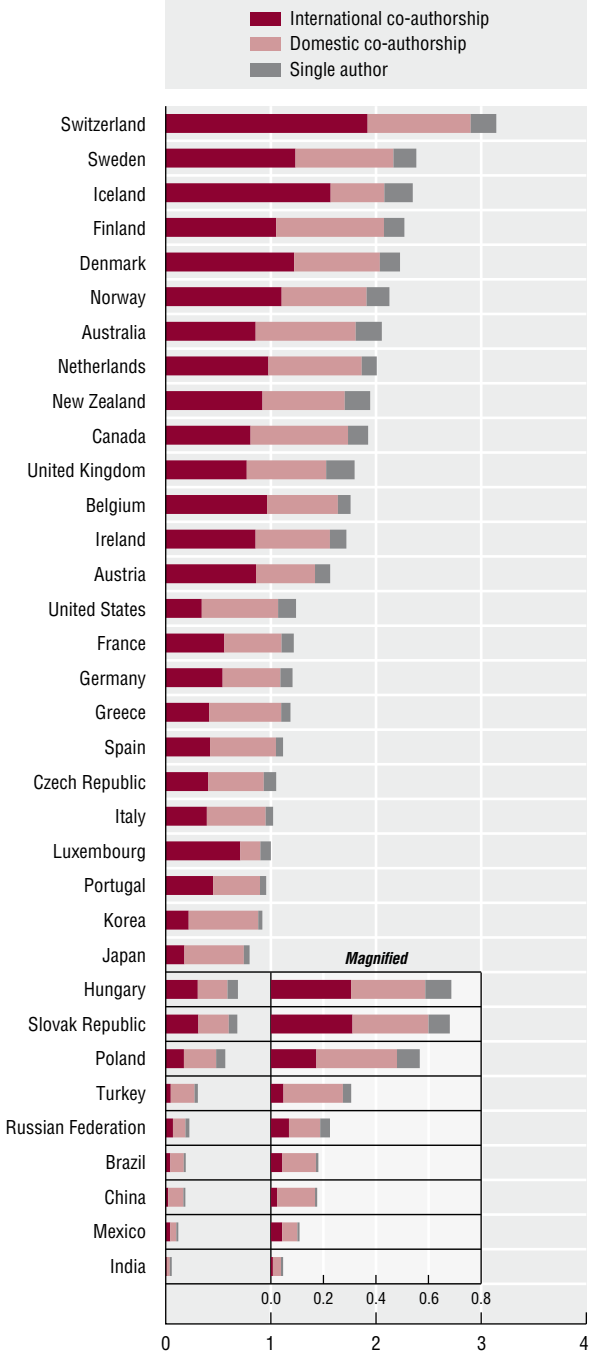
In an economy increasingly based on knowledge and innovation, the development of fully functioning knowledge networks and markets can have a significant impact on the efficiency and effectiveness of the innovation effort. Knowledge linkages and diffusion are hard to measure. Citation analysis is one way to capture science and industry linkages. For example, a new indicator is developed here using "green" innovations as the unit of analysis. Who is capturing the returns to innovation? New ways of looking at traditional indicators (for example, patent granted instead of filed or foreign ownership of inventions) can shed some light on this, although it is clear that developing metrics of knowledge "networks", as well as of markets for knowledge is still uncharted territory.

5.1 • Scientific collaboration 98
5.2 • Science and industry linkages 100
5.3 • Knowledge clusters 102
5.4 • Commercialisation 104
5.5 • Knowledge circulation 106

Collaboration is important for innovation at all stages of knowledge production. The increasing specialisation of scientific disciplines and the increasing complexity of research encourage scientists to engage in collaborative research.

Scientific articles, by type of collaboration, 2008

Per capita



Source: OECD calculations, based on Scopus Custom Data, Elsevier, December 2009; and OECD (2009), *OECD Factbook 2009: Economic, Environmental and Social Statistics*, OECD, Paris.

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DID YOU KNOW?

37% of all scientific articles published in the last decade have not been cited.

(Scopus, Elsevier, 2009.)

Co-authorship of scientific articles provides a direct measure of collaboration in science. National and international co-authorship is far more prevalent than single authorship for all countries.

International collaboration varies with country size. Small countries are generally more likely to engage in international collaboration than larger ones. However, when the number of scientific articles is taken into account, Germany, the United Kingdom and the United States attract the most international collaborations.

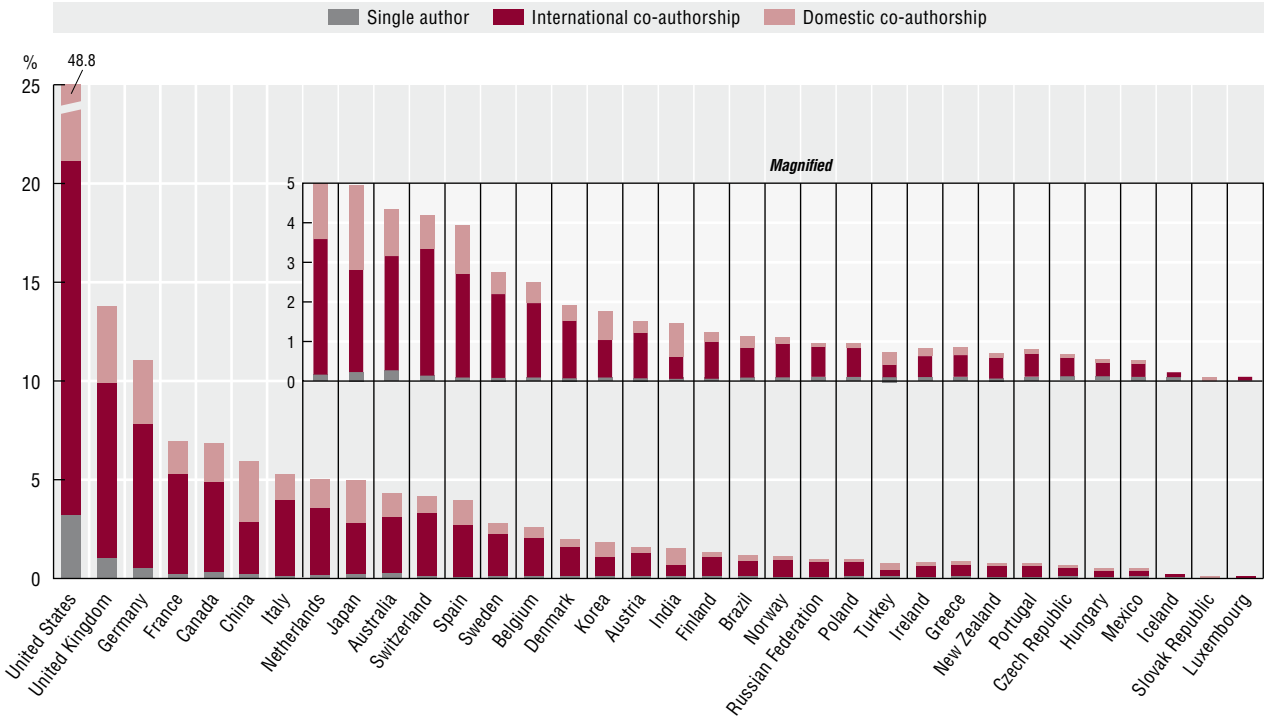
Top-cited articles provide a measure of "quality-adjusted" scientific output. This indicator reveals countries' relative contribution to the pool of the top 1% of cited scientific knowledge. It clearly shows the premium from international scientific collaboration. For almost all countries, internationally co-authored articles are the most frequently included in the world's most-cited publications. The exceptions are China, India and the United States, which have a large pool of national researchers.

Definitions

Single authorship refers to scientific papers with a single author. *Domestic co-authorship* refers to scientific articles with two or more authors in the same country. *International co-authorship* refers to scientific articles with two or more authors from different countries. The classification is based on the number of addresses listed in each article. *Top-cited articles* are the 1% of scientific articles receiving the most citations for 2006-08.

Highly cited (top 1%) scientific articles, by type of collaboration, 2006-08

As a percentage of highly cited scientific articles worldwide



Source: OECD calculations, based on Scopus Custom Data, Elsevier, December 2009.

StatLink http://dx.doi.org/10.1787/836087047406

Measurability

The volume of scientific articles published worldwide is a key indicator as publication is the main means of disseminating and validating research results. Publication counts are based on science and engineering articles, notes and reviews published in a set of the world's most influential scientific and technical journals. It excludes all documents for which the central purpose is not the presentation or discussion of scientific data, theory, methods, apparatus or experiments. Fields are determined by the classification of each journal. Publications are attributed to countries by the author's institutional affiliation at the time of publication.

Indicators of co-authorship are affected by language barriers and geographical factors. However, these obstacles have lessened as English has become the language most commonly used internationally by researchers. Physical distance between researchers is likely to have some correlation with the ratio of co-authorship, although the effect of information and communication technologies on knowledge flows has undoubtedly lessened its effect.

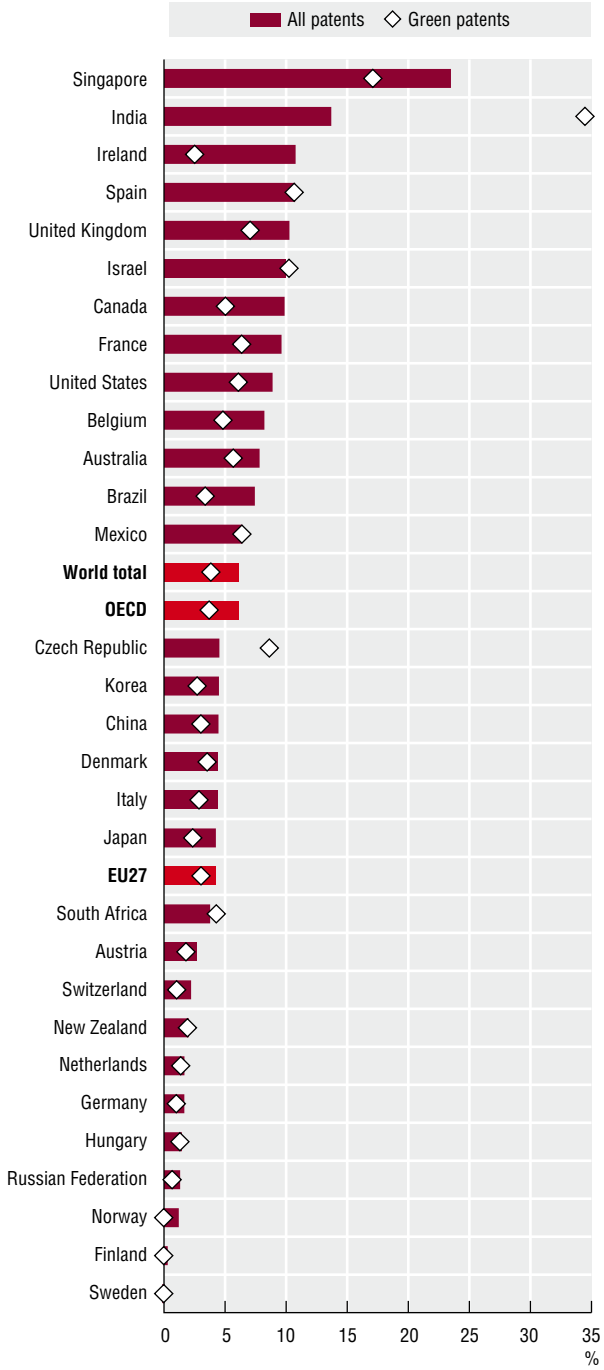
Because the incentive to publish raises a question of quality, articles can be weighted by the frequency of citations. Citations attest to the productivity and influence of scientific literature. A total of 35 594 highly cited articles, *i.e.* the top 1% of cited articles in the database for 2006-08, were identified and distributed by country and type of collaboration.

Science and engineering include life science (clinical medicine, biomedical research and biology); physical science (chemistry, physics and Earth and space sciences); mathematics, social and behavioural sciences (social sciences, psychology, health sciences and professional fields). Finally engineering includes computer sciences and engineering and technology).

Public research has always been an important part of innovation systems and the source of significant scientific and technological breakthroughs. Effective linkages between public research institutions and industry are necessary to optimise the benefits from research.

Patents filed by public research organisations, 2000-07

As a percentage of patent applications filed under the PCT



Source: OECD, Patent Database, January 2010. See chapter notes.

StatLink http://dx.doi.org/10.1787/836143718831

DID YOU KNOW?

The Indian Council of Scientific and Industrial Research accounted for over 30% of all green patent applications by India between 2000 and 2007.

(OECD, Patent Database, 2010.)

Actors (business, non-profit organisations) can draw on the pool of available public research through different channels, one of which is commercialisation *via* patenting and licensing. Most patent applications are filed by the private sector. Public research organisations (PROs) usually file applications in specialised technological fields such as biotechnology but they also engage in research relating to green technologies (*e.g.* renewable energy and hybrid and electrical cars).

Links between PROs and industry also occur through spin-offs, joint research projects, training, consultancy and contract work, staff mobility between workplaces and informal co-operation by researchers.

Citation analysis (the analysis of non-patent literature cited in patents) is a novel way to assess science and industry linkages. For example, an indicator is developed using "green" innovations (patents) as the unit of analysis. Results show that green innovations mostly draw on material science, chemistry and engineering. However, compared to the United States, green innovations patented by Japanese inventors are more likely to draw on scientific production in chemistry and physics, while in Germany they are more likely to be linked to the engineering and energy fields.

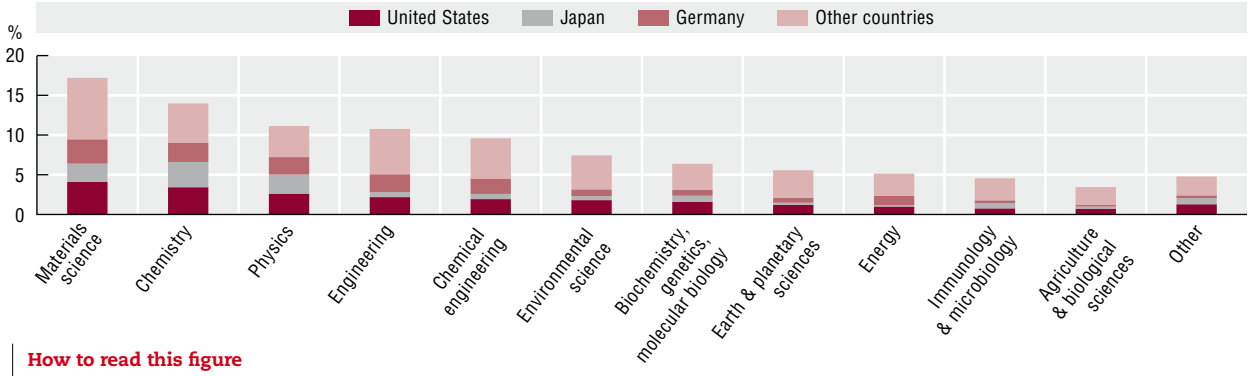
Definitions

Public research organisations (PROs) include government laboratories, universities and research hospitals. Data relate to patent applications filed under the Patent Co-operation Treaty (PCT), at international phase, designating the European Patent Office (EPO). The green patent category is a sub-sample of patents for pollution abatement and waste management and climate change mitigation technologies. For the classification of green patents, see *www.oecd.org/environment/innovation/indicator.*

The low share of patents filed by PROs in 2000-07 in some countries may be explained by a measure called the Teachers' Exemption or "Professor privilege", whereby academics own the intellectual property rights for their inventions. Over time this exemption has been removed, except in Sweden.

Main scientific fields cited in "green" patents, by inventor country, 2000-07

As a percentage of all citations



How to read this figure

Environmental technologies draw on scientific knowledge that comes from material science (17%), from chemistry (14%), etc. The link to publications from material science (17%) originate from US patents (4%), from Japanese patents (2%), from German patents (3%), and the remaining 8% from all other countries.

Source: OECD calculations, based on Scopus Custom Data, Elsevier, July 2009; OECD, Patent Database, January 2010; and EPO, Worldwide Patent Statistical Database, September 2009.

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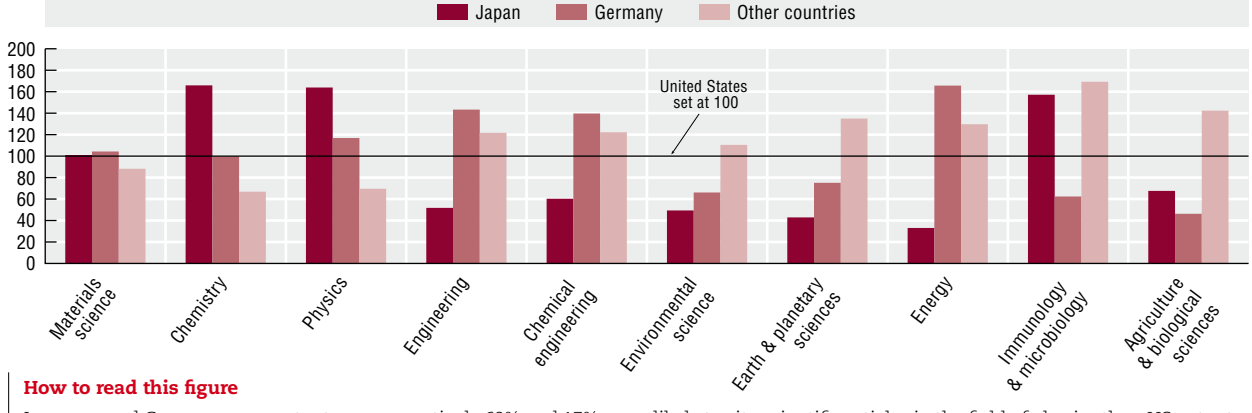
Relative citation rate in "green" patents, by main scientific fields, 2000-07

United States citation rate = 100



How to read this figure

Japanese and German green patents are respectively 63% and 17% more likely to cite scientific articles in the field of physics than US patents.

Source: OECD calculations, based on Scopus Custom Data, Elsevier, July 2009; OECD, Patent Database, January 2010; and EPO, Worldwide Patent Statistical Database, September 2009.

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Measurability

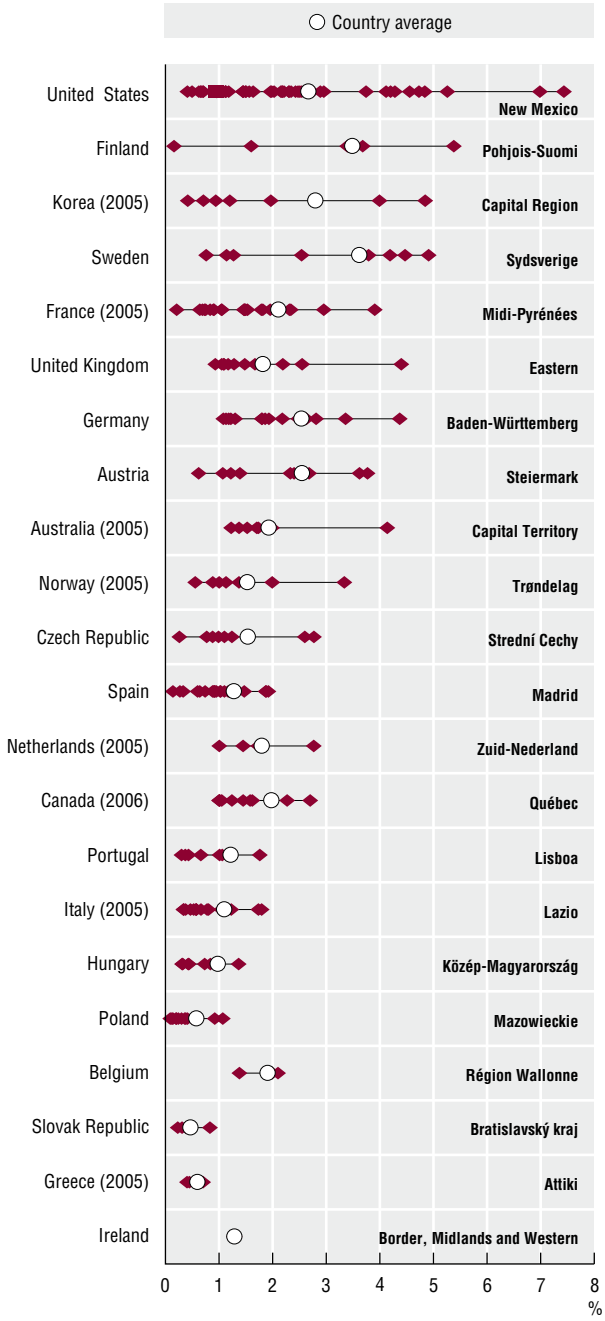
A search algorithm developed by the OECD and the EPO is used to generate the list of environmental patent applications. Fields include: renewable energy; fuel cells and energy storage; alternative-fuelled vehicles; energy efficiency in the electricity, manufacturing and building sectors; and "clean" coal (including carbon capture and storage).

The link between patents and the scientific literature is based on an analysis of the "non-patent literature" (NPL) listed in patent documents. NPL includes peer-reviewed scientific papers, conference proceedings, databases and other literature. The listed NPL gives journal title, author name(s), volume and page number, article title, but usually not information needed for bibliometric analysis (*e.g.* name and address of the author's organisation, names of authors other than the first listed). To fill in information gaps, NPL was matched with Scopus, the scientific literature database. This makes it possible to know if the NPL is a scientific article and to obtain bibliographical information not recorded in NPL. The matches were based on combinations of volume, page, year, journal name, author name, and article title. As a result, 1 612 green patents were retained out of the 48 249, and 2 803 NPL were scientific papers recorded in Scopus.

While different forms of innovation activity may occur in all regions, R&D-based innovation is geographically concentrated. Industrial structure, research capabilities and other territorial characteristics affect the capacity of actors to generate and absorb knowledge. Governments increasingly focus on regional clusters of innovation.

R&D intensity, by region, 2007

Regional R&D expenditures as a percentage of regional GDP



DID YOU KNOW?

Half of OECD R&D investment is performed in less than 13% of OECD regions.

(OECD, Regional Database, 2009.)

OECD regions with high GDP per capita are generally also those with high R&D intensity. A key policy debate is whether it is better to concentrate resources in leading regions or to use innovation resources to trigger catch-up outside the leading regions.

Countries with high R&D intensity often display large regional disparities. They are greatest in Finland, Korea, Sweden and the United States. Moreover, in Australia, Norway, the United Kingdom and the United States the R&D intensity of the leading region is at least twice the national average. The intensity of investment in a given region is affected by regional sectoral specialisation, the presence of research hubs of multi-national firms, and the location of public research labs and leading research universities. It may be partly influenced by regional actions and policies as well as national policies and global trends.

Proximity is important for knowledge creation and technological progress. Domestic co-patenting is the most frequent mode of co-patenting in almost all countries. On average for OECD regions, it is slightly more frequent when the inventors are in the same region (39%), than when they are in different regions in the same country (35%) or in another country (19%).

Definitions

Gross domestic expenditures on R&D is the total intramural expenditure on R&D performed in the sub-national territory (region) during a given period. *Patent Co-operation Treaty (PCT) applications* are regionalised according to the inventor's residence. The same patent may be classified in more than one region if there are multiple co-inventors.

How to read this figure

The most R&D-intensive region in Finland is Pohjois-Suomi with R&D intensity of 5.4%, above the country average (3.5%).

Source: OECD, Regional Database, March 2010; OECD, Main Science and Technology Indicators Database, December 2009. See chapter notes.

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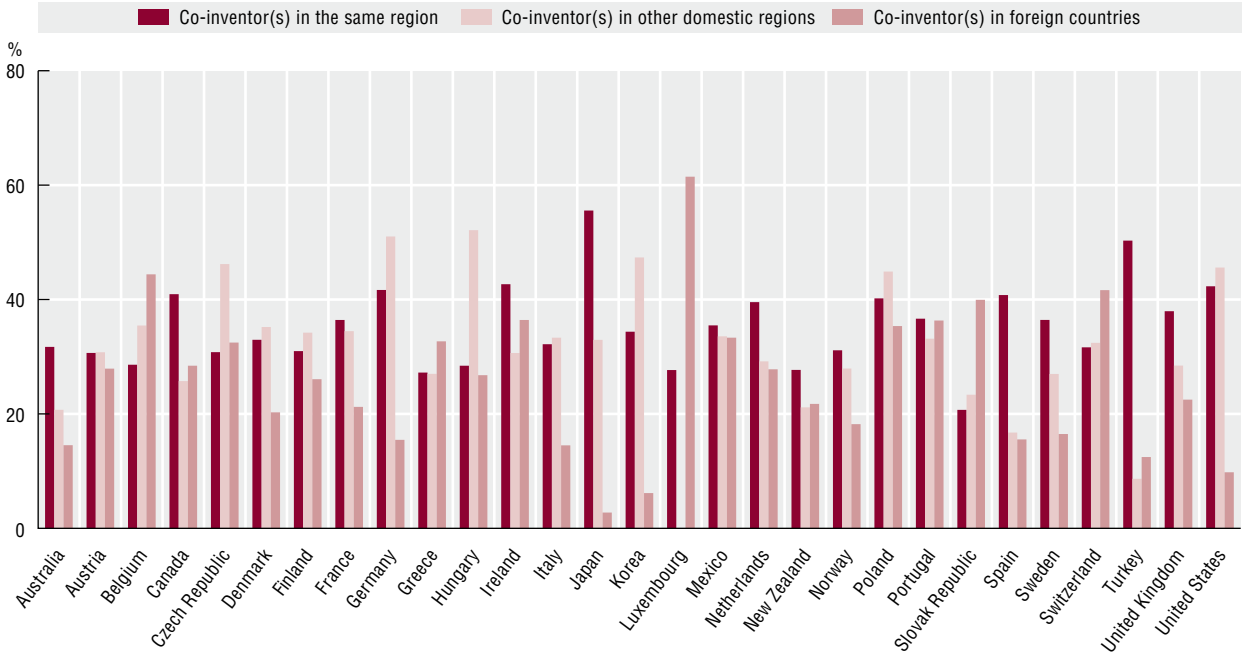
Regional average of PCT patents with co-inventor(s), by location, 2005-07

As a percentage of all patents



Source: OECD, REGPAT Database, January 2010. See chapter notes.

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Measurability

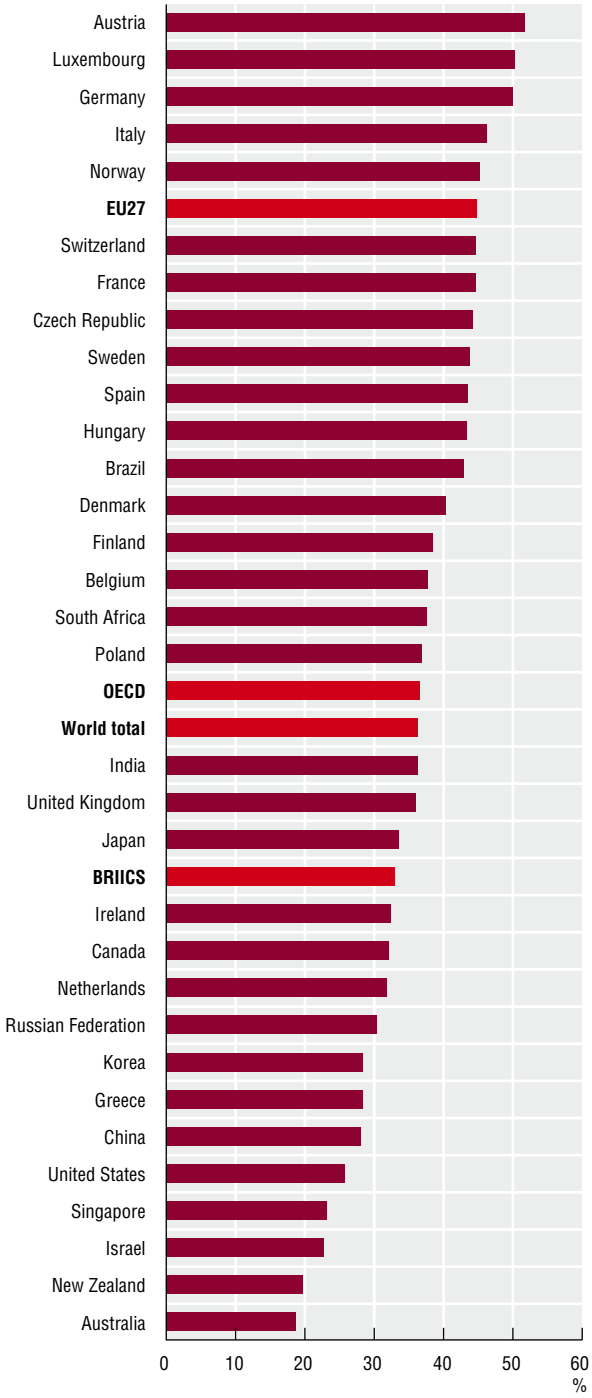
Defining the territorial unit is of prime importance as the word "region" can mean very different things both within and across countries. To address this issue, the OECD has classified the regions of each member country into two territorial levels. The higher level (territorial level 2 – TL2) consists of 335 large regions and the lower level (territorial level 3 – TL3) is composed of 1 681 small regions. All the regions are defined within national borders and in most cases correspond to administrative regions. Each TL3 region is contained within a TL2 region except in Germany and the United States. This classification – which, for European countries, is largely consistent with the Eurostat classification – facilitates comparability of regions at the same territorial level. Indeed these two levels, which are officially established and relatively stable in all member countries, are used as a framework for implementing regional policies in most countries.

A limited number of indicators are available at regional level to characterise collaboration in the innovation process. Co-patents represent collaboration that leads to an invention which may or may not be commercialised. Patenting is more likely in certain sectors and focuses on technological innovation. Therefore sectors of activity with a low propensity to patent are under-represented, as are non-technological forms of innovation. More detailed analysis of networks is needed to better understand collaboration dynamics and determine whether it involves inventors in the same entity or across different types of actors (*e.g.* firms, research institutions), as well as the intensity of such interaction. Patterns of collaboration for knowledge generation by individuals within and across regions may also be explored through co-publications.

Investing in innovation is risky. Several R&D projects will not result in an invention, and not all patent applications will be novel enough to receive a patent.

Patents granted at the European Patent Office by 2009

As a percentage of patent applications first filed in 2000-03



Source: OECD, Patent Database, January 2010. See chapter notes.

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DID YOU KNOW?

By 2009, less than 40% of all patent applications filed at the EPO between 2000 and 2003 had been granted.

(OECD, Patent Database, 2010.)

Patent applications are used as an indicator of inventive activity. However, to receive patent, the invention must be of practical use and have an element of novelty ("inventive step").

An indicator of patents granted can show the likelihood of an invention being commercialised. Depending on the patent office, a patent is granted on average three to five years, but sometimes up to ten years, after application.

The indicator shows grant rates for patents filed at the EPO. Use of a single patent office eliminates differences in time to process, stringency of requirements for granting a patent or other institutional differences, but differences in the grant rate for countries remain. This may be due to applicants' patenting strategies (how selectively businesses choose which inventions to patent) and time needed to process applications in different technological fields. Grant rates are usually lower for non-European than for European countries, notably owing to a longer examination phase.

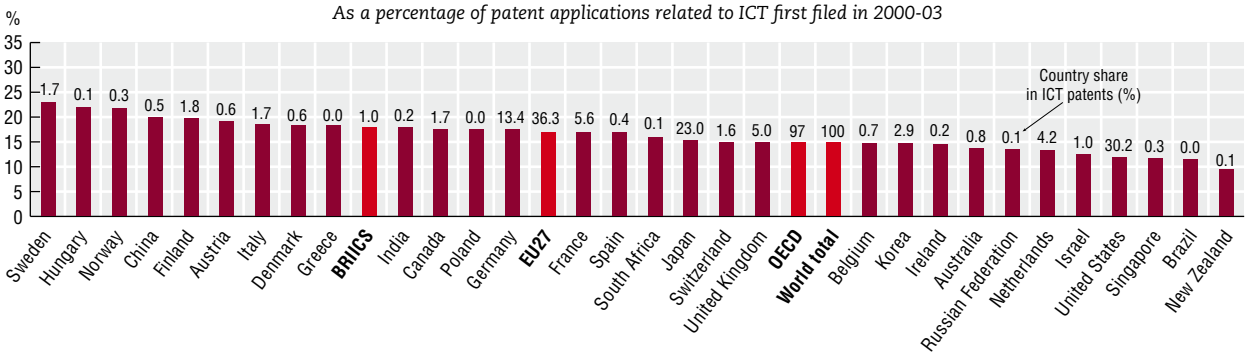
Grant rates for new technology fields (ICT, nanotechnology, biotechnology, renewable energy) are around 15%, less than for grant rates overall. In these fields, applications are filed for a large share of inventions because of uncertainty about their potential value. Also, processing time at the EPO for these technologies is longer. Thus, the average examination period for the United States, which has a relatively large share of applications in high-technology fields, is longer. However, indicators of grant rates for a given technology also show differences among European countries.

Definitions

Data relate to overall patent applications and applications in selected fields (ICT, biotechnology, nanotechnology and renewable energy) filed at the EPO with a priority date in 2000-03. Patent counts are based on the priority date, the inventor's country of residence and fractional counts. Only economies with more than 20 patents (in nanotechnology and renewable energy) or 50 patents (in biotechnology and ICT) are included.

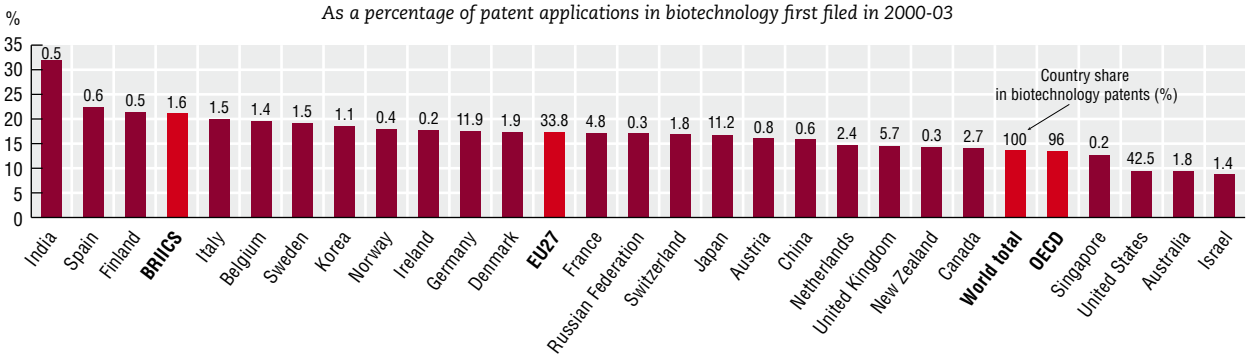
ICT-related patents granted at the European Patent Office by 2009

As a percentage of patent applications related to ICT first filed in 2000-03



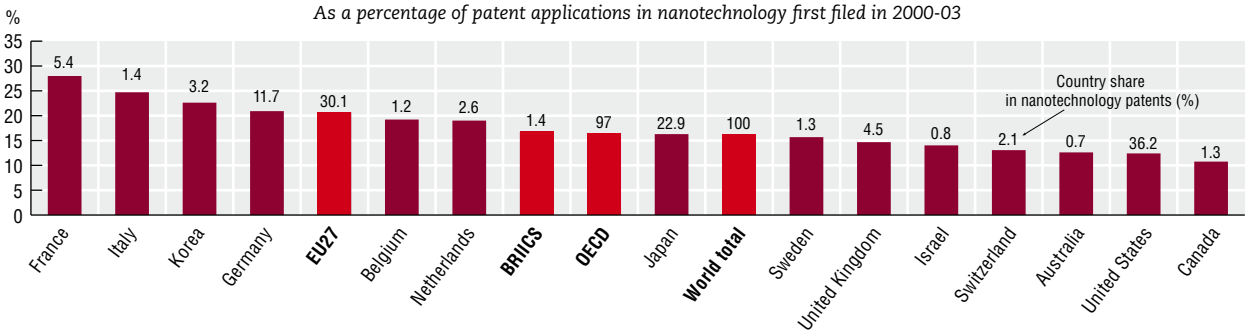
Biotechnology patents granted at the European Patent Office by 2009

As a percentage of patent applications in biotechnology first filed in 2000-03



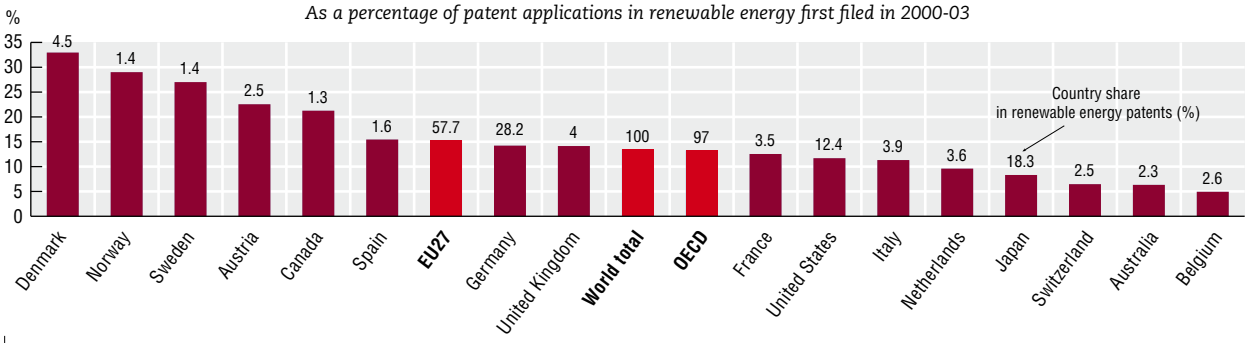
Nanotechnology patents granted at the European Patent Office by 2009

As a percentage of patent applications in nanotechnology first filed in 2000-03



Renewable energy patents granted at the European Patent Office by 2009

As a percentage of patent applications in renewable energy first filed in 2000-03



How to read this figure

Germany has the highest share in renewable energy patent applications (28.2%), but only about 14% of patents applied for in 2000-03 had been granted in 2009.

Source: OECD, Patent Database, January 2010. See chapter notes.

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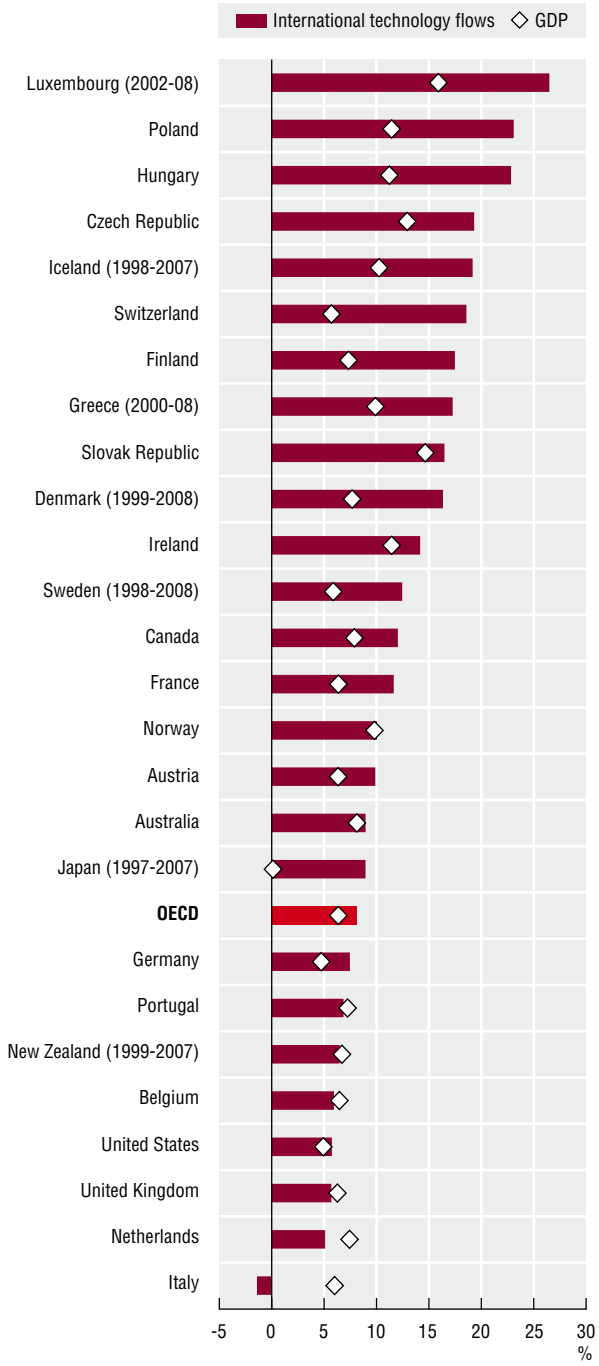
Circulation of knowledge – in particular international circulation of knowledge – has increased over time and is now an important component of technology transfer. Well-designed knowledge networks and markets can reduce transaction costs, enable new knowledge transfers and make existing transfers more efficient.

International technology flows, 1997-2008

Average annual growth rate, based on USD, percentage



Source: OECD, Technology Balance of Payments Database, December 2009; and OECD, Trade in Services Database, December 2009.

StatLink http://dx.doi.org/10.1787/836172515787

DID YOU KNOW?

One-third of young patenting European firms consider patents important for convincing private investors to provide them with funds.

(Zuniga and Guellec, 2009.)

Technology receipts on patents and licences and payments from R&D services are the main forms of disembodied technology diffusion. The internationalisation of technology flows reflects to some extent cross-border trade in R&D outcomes. Unlike R&D expenditures, these are payments for production-ready technologies. While it is not possible to distinguish between intra- (parents and affiliates) and inter-firms transactions, the rise in international technology flows shows that knowledge is increasingly implemented in a different country from the one in which it was developed.

Results from a pilot study on patent licences show that licensing is widespread among patenting firms. Around one patenting company in five in Europe licenses patents to non-affiliated partners, and more than one in four does so in Japan. The relation between size of firm and probability to license out is U-shaped: small and large firms are more likely to license out their patented inventions. The major barrier to licensing out patents is identifying partners.

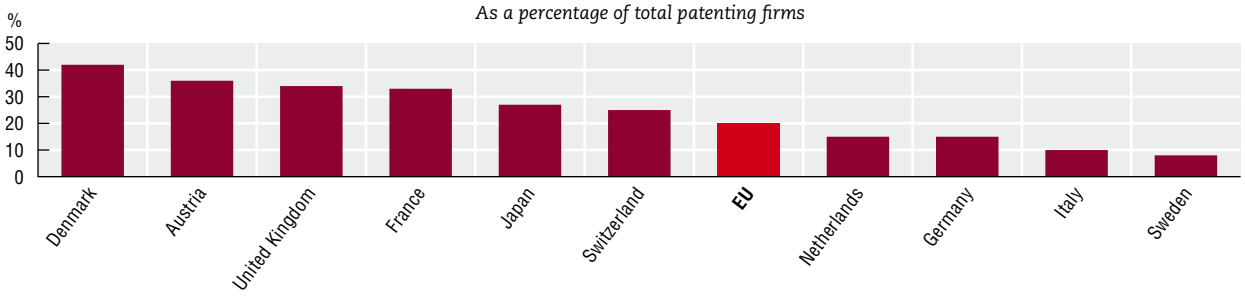
Many countries with a high share of patents invented by foreign businesses either have large multinational firms that perform R&D abroad or are low-tax countries with no track record of innovation activities. In this case, the intellectual property (IP) may be located there as a way to minimise taxes.

Definitions

Technology flows refer to the average of technological payments and receipts. *Trade in technology* comprises four main categories: transfer of techniques (through patents and licences, disclosure of know-how); transfer (sale, licensing, franchising) of designs, trademarks and patterns; services with a technical content, including technical and engineering studies as well as technical assistance; industrial R&D. *Foreign inventions* refer to patents none of whose inventors resides in the country in which a resident owns the patent. Patent applications are filed through the Patent Co-operation Treaty (PCT) at international phase.

Patenting firms licensing out at least one patent to non-affiliated companies, 2006

As a percentage of total patenting firms

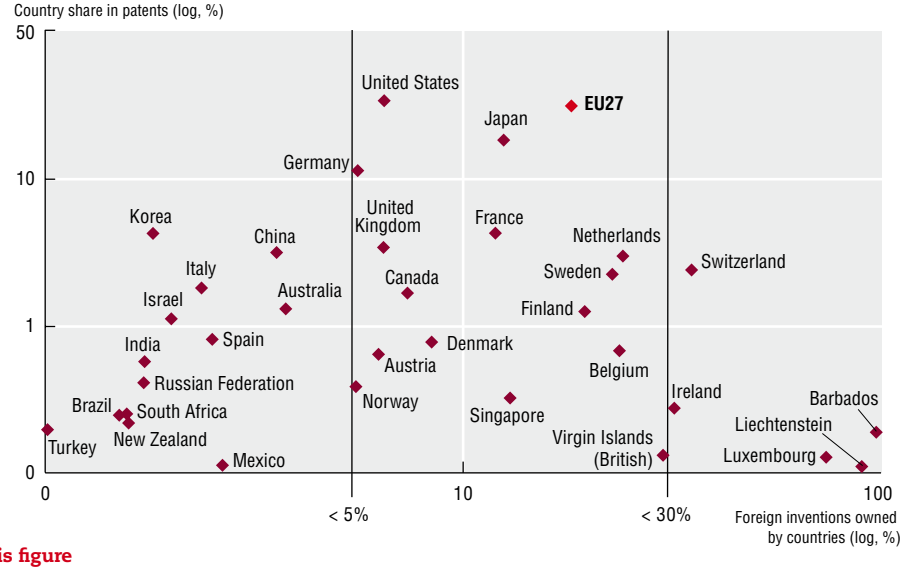


Source: Zuniga, M.P. and D. Guellec (2009), "Who licenses out patents and why? Lessons from a business survey", OECD Science, Technology and Industry Working Papers 2009/5, OECD, Paris.

StatLink http://dx.doi.org/10.1787/836172515787

Foreign inventions owned by countries, 2005-07

Relative to country shares in patent applications



How to read this figure

Switzerland filed 2.2% of all patent applications, and 35% of these patent applications have no inventor residing in the country.

Source: OECD, Patent Database, January 2010. See chapter notes.

StatLink http://dx.doi.org/10.1787/836172515787

Measurability

Technology receipts and payments reflect a country's ability to sell technology abroad and use of foreign technologies. Most transactions involve operations between parent companies and affiliates. Additional qualitative and quantitative information is needed to analyse a country's deficit or surplus position in a given year correctly. As it is difficult to dissociate its technological from its non-technological content, trade in services may be underestimated if a significant portion does involve financial payments or if payments are not in the form of technology payments.

In 2007 the OECD, the European Patent Office and the University of Tokyo surveyed businesses to investigate licensing out to affiliated and non-affiliated companies, its intensity, evolution, characteristics, motivations and the obstacles encountered by companies that licensed or were willing to do so. Some 600 European firms and 1 600 Japanese firms that were patent holders responded to the survey.

The location of patent ownership may reveal the importance of IP tax shifting in OECD countries and may indirectly reveal attractive tax incentives for IP revenue and tax planning strategies. However, the data currently available do not include revenue generated by patents. This limits the analysis that can be undertaken.

Notes

Cyprus

The following note is included at the request of 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 recognizes 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 »".

The following note is included at the request of all the European Union Member States of the OECD and the European Commission:

"The Republic of Cyprus is recognized 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".

Israel

"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."

"It should be noted that statistical data on Israeli patents and trademarks are supplied by the patent and trademark offices of the relevant countries."

5.2 SCIENCE AND INDUSTRY LINKAGES

Patents filed by public research organisations, 2000-07

- Data relate to patent applications filed under the Patent Co-operation Treaty (PCT), by priority date and applicant's country of residence. Institutional sectors are identified using an algorithm developed by Eurostat and Katholieke Universiteit Leuven. Public research organisations cover the government sector, higher education and hospitals. Green patents are patents applied for technologies relating to pollution abatement and waste management and climate change mitigation. Only economies with more than 50 green patents over the period are included in the figure.

5.3 KNOWLEDGE CLUSTERS

R&D intensity by region, 2007

- Data for Denmark, Iceland, Japan, Mexico, New Zealand, Switzerland and Turkey are not available at the regional level.
- The regional breakdown is provided at Territorial Level 2 (TL2).

Regional average of PCT patents with co-inventor(s) by location, 2005-07

- Data relate to patent applications filed under the Patent Co-operation Treaty (PCT), by priority date and inventor's region of residence.
- The regional breakdown is provided at Territorial Level 2 (TL2).

5.4 COMMERCIALISATION

Patents granted at the European Patent Office by 2009

- Data relate to patent applications filed at the European Patent Office (EPO) with a priority date in 2000-03. Patent counts are based on the priority date, the inventor's country of residence and fractional counts. Only economies with more than 250 patent applications in 2000-03 are included in the figure.

ICT-related patents granted at the European Patent Office by 2009

- Data relate to patent applications in ICT filed at the European Patent Office (EPO) with a priority date in 2000-03. Patent counts are based on the priority date, the inventor's country of residence and fractional counts. Only economies with more than 50 ICT-related patents in 2000-03 are included in the figure.

Biotechnology patents granted at the European Patent Office by 2009

- Data relate to patent applications in biotechnology filed at the European Patent Office (EPO) with a priority date in 2000-03. Patent counts are based on the priority date, the inventor's country of residence and fractional counts. Only economies with more than 50 biotechnology patents in 2000-03 are included in the figure.

Nanotechnology patents granted at the European Patent Office by 2009

- Data relate to patent applications in nanotechnology filed at the European Patent Office (EPO) with a priority date in 2000-03. Patent counts are based on the priority date, the inventor's country of residence and fractional counts. Only economies with more than 20 nanotechnology patents in 2000-03 are included in the figure.

Renewable energy patents granted at the European Patent Office by 2009

- Data relate to patent applications in renewable energy filed at the European Patent Office (EPO) with a priority date in 2000-03. Patent counts are based on the priority date, the inventor's country of residence and fractional counts. Only economies with more than 20 renewable energy patents in 2000-03 are included in the figure.

5.5 KNOWLEDGE CIRCULATION

Foreign inventions owned by countries, 2005-07

- Data refer to counts of patent applications filed through the Patent Co-operation Treaty, at international phase, by applicant's country of residence and priority date. Foreign inventions owned by countries are the share of patents owned by a resident of a country, for which no inventors reside in the country, as a share of total patents owned by that country. Only economies that applied for more than 100 patents over the period are included in the figure.

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Zuniga, M.P. and D. Guellec (2009), "Who Licenses out Patents and Why? Lessons from a Business Survey", *OECD Science, Technology and Industry Working Paper 2009/5*, OECD Directorate for Science, Technology and Industry, OECD, Paris.

Chapter 6

ADDRESSING GLOBAL CHALLENGES

Innovation is a means of dealing with global and social challenges. A selection of R&D and innovation indicators in the areas of health, climate change and other environmental technologies is presented.

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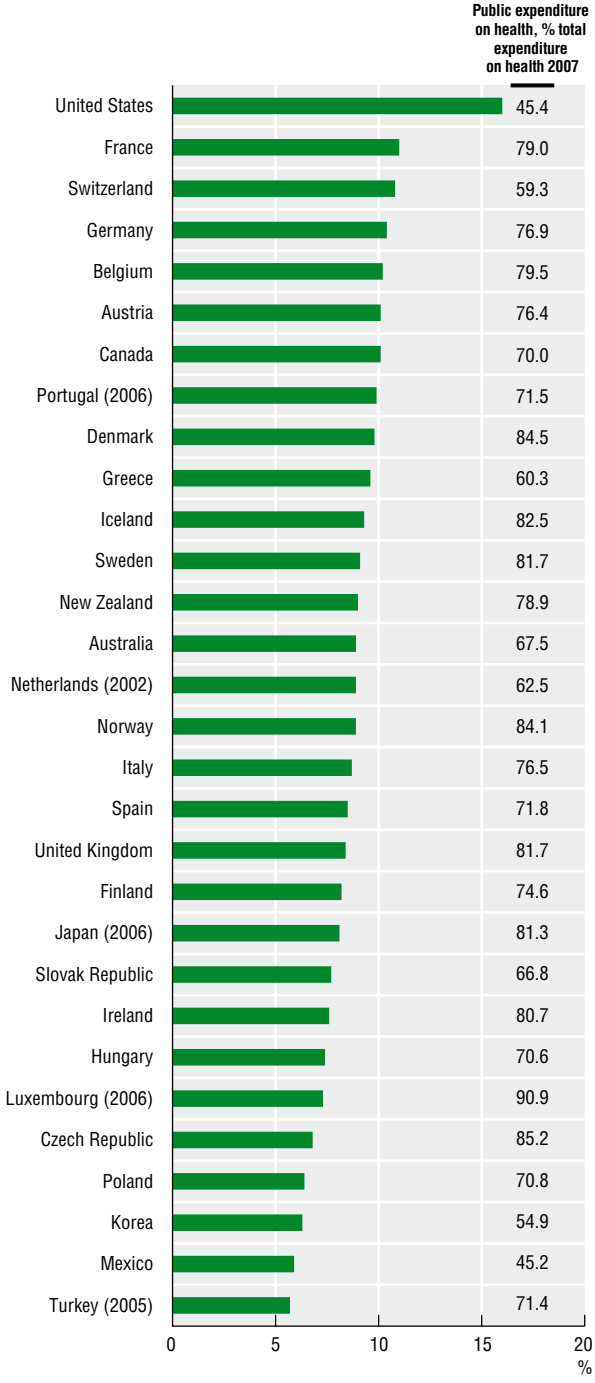
Improving world health is an enormous policy challenge which requires both national and international policy action. Over the coming decades, innovation – both technical and organisational – will play a major role in delivering more personal, predictive and preventive health-care products and will radically change how medicine is practised and health care is delivered.

Total expenditure on health, 2007

As a percentage of GDP



Source: OECD Health Data 2009, *www.oecd.org/health/healthdata*. See chapter notes.

StatLink http://dx.doi.org/10.1787/836200183171

DID YOU KNOW?

The US stimulus package contains over USD 25 billion for the adoption and use of health information technologies by 2014.

(US Department of Health and Human Services, 2010.)

Health-related expenditure is one of the most important budgetary expenses of governments and households. For most OECD countries, health-related expenditures account for 6% to 11% of GDP, two-thirds of which is spent by governments.

Population ageing, the growing impact of chronic diseases such as diabetes, HIV/AIDS, malaria and tuberculosis, and emerging infectious diseases such as new influenza strains are major challenges for the coming decades. Innovation can help to meet these challenges by improving the performance of health systems and making them more efficient and effective. Health-related research and development (R&D) expenditures provide a useful indicator of innovative efforts in this field.

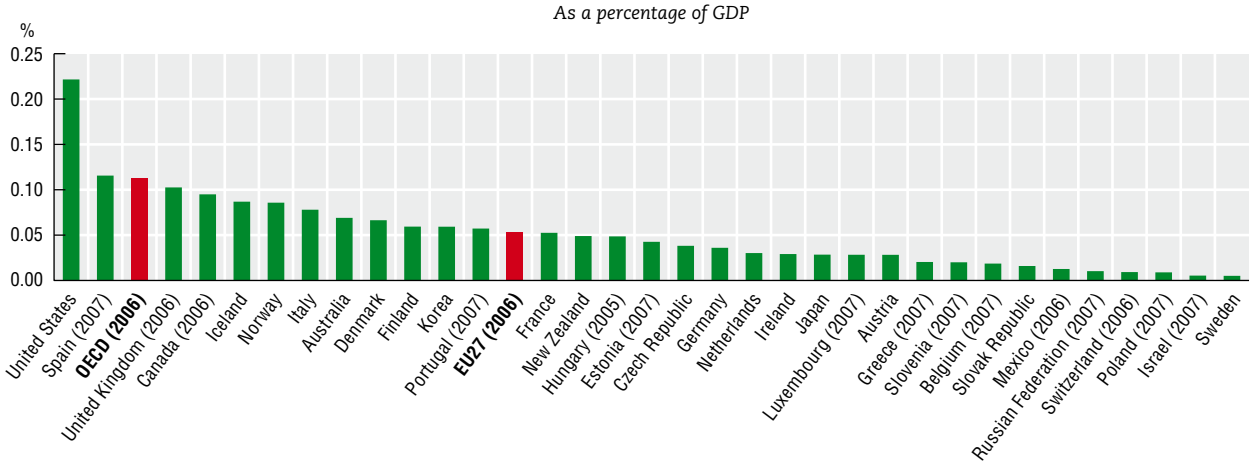
The data on health R&D in GBAORD suggest that the United States accounts for around three-quarters of the OECD total. However, when data from additional government R&D funding categories (general university funds and non-oriented research) are used to adjust for institutional differences in the funding of health R&D, the picture changes.

Definitions

Government budget appropriations or outlays for R&D (GBAORD) measures the funds committed by the federal/central government for R&D. It can be broken down by various socioeconomic objectives, including health care. *Advancement of knowledge* comprises non-oriented R&D and general university funds (the estimated R&D content of government block grants to universities). *Other* includes other relevant national and international categories such as general support for R&D in hospitals.

Health R&D in government budget appropriations or outlays for R&D, 2008

As a percentage of GDP

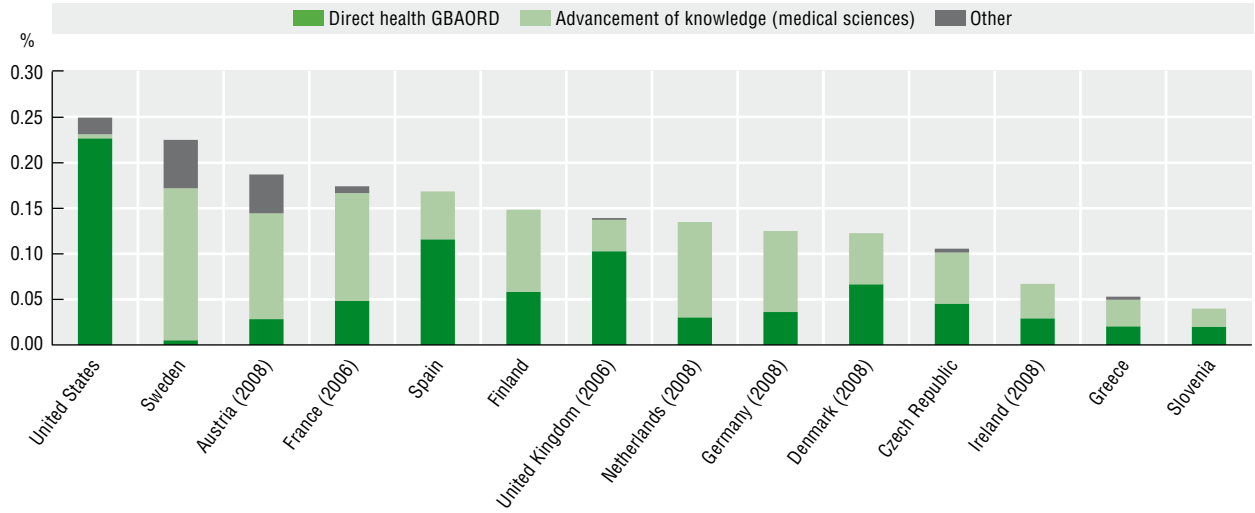


Source: OECD (2009), *OECD Science, Technology and Industry Scoreboard 2009*, OECD, Paris.

StatLink http://dx.doi.org/10.1787/836200183171

Public funding of health-related R&D, 2007

As a percentage of GDP



Source: OECD (2009), *OECD Science, Technology and Industry Scoreboard 2009*, OECD, Paris.

StatLink http://dx.doi.org/10.1787/836200183171

Measurability

Health-related R&D is difficult to measure owing to institutional complexity and diversity; it may be publicly or privately funded and be carried out in firms, universities, hospitals and private non-profit institutions.

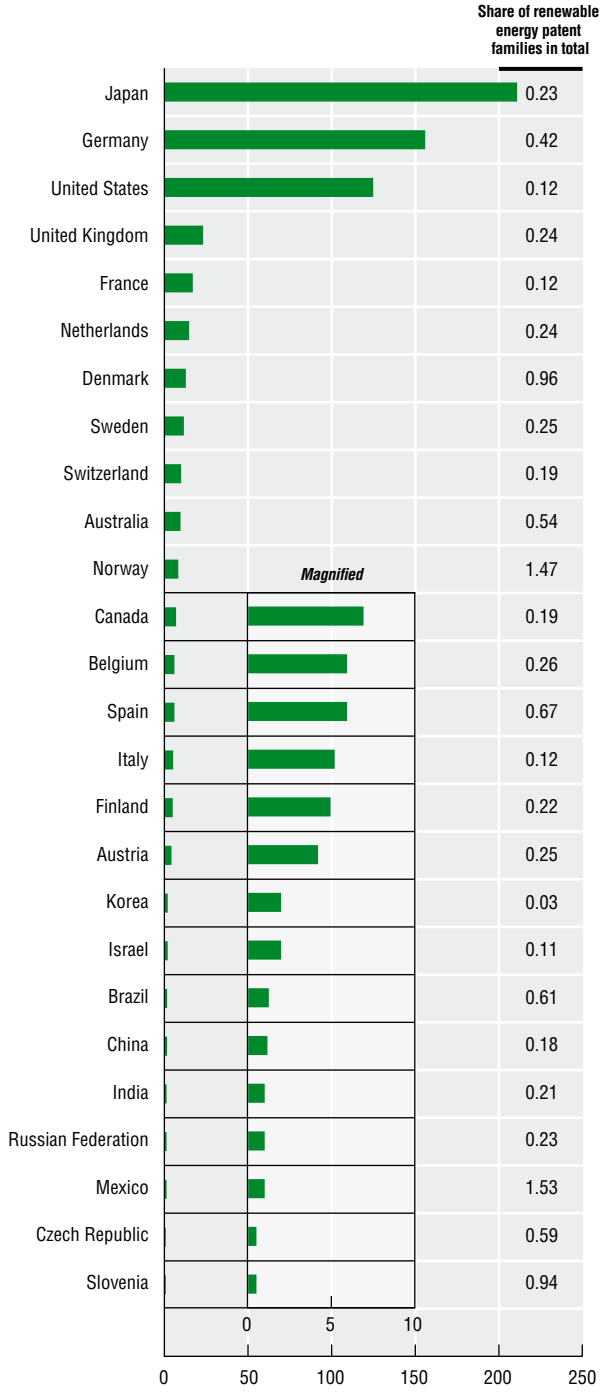
The GBAORD health category is used here as a proxy for total central government funding of health-related R&D. However, it only covers programmes for which health is the primary objective. Furthermore, the classification of programme and institutional funding depends on how governments present their R&D priorities as well as on the formal mandate of the institutions concerned. Arrangements for funding R&D in hospitals also vary among countries.

To address some of these limitations and to provide a more complete picture of health-related R&D, funding of medical sciences *via* non-oriented research and general university funds are included when available as are other relevant funds, notably general support for R&D in hospitals.

Climate change is one of the most significant policy challenges faced by OECD and non-OECD countries. The costs of meeting this challenge depend crucially on the pace of innovation in mitigation technologies. While there is some evidence that the pace is accelerating, further policy efforts are needed to ensure a sufficient response.

Renewable energy patents, 1998-2006

Number of triadic patent families



Source: OECD, Patent Database, January 2010. See chapter notes.

StatLink http://dx.doi.org/10.1787/836230555431

DID YOU KNOW?

Patents to address climate change challenges are increasing and represent approximately 2% of total patent applications.

(OECD, *The Invention and Transfer of Environmental Technologies*, based on patent data, forthcoming.)

A number of technologies associated with energy use result in reduced emissions of greenhouse gases. Technological advances which allow for more efficient combustion, capture of emissions, or substitution of fossil fuels by renewable energy sources will result in reduced atmospheric emissions.

Innovation in climate change mitigation technologies has been increasing, driven largely by public policy incentives. However, in most fields it is still concentrated in Germany, Japan and the United States.

Countries tend to specialise. In 2007, Japan's patent applications were mostly for innovation in energy-efficient buildings and lighting, as well as electric and hybrid vehicles. Efforts in the United States focused particularly on renewable energy.

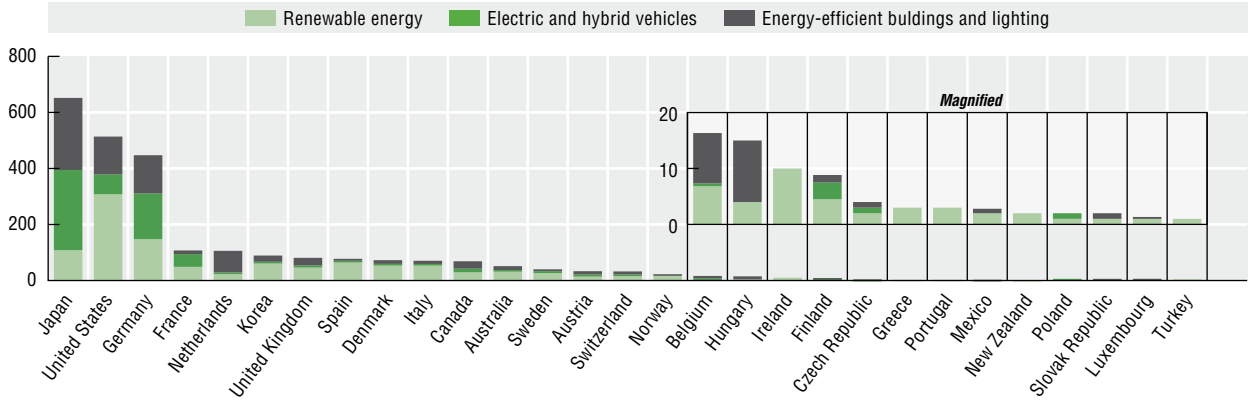
Some countries have begun to invest considerable resources in advanced climate change mitigation technologies (*e.g.* solar photovoltaic energy, hydrogen and fuel cells, carbon capture and storage). Such technologies are currently the most promising in terms of long-term abatement.

Definitions

Renewable energy patents include energy-generation technologies such as wind, solar, geothermal, ocean, hydro, biomass and waste-to-energy. For classifications see *www.oecd.org/environment/innovation/indicator*. The *OECD triadic patent families* are defined as a set of patents protecting the same invention filed at the European Patent Office (EPO), at the Japan Patent Office (JPO) and granted by the US Patent and Trademark Office (USPTO).

Patents for climate change mitigation technologies, 2007

PCT patent applications

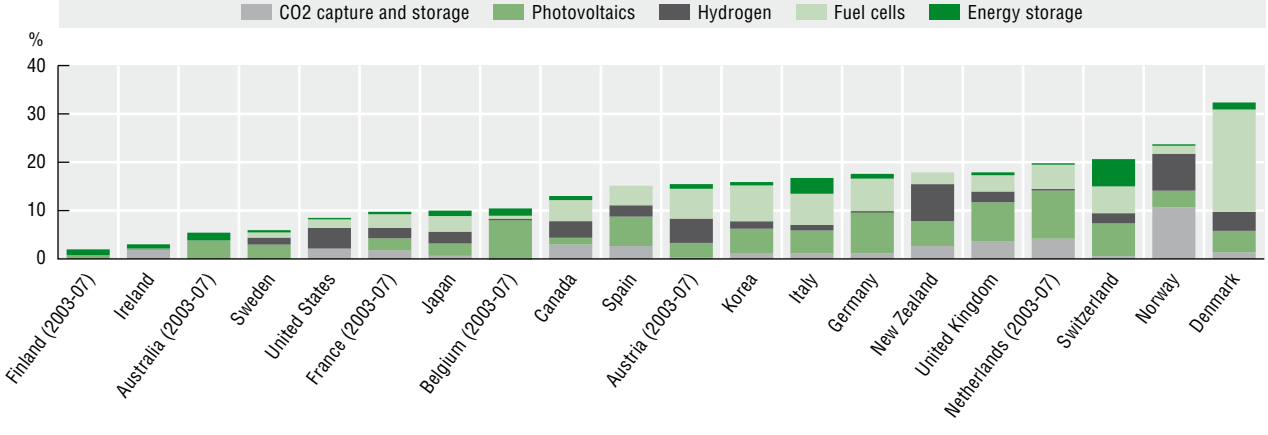


Source: OECD, Patent Database, January 2010. See chapter notes.

StatLink http://dx.doi.org/10.1787/836230555431

Government research, development and demonstration (RD&D) expenditures on selected climate change mitigation technologies, 2004-08

As a percentage of yearly average RD&D budget



Source: OECD, Patent Database, January 2010; IEA, Energy Technology Research and Development Database, December 2009. See chapter notes.

StatLink http://dx.doi.org/10.1787/836230555431

Measurability

The OECD uses search algorithms to generate data on patent applications for environmental technologies. The data are being further refined with inputs from the European Patent Office. Fields covered are: renewable energy; fuel cells and energy storage; alternatively fuelled vehicles; energy efficiency in the electricity, manufacturing and building sectors; and "clean" coal (including carbon capture and storage).

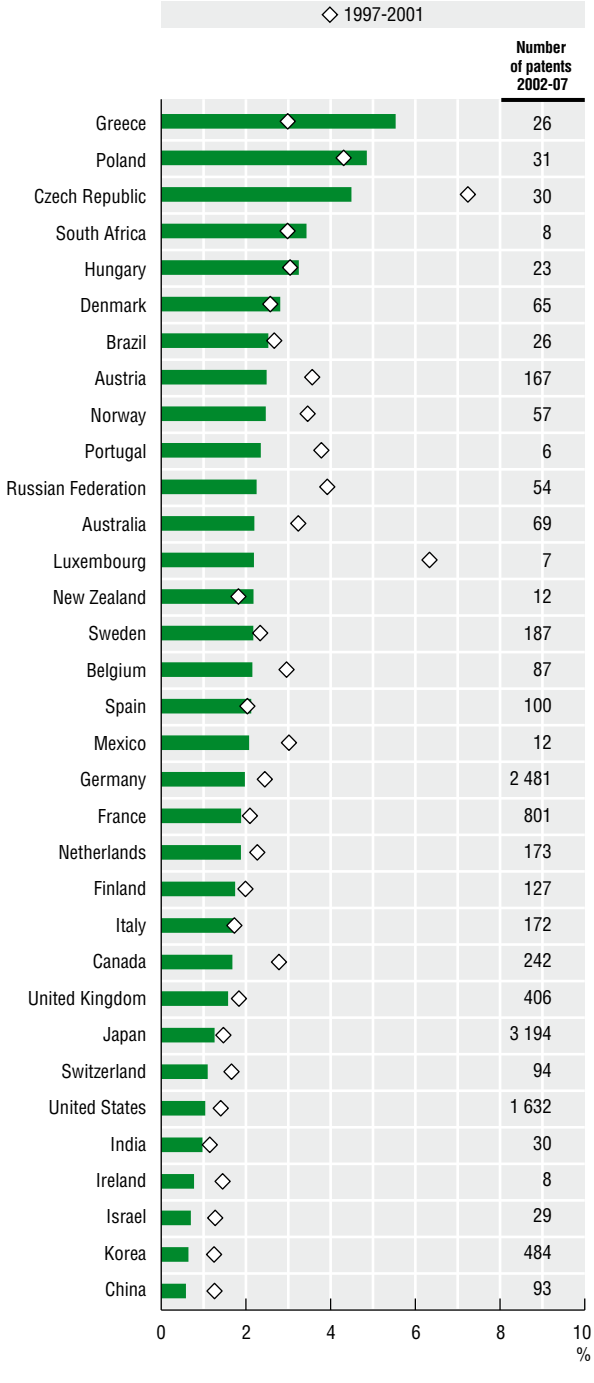
Data on government appropriations and outlays for R&D (GBAORD) by socioeconomic objectives classify energy and the environment separately. However, R&D on climate change mitigation is not explicitly distinguished. In addition, the International Energy Agency (IEA) collects data on public-sector RD&D budgets through inputs from the IEA Implementing Agreements on renewable energy technologies and from members of the Renewable Energy Working Party. In both cases coverage is restricted to OECD/IEA countries and a small number of non-member countries.

A significant gap concerns harmonised data on private-sector R&D expenditures on climate change mitigation. In addition, harmonised microdata are not available on the development and adoption (including licensing) of climate change mitigation technologies. Given the global scale of the challenge, data on non-OECD countries and technology transfer are sorely needed.

Technological change is essential to ensure that economic growth and environmental improvements progress together. It is important for environmental and technology policies to provide appropriate incentives to develop and diffuse environmental technologies.

Patent applications in pollution abatement and waste management technologies, 2002-07

As a percentage of patenting in all sectors



Source: OECD calculations based on EPO, Worldwide Patent Statistical Database, September 2009. See chapter notes.

StatLink http://dx.doi.org/10.1787/836234010113

DID YOU KNOW?

The share of the government R&D budget devoted to the environment decreased by 7% in the OECD area in the last decade.

(OECD, Research and Development Database, 2009.)

While the major OECD economies are generally the most active innovators in air and water pollution abatement and solid waste management, some smaller economies have developed specialisations in this area. Work undertaken at the OECD indicates that predictability, flexibility and stringency of environmental policies are conducive to higher investment in innovation.

Over the last decade, both the level of patenting and public research efforts related to environmental technologies have decreased. However, while patent levels for air pollution abatement have generally increased, innovation for solid waste management has decreased.

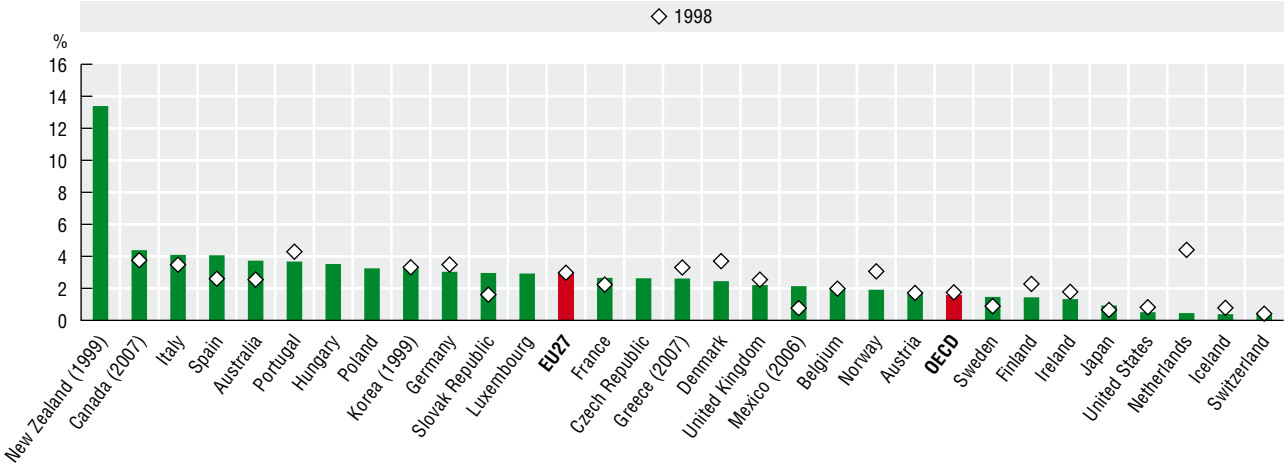
Evidence at the plant level shows differences in innovation efforts across sectors and countries. Empirical analysis indicates that the propensity to report environmentally related R&D increases with the use of incentive-based measures such as environmentally related taxes.

Definitions

Pollution abatement technologies include air pollution control, water pollution control and wastewater treatment. *Waste management technologies* cover disposal of solid waste, waste material re-use and recycling, and energy recovery from waste. For further details on classifications see *www.oecd.org/environment/innovation/indicator. Government budget appropriations or outlays for R&D* (GBAORD) measures the funds committed by the federal/central government for R&D. It can be broken down by various socioeconomic objectives, including control and care for the environment. *Facility* is defined as business establishment. For more information see the OECD Project on Environmental Policy and Corporate Behaviour (*www.oecd.org/env/cpe/firms*).

Government R&D budget devoted to control and care for the environment, 2008

As a percentage of total government R&D budget

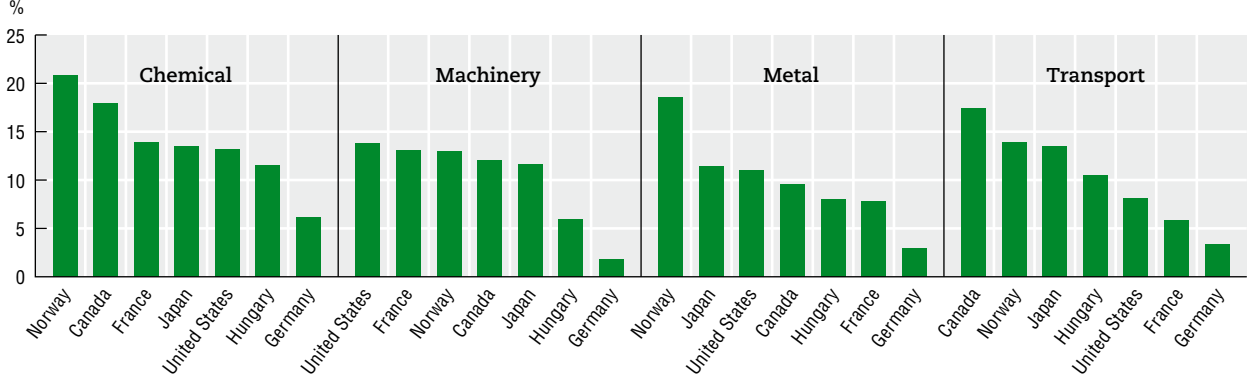


Source: OECD, Research & Development Database, December 2009.

StatLink http://dx.doi.org/10.1787/836234010113

Facilities with environmentally related R&D in selected manufacturing sectors, 2003

As a percentage of facilities with at least some R&D expenditures



Source: OECD (2007), *Business and the Environment*, OECD, Paris.

StatLink http://dx.doi.org/10.1787/836234010113

Measurability

Collection of data on environmental innovation is complicated because many innovations with positive environmental consequences are not explicitly concerned with environmental improvement. Many environmentally significant innovations involve changes in production processes that reduce operating costs or improve product quality. Determining whether an innovation is environmental or not is a question of degree and not of kind. Bearing this in mind, search algorithms developed by the OECD Secretariat with the help of researchers from the Paris Graduate School of Economics, Statistics and Finance were used to generate data on environmental technology patent applications. The data cover technologies for water and wastewater treatment, air pollution abatement, and waste management, recycling and prevention.

A 2003 OECD survey of over 4 000 manufacturing facilities collected data on environmental R&D expenditures, the adoption of integrated environmental technologies, and organisational innovations with positive environmental consequences. Development of a panel database would help to understand the determinants of environmental innovation.

Notes

Cyprus

The following note is included at the request of 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 recognizes 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 »".

The following note is included at the request of all the European Union Member States of the OECD and the European Commission:

"The Republic of Cyprus is recognized 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".

Israel

"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."

"It should be noted that statistical data on Israeli patents and trademarks are supplied by the patent and trademark offices of the relevant countries."

6.1 HEALTH

Total expenditure on health, 2007

- Total expenditure on health, % of GDP: Estimated data for Belgium, Luxembourg, the Netherlands and Switzerland.
- Public expenditure on health, % of total expenditure on health 2007: Estimated data for Switzerland.
- Current expenditure on health: New Zealand.
- Public and private expenditures are current expenditures (excluding investments): Belgium and the Netherlands.
- Health expenditure is for the insured population rather than the resident population: Luxembourg.

6.2 CLIMATE CHANGE

Renewable energy patents, 1998-2006

- Triadic patent families are patents filed at the European Patent Office (EPO), the US Patent and Trademark Office (USPTO) and the Japan Patent Office (JPO) which protect the same invention. Counts are presented according to the priority date and the residence of the inventors.

Patents for climate change mitigation technologies, 2007

- Data relate to patent applications filed under the Patent Co-operation Treaty (PCT), by priority date and inventor's country of residence.

Government research, development and demonstration (RD&D) expenditures on selected climate change mitigation technologies, 2004-08

- Average taken over the four-year period, zeros are treated as missing.
- Only countries with budget of RD&D higher than USD 10 million are included.

6.3 OTHER ENVIRONMENTAL CHALLENGES

Patent applications in pollution abatement and waste management technologies, 2002-07

- Data refer to counts of patent applications (claimed priorities), by priority date and inventor's country of residence.
- Only countries with at least five pollution abatement and waste management technology patents in both periods are included.

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Measuring Innovation

A NEW PERSPECTIVE

Measuring Innovation: A New Perspective presents new measures and new ways of looking at traditional indicators. It builds on 50 years of indicator development by OECD and goes beyond R&D to describe the broader context in which innovation occurs. It includes some experimental indicators that provide insight into new areas of policy interest. It highlights measurement gaps and proposes directions for advancing the measurement agenda.

This publication begins by describing innovation today. It looks at what is driving innovation in firms, and how the scientific and research landscape is being reconfigured by convergence, interdisciplinarity and the new geography of innovation hot spots. It presents broader measures of innovation, for example using new indicators of investment in intangible assets and trademarks.

Human capital is the basic input of innovation, and a series of indicators looks at how well education systems are contributing to the knowledge and research bases. Further series examine how firms transform skills and knowledge, and shed light on the different roles of public and private investment in fostering innovation and reaping its rewards, with concrete examples from major global challenges such as health and climate change.

Measuring Innovation is a major step towards evidence-based innovation policy making. It complements traditional "positioning"-type indicators with ones that show how innovation is, or could be, linked to policy. It also recognises that much more remains to be done, and points to the measurement challenges statisticians, researchers and policy makers alike need to address.

For more information about the OECD Innovation Strategy, see ***www.oecd.org/innovation/strategy***.

Further reading

The OECD Innovation Strategy: Getting a Head Start on Tomorrow

The full text of this book is available on line via these links:
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