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STIMULATING DIGITAL INNOVATION FOR GROWTH AND INCLUSIVENESS

THE ROLE OF POLICIES FOR THE SUCCESSFUL DIFFUSION OF ICT

2016 MINISTERIAL MEETING ON THE DIGITAL ECONOMY

BACKGROUND REPORT



2016 MINISTERIAL MEETING
THE DIGITAL ECONOMY:
INNOVATION, GROWTH
AND SOCIAL PROSPERITY

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BETTER POLICIES FOR BETTER LIVES

FOREWORD

This report was prepared as part of the documentation for Panel 1.2 of the OECD Ministerial Meeting on the Digital Economy, "Stimulating Digital Innovation across the Economy". It provides information and discussion on policies for the successful adoption and use of information and communication technologies (ICTs) across the economy.

Preparation of the document was undertaken by Christian Reimsbach-Kounatze, OECD, based on key work in science, technology and innovation across the OECD since 2013 and case studies provided by a group of volunteer countries including: Canada, China, Colombia, Germany, Japan, Korea, Mexico, Norway and Sweden. These case studies are made available in the Annex of the report.

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EXECUTIVE SUMMARY

Adoption and use of Information and Communication Technology (ICT) foster productivity, green and inclusive growth through digital innovation. Digital innovation refers to: (i) in a narrow sense, the implementation of a new or significantly improved ICT product (good or service), i.e. *ICT product innovation*; and (ii) in a broader sense, to the use of ICTs to implement a new or significantly improved product, process, marketing method, or organisational method, i.e. *ICT-enabled innovation*. ICT product innovation is a major factor for the progressive decrease in ICT prices which remains a key driving force for ICT adoption, and thus for ICT-enabled innovation, across the economy.

Data and its analysis have become a fundamental input to innovation, akin to research and development (R&D). Data are an infrastructural resource – a form of capital that cannot be depleted and that can be used for a theoretically unlimited range of productive purposes. Available evidence suggests that firms using data-driven innovation (DDI) have raised productivity faster than non-users by around 5-10%. Greater access to data also has beneficial spill-overs, whereby data can be used and re-used to open up significant growth opportunities, or to generate benefits across society in ways that could not be foreseen when the data were created. In this sense, data are the new "R&D" for 21st century innovation systems.

The adoption and use of ICTs including data analytics are associated with higher innovation performance. The share of businesses adopting ICTs is (20% to up to 70%) higher among innovators, depending on the year, the type of ICTs and the type of innovation considered. While differences between innovators and non-innovators are diminishing over time with regard to adoption and use of basic ICTs (such as broadband), they persist and even grow with respect to the use of more advanced ICTs (such as cloud computing). Evidence also shows that firms using data and analytics are more likely to innovate. Furthermore, ICT investments have relatively more profound effects on innovation in services, compared to manufacturing where investments in R&D are still more significant for innovation performance.

The diffusion of advanced ICTs still remains short of its potential. In particular small- and medium-sized enterprises (SMEs), which lag in productivity relative to larger firms and governments, lag in their adoption and use. For example, while almost 95% of enterprises in the OECD had a broadband connection in 2014, 40% of enterprises with 250 or more employees used cloud computing, compared to less than a quarter of SMEs. This is a concern because evidence suggests that a slowdown in the diffusion of technologies and knowledge from frontier to lagging firms may be an important source of the current aggregate productivity slowdown. Poor diffusion of ICTs thus contributes to a *digital divide* that can undermine policies aimed to stimulate growth, and foster resilient economies and inclusive societies.

Poor ICT diffusion results from barriers affecting organisations' and individuals' decision and ability to adopt and use ICTs effectively, and these barriers can have a strong regional bias. *Lack of access to digital infrastructures at competitive prices* is the first barrier. In particular, access to ICTs such as (mobile) broadband, including in rural and remote areas, as well as access to data which are becoming an infrastructure for data-driven innovation (DDI), are crucial. The *lack of appropriate (open) standards* and *fears of vendor lock-in*, often due to proprietary solutions, are another barrier to adoption in particular for SMEs. With the growth of digital security risks and concerns that privacy and intellectual property rights are violated and not sufficiently enforced, *lack of trust in the digital economy* is also a potential barrier to adoption and use of ICTs across society.

Investing in ICTs alone is not enough. The effective use of ICTs and data requires additional investments in complementary knowledge-based capital (KBC), in particular in (organisation-specific) skills and know-how, and in organisational change including new business models and processes. However, many businesses, in particular SMEs, but also governments and individuals – in particular those with low or no formal education – lack the necessary skills and know-how, and financial resources to take advantage of ICTs, and to introduce the changes needed for their productive use in businesses and across society.

While digital innovation brings benefits across society, it may induce disruptive changes that are perceived as too threatening (at least in the short run). Established businesses, in particular, may have too low incentives to invest in ICTs and in the necessary complementary KBC (in particular organisational change). One reason is that investments in ICTs can take scarce resources away from sustaining the most profitable business units, in particular when ICT investments have to be complemented with additional investments in organisational change and human capital. In addition, these investments are risky: they may not be profitable enough in the short run and are often associated with sunk costs (that cannot be recovered often due to a high degree of organisation specificities). This leads to what Christensen refers to as the *innovator's dilemma*, where successful organisations put too much emphasis on current success, and thus fail to innovate in the long run.

Inertia to change in established businesses can explain why digital innovation is often introduced by start-ups, and puts a premium on framework conditions affecting business dynamics and entrepreneurship. These typically include, but are not limited to, regulations related to competition and product market regulation, to employment protection, to bankruptcy, and to access to finance. These framework conditions are crucial for ICT adoption as they influence the incentives to experiment with (disruptive) innovations, and the ability to scale up successful digital innovations and to scale them down if they turn out to be a failure. They thereby also affect the ability of economies to reallocate scarce resources needed for digital innovation (such as ICT-related skills) to more successful firms, and are thus an important determinant for business dynamics. Differences in framework conditions may explain the relative sluggishness of some countries to capitalise on the digital revolution.

Governments have developed national strategies to stimulate digital innovation. Many *national digital economy strategies* put a strong emphasis on the promotion of ICT-related knowledge diffusion, including between large firms and SMEs or towards disfavoured social groups. Some initiatives focus on ICT adoption and use with a view to addressing specific social challenges such as climate change and aging societies. Besides national digital economy strategies, many countries have also developed *national science, technology and innovation (STI) strategies*, including new industrial policies, (regional) cluster policies and smart specialisation strategies, in which digital innovation is a key element.

However, many government strategies still have significant room for improvements. Many national digital and STI strategies still poorly support the complementarities between investments in ICTs and KBCs (in particular organisational change), and the difficulties that established firms face in investing in complementary KBCs. Also, better co-ordination between ICT-related policies with policies affecting the broader regulatory frameworks and market conditions is needed, in particular in ICT-using sectors of public policy interest such as energy, healthcare and transport. Furthermore, there is still a need to promote "openness" in the digital economy, and at the same time to address legitimate considerations of individuals' and organisations' opposing interests (including in particular their interests in the protection of privacy and intellectual property rights).

All this calls for *more holistic and whole-of-society approaches* that encompass coherent evidence-based policies to stimulate digital innovation for economic growth and social prosperity across society.

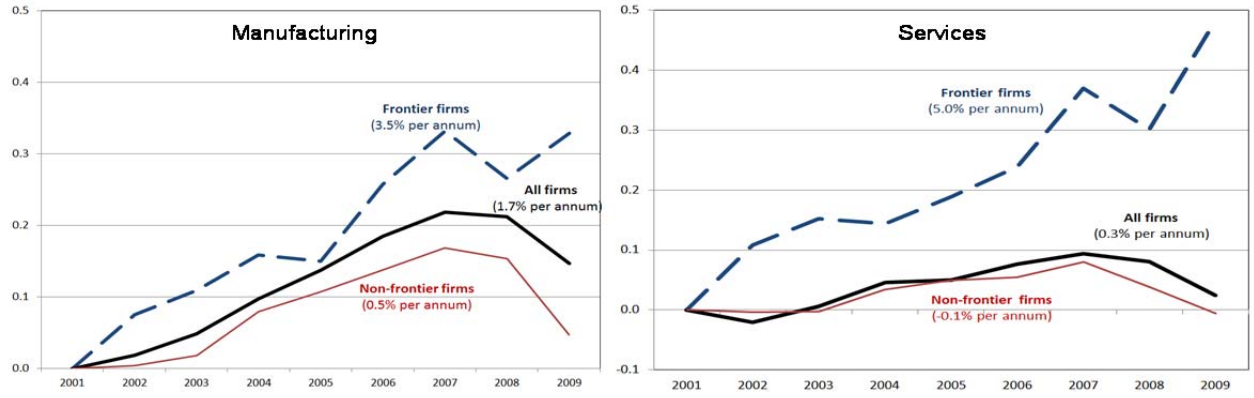
INTRODUCTION

The digitalisation[1] of economies and societies is progressing with the increasing adoption and use of information and communication technologies (ICTs), and the continuous migration of social and economic activities to the Internet (through digital services such as social networks, e-commerce, e-health and e-government). Today, three out of four inhabitants in the OECD area have a subscription to a mobile wireless broadband service, which they use daily, and up to 95% of all businesses are now connected to the Internet, with three quarters having an online presence and almost half using this platform to do e-commerce (OECD, 2015a; 2015b). The transformation of entire economies into *digital economies* will intensify with the increasing number of real world objects becoming "smarter", thanks to their embedded software and their interconnection via the Internet of Things (IoT) (see OECD, 2016i). The analysis of unprecedented volumes of digital data ("big data") generated in all areas of social life will be a further driver of this transformation process (OECD, 2015d).[2]

Digitalisation promises to boost productivity growth and economic competitiveness. This promise is much sought-after in current times of stagnating to declining working age population[3] and productivity growth, and the resulting risk of a slowing of GDP growth or a "secular stagnation" as discussed in Gordon (2015).[4] Recent OECD work by Andrews et al. (2015a) shows that productivity growth of the most productive firms worldwide remained robust in the 21st century, despite the slowdown in aggregate productivity growth (Figure 1).[5] "This suggests that the main source of the productivity slowdown is not so much a slowing of innovation – which is continuing apace in the most globally-advanced firms – but rather a slowing of the pace at which innovation spread through the economy, i.e. a breakdown of the diffusion machine" (Andrews et al., 2015b). This *breakdown of the diffusion machine* may be leading to a widening (new) *digital divide* between (frontier) firms that are able to take advantage of digitalisation, and the rest of an economy.

Figure 1. Labour productivity growth, 2001-09

Index 2001 = 0



Note: "Frontier firms" corresponds to the average labour productivity of the 100 globally most productive firms in each 2-digit sector. "Non-frontier firms" is the average of all other firms. "All firms" is the sector total from the OECD STAN database. The average annual growth rate in labour productivity over the period 2001-09 for each grouping of firms is shown in parentheses.

Source: Andrews et al. (2015b)

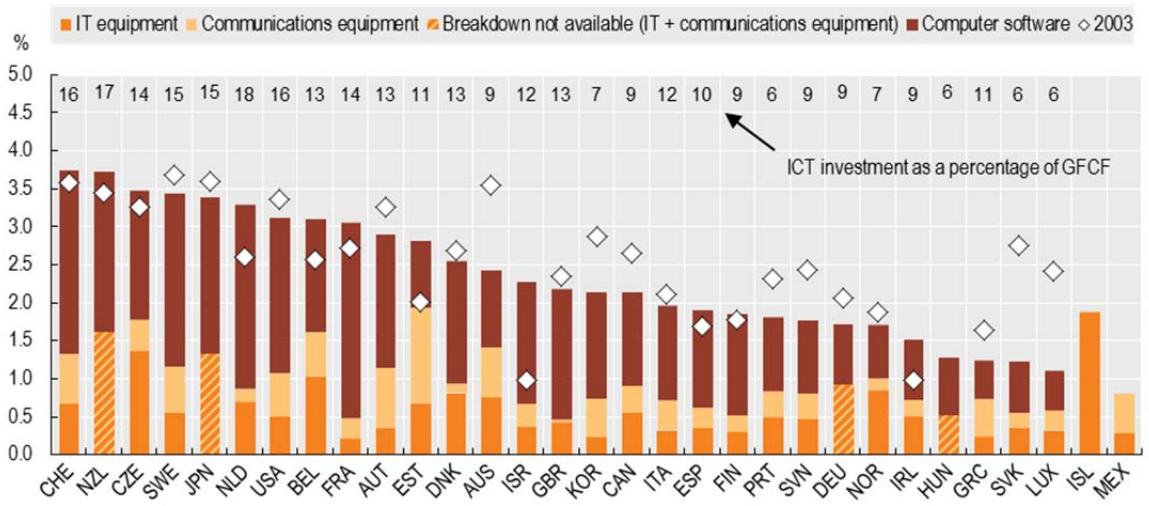
The role of digitalisation for growth

Digitalisation contributes directly to economic growth through the ICT supply side by enhancing the contribution of ICT goods and services in total value added (i.e. production effect). In 2013, the ICT sector

accounted for 5.5% of total value added, equivalent to about USD 2.4 trillion, in the OECD (OECD, 2015a). More importantly, the adoption and use of ICTs, and software in particular, continue to have a profound impact across the economy (the ICT demand side). Investments in ICT goods and services across the economy are therefore seen as an important driver of growth (OECD, 2015a). In 2014, ICT investment in the OECD area represented 13.5% of total fixed investment or 2.7% of GDP, with almost two thirds of ICT investment being devoted to software and databases (Figure 2).[6]

Figure 2. ICT investment, by asset, 2014

As a percentage of GDP and Gross Fixed Capital Formation (GFCF)



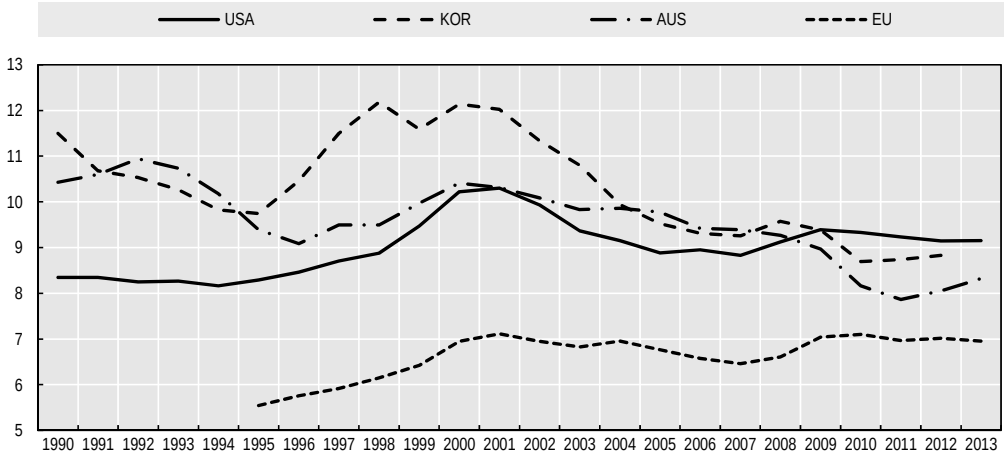
Note: For Australia, Ireland, Norway, Portugal, Slovenia and Spain data refer to 2013. For Mexico data refer to 2012. Data for Iceland and Mexico were incomplete and only represent the asset for which data were available.

Source: OECD National Accounts (SNA) Statistics database, Eurostat National Accounts Database and national sources, May 2016.

Even though there is no strict consensus over the magnitude of the productivity effects of ICTs, available evidence strongly points to an overall positive influence.[7] Kretschmer (2012), for instance, confirms the significant and positive productivity effects of ICTs, but reports that the results vary with the methodology employed.[8] However, there are signs that the contribution of ICTs to (productivity) growth may indeed have slowed down since the bust of the dot-com bubble in 2001, and in particular since the onset of the financial crisis in 2007. Over 2001-13, ICT investment dropped from 3.4% to 2.7% of GDP, or 14.8% to 13.5% of total fixed investment. This slowdown in ICT investment was mainly due to an investment decrease in IT and communication equipment.[9] Investments in software, in contrast, increased to 69% of total ICT investment in 2013, from 51% in 2000. Overall, however, the contribution of ICT investment to growth has slowed in recent years: while ICT investment accounted for between 0.22 and 0.59 percentage points of annual growth in GDP for the 2001-07 period, the contribution dropped to 0.07 to 0.45 percentage points for the 2008-13 period (OECD, 2015a). As a result, the ICT capital coefficient at current prices (ratio of ICT capital stock to GDP in current prices) has decreased or stagnated since 2001 in most OECD countries, with the financial crisis undermining its possible uptake, or even accelerating its slump, in some countries (Figure 3).[10]

Figure 3. ICT capital coefficient in selected economies, 1990-2013

Percentage, net fixed assets in current prices for total activities



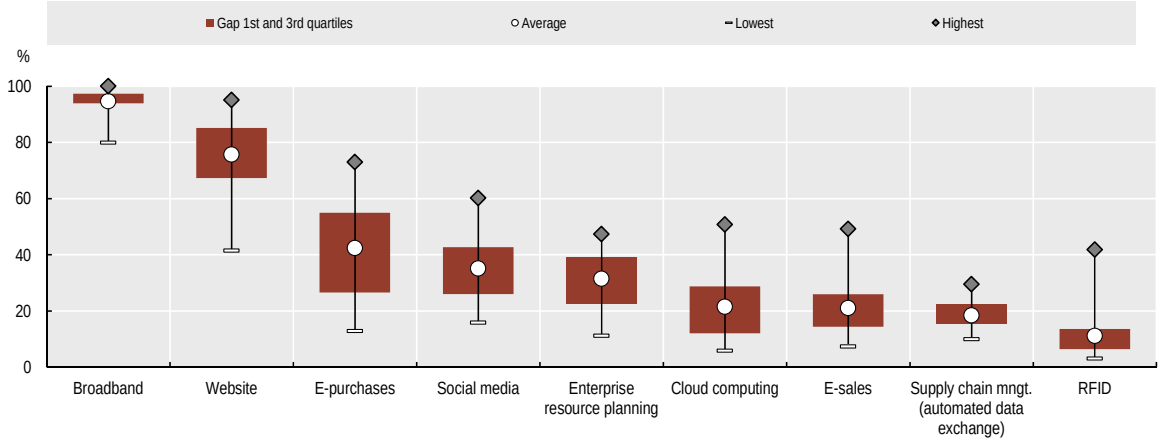
Note: Figure covers ICT equipment (computer hardware and telecommunications equipment) plus computer software and databases and only countries for which SNA 2008 data were available. EU therefore only includes the unweighted average of Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Greece, Ireland, Italy, Luxembourg, the Netherlands, the Slovak Republic, and Slovenia.

Source: OECD National Accounts Statistics (database), January 2016.

Some studies have concluded that the stagnation may be the result of a break in the ICT productive capital diffusion that started from the beginning of the 2000s (see Cette 2014; 2015). Others have highlighted that this stagnation or decrease was mainly due to a shift in favour of the intermediate use of ICT services (such as cloud computing), which has decreased the need to invest in ICTs. In any case, evidence shows that the diffusion of ICTs (including the use of ICT services) across the economy may remain short of its potential. Current surveys on the diffusion of ICT tools and activities in enterprises, for instance, confirm that many businesses, and in particular small- and medium-sized enterprises (SMEs), which lag in productivity relative to larger firms, lag in the adoption and use of ICTs. In particular, the adoption of advanced ICTs such as cloud computing, supply chain management, and enterprise resource planning (ERP) applications by firms is still much below that of broadband networks or websites (Figure 4), although it is these advanced ICTs that promise to have a strong impact on productivity.[11]

Figure 4. Diffusion of selected ICT tools and activities in enterprises, 2014

Percentage of enterprises with ten or more persons employed



Source: OECD (2015), OECD Science, Technology and Industry Scoreboard 2015, OECD Publishing, Paris. Based on OECD, ICT Database; Eurostat, Information Society Statistics Database and national sources, July 2015.

Another reason put forward to explain the diminishing productivity effects of ICTs is the relative slowdown in ICT performance that translates into an observed slowdown of the ICT price decrease – that would also slow down ICT diffusion.[12] The temporary acceleration of price decline in the late 1990s and the successive slowdown after 2013 occurred at the same time as economy-wide productivity experienced its respective acceleration and slowdown. The slowdown of price decline also coincides with the lingering diffusion of ICT productive capital according to Cette (2014; 2015).

The reason often assumed behind the slowing decrease in the ICT relative price are possible limits of Moore's law which holds that the number of transistors on a chip, and thus processing power, doubles about every 18 months, relative to cost or size. While Moore's law remains more or less valid in respects to the number of transistors on a chip, clock speed and, in particular, power consumption seem to have hit fundamental limits starting between 2000 and 2005.[13] However, as innovation in ICTs (i.e. ICT product innovation), including in microprocessors, is progressing, it is likely that these fundamental limits are becoming less significant. For instance, the development of three-dimensional integrated circuit (3D IC)[14], but more importantly, the development and increasing use of parallel computing and the ubiquity of large processing power through cloud computing, have been able to offset the limitations encountered on single microprocessors.[15]

There are some indications that the slowing decrease in the ICT relative price could also be the result of weakening competition in the ICT sector. As documented by the OECD (2004; 2006; 2008; and 2010), consolidation and concentration tendencies in the ICT sector continue. Since 2003 the top 10 ICT firms accounted on average for a faster growing revenue share than the top 250 ICT firms. As a result, the top ten ICT firms together accounted for a quarter of the total revenue of all top 250 ICT firms in 2014 (compared to 21% in 2004).[16] While greater consolidation and concentration may reflect a higher level of maturity in the ICT sector, and may not automatically lead to a slowing decrease in the ICT relative price, there are an increasing number of issues related to competition in the ICT sector that have raised concerns and could have led to a slowing decrease in the ICT relative price. A recent report by the (former) United Kingdom's Office of Fair Trading (OFT, 2014) on the supply of ICTs to the public sector, for instance, highlights a number of competition issues specific to the ICT sector. These include issues related to (i) the relatively small number of suppliers, (ii) the information asymmetry between suppliers and purchasers, and (iii) lock-ins and high switching costs.[17] Furthermore, OECD (2013c) shows that ICTs enable economies of scale and scope that paired with multi-sided markets and network effects can lead to a "winner takes all" outcome where monopoly is the nearly inevitable outcome of market success.[18] (See also section on the role of competition for ICT adoption in the ICT demand side.)

While the slowdown in the price decrease has been documented by several authors (see Aizcorbe et al. 2008; Bryne et al., 2013; Pillai, 2011; and Gordon, 2012; 2013; 2015), "it cannot be excluded that the slowdown of the chip price decrease observed from the early 2000s in the US national account statistics, and which would mean a deceleration of the chip and ICT performances, is in reality at least partly a chip price mis-measurement" (Cette, 2014). Already Wyckoff (1994) noted that "the variations which exist in the price indexes are largely due to differences in the methods countries use to capture changes in the quality of an industry's output over time." Despite progress made in the last decades, further improvements in hedonic pricing methods are still needed.[19] In addition, there are other factors that have been put forward as more pertinent sources of the diminishing productivity effects of digitalisation, namely low-level investments in complementary knowledge-based capital (KBC).

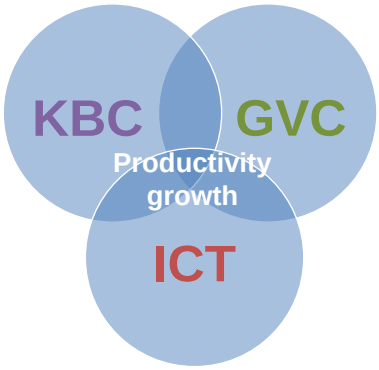
Complementarities beyond ICTs

Available firm-level evidence strongly suggests that investing in ICTs alone is not enough, as it is mainly its effective use that generates the positive productivity effects (at least in the mid to longer run).[20] And the degree of effectiveness in ICT use will typically depend on additional complementary investments in KBC, in particular firm-specific skills and know-how, and organisational change including new business processes and business models (see Bresnahan, 1998; Pilat, 2004; van Ark et al., 2008; Bloom 2012; Corrado et al., 2014). Failing to invest in (and then account for) these complementary assets limits the (measured) productivity impacts of ICTs, and partly explains *Solow's productivity paradox*, according to which "computers were everywhere but in the productivity statistics".[21]

A series of empirical studies have confirmed the crucial role of complementary investments, in particular in organisational capital, as explanations for the difference in the impact of ICTs between the United States and Europe.[22] Basu et al. (2003), for instance, present evidence according to which the difference in total factor productivity (TFP) between the United States and the United Kingdom from 1995 onwards can be explained by a combination of unmeasured investments in (intangible) organisational capital and ICTs, and in particular the innovation these investments induce. Similarly, van Ark et al. (2008) assign a large portion of the difference in TFP between the United States and Europe to differences in complementary investments in organisational change. By comparing the productivity of United States multinationals and their subsidiaries in Europe, Bloom et al. (2010) find that United States subsidiaries in Europe use ICT more effectively than other comparable European multinationals, and therefore also gain a higher return from their ICT investments. This suggests that the internal organisation of United States firms, and in particular their management capabilities, plays a crucial role in their ability to use ICTs more effectively (see also Bloom et al., 2007). In a recent study, Corrado et al. (2014) find strong evidence at the macroeconomic level confirming that "the marginal impact of ICT capital is higher when it is complemented with intangible [knowledge based] capital." More specifically, their study shows that ICT-intensive industries have better productivity outcomes in countries that are more KBC intensive, in particular with relative higher investments in organisational capital (see also section below on the role of organisation change and knowhow for digital innovation).

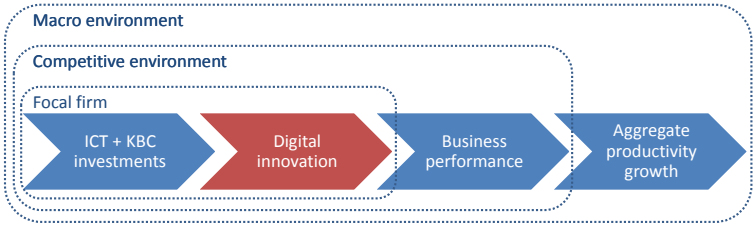
The importance of complementarities is also confirmed in OECD work on global frontier firms by Andrews et al. (2015a). The work shows that firms at the global productivity frontier are typically more likely to patent, than other firms. Moreover, they have a better "capacity to both 'innovate' and to optimally combine technological, organisational, and human capital in production processes throughout global value chains (GVCs) and harness the power of digitalisation to rapidly diffuse and replicate leading-edge ideas" (Andrews et al., 2015b). The exploitation of GVCs is thus another complementarity factor besides investments in KBCs that can leverage investments in ICTs for productivity growth. This makes ICTs, KBCs, and GVCs the *drivers of productivity growth* in 21st century knowledge economies (Figure 5).

Figure 5. The confluence of the drivers of productivity growth in 21st century knowledge economies



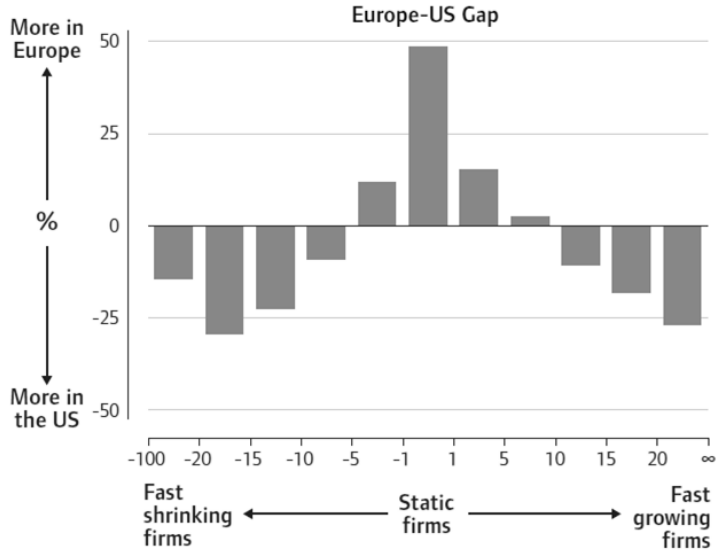
The confluence of the drivers of productivity growth presented above suggests that the mechanisms leading to aggregate productivity growth are more complex than often presented, and further work is therefore needed to disentangle the role of these different factors involved, and their interactions. In particular, there is a need to better understand, and make the processes explicit, through which the effects of ICT investments are mediated so to lead to aggregate productivity growth. Because as Barua et al. (1995) already argued, "the association between IT investment and performance attenuates as the distance between cause and effects widens." Based on the IT business model developed in Melville et al. (2004) and work[23] by Andrews and Criscuolo (2013), this report suggests the following process through which ICT investments are complemented with investments in KBC to enable digital innovation[24], which in turn enhances business performance (e.g. higher productivity, profitability, and market share) and ultimately leads to higher aggregate (productivity) growth (Figure 6). Furthermore, more work is also needed to understand the incentive mechanisms for investing in ICTs and the complementary KBC that may eventually require disruptive changes (and the "creative destruction") of established businesses, markets and value networks (see section below on the role of organisational change for the digital transformation of businesses).

Figure 6. From ICT investments to aggregate productivity growth



The diffusion of digital innovation depends on the environment in which the innovation takes place, in particular, the competitive and macro environments. These environments are essentially shaped by regulatory and legal frameworks (framework conditions) related to e.g. trade, competition, privacy and intellectual property rights, and product and labour markets. As these frameworks influence the perceived flexibility (cost) of businesses to experiment with (disruptive) innovations, framework conditions can affect the ability of businesses to scale-up those innovations that have been successful in smaller scale experiments, and to scale them down if they turn out to be a failure. At the macro level, framework conditions thereby affect the ability of economies to reallocate scarce resources needed for digital innovation (such as ICT-related skills) to more successful firms, and are thus an important determinant for business dynamics. The difference in business dynamics between Europe and the United States between 2002 and 2005 is a case in point (Figure 7). Although this is a short period to deduce a general statement, it suggests that the United States could have a stronger ability to reallocate scarce complementary resources towards more productive firms (see also section below on the role of framework conditions for digital innovation).[25]

Figure 7. Share of firms by growth bracket, Europe-United States comparison, 2002-05



Note: Based on individual records of six million firms, for which employment growth has been calculated for the period between 2002 and 2005 and placed in one of the 11 growth intervals between fast shrinking firms and fast growing firms. Europe corresponds to the average for the European countries (Austria, Denmark, Italy, Netherlands, Spain, Norway and the United Kingdom) that participated in the Nesta-FORA firm growth project.

Source: Bravo-Biosca (2011)

The role of digitalisation for well-being

The importance of digitalisation goes beyond its potential to boost productivity and competitiveness. Digitalisation can also help address pressing policy (social and global) challenges, with opportunities particularly around promoting inclusiveness by addressing the special needs of disfavoured social groups (e.g. poor, rural or ageing populations) and helping mitigate the risks of climate change, water, food, and energy shortage, and mass urbanisation (OECD, 2015a; 2015b). For emerging countries, digital innovation is therefore seen as an important lever for economic development including the reduction of poverty, and progress towards a more inclusive society. And this remains true, even if quantification of that contribution is challenging because many if not most of the benefits related to the use of ICTs are still not captured by market transactions, thereby exacerbating *Solow's productivity paradox*.[26]

There are some areas where digitalisation promises to enhance well-being and efficiency in the relative short run. OECD (2015b) has identified science and education, health care services and public administration as the low hanging fruit policy makers can target to leverage digitalisation for growth and well-being. These sectors still employ the largest share of people who perform work related to the collection, processing and analysis of information and data. However, in these sectors, people are also still performing that work at a relatively low level of computerisation.[27] Targeted promotion of the adoption of ICTs, and data and analytics in particular, could thus boost efficiency gains even further in these sectors, while enhancing quality of service.[28] In these areas, the public sector can also act as a catalyst and lead user. For instance, citizens' use of open data as enabled by governments through their open data initiatives can increase the openness, transparency and accountability of government activities, and thus boost public trust in governments. At the same time, it can enable an unlimited range of commercial and social services across society.[29]

Objectives and structure

Acknowledging the important role of digitalisation for growth and inclusiveness, governments have been developing *national digital economy strategies*, many of which put a strong emphasis on the promotion of ICT and ICT-related knowledge diffusion, including between large firms and SMEs or towards disfavoured social groups. Examples include Korea's strategy "Creative Korea – Smart Nation" and Colombia's "Vive Digital" strategies. Some initiatives also have an explicit focus on SMEs such as Germany's initiative "Mittelstand-Digital" (EN „SMEs digital"), which aims at promoting the use of software for enhancing business processes by SMEs including skilled crafts. Others have an explicit focus on ICT adoption and use for addressing specific social challenges, such as Japan which is addressing the needs of an ageing society through its programme on the "Platinum Society". Besides these national digital economy strategies, many countries have also developed *national science, technology and innovation strategies* in which digital innovation is highlighted as a key pillar. For example the Swedish Innovation Strategy complements Sweden's national digital strategy and the National Strategy for Regional Growth and Attractiveness.

This report analyses the importance of ICT diffusion for enabling digital innovation for growth and inclusiveness, and discusses the role of public policies in stimulating such diffusion. Given the emergence of a new *digital divide* caused by a possible breakdown of the "diffusion machine", and given the strong interest of governments in furthering ICT adoption and use in particular by SMEs and disfavoured social groups, emphasis is put on policies stimulating ICT diffusion across society, i.e. ICT demand side policies. However, it is acknowledged that ICT demand side policies need to be complementary to (existing) ICT supply side policies such as ICT-related R&D programmes and national broadband strategies, which are not discussed in the report.

The report is structured around an analytical framework and used to help guide policy discussions on digital innovation and to support the analysis of the different case studies provided by the volunteer countries (Canada, the People's Republic of China, Colombia, Germany, Japan, Korea, Mexico, Norway and Sweden) made available in the Annex of the report. The following sections of the report include:

i. A *definition of digital innovation* based on the OECD/Eurostat (2005) Oslo Manual definition of innovation.

ii. The *rationale for digital innovation policies* based on the OECD's revised Innovation Strategy (OECD, 2015e) with a discussion on the policy levers to leverage the complementary factors (KBC and GVC) to stimulate digital innovation; and

iii. The *implementation of digital innovation policies* with a discussion on recent policy initiatives in OECD and Partner countries, including the case studies provided by volunteer countries.

Understanding digital innovation

The discussion presented in the introduction strongly suggests that it is the innovation related to ICTs (*digital innovation*) that ultimately drives aggregate productivity growth, subject to its successful diffusion and use across society (inclusiveness). There is no widely agreed definition of digital innovation however. For Henfridsson et al. (2009), for instance, digital innovation "refers to the embedding of digital computer and communication technology into a traditionally non-digital product". By digital innovation, Yoo at al. (2010) "mean an innovation enabled by digital technologies that leads to the creation of new forms of digitalisation".[30] Åkesson (2009) also refers to innovation enabled by ICTs, but occasionally also refers to new ICT products. And Whittle et al. (2012) refer to digital innovation simply as "innovation in the digital economy".

The latest (3rd) edition of the OECD and Eurostat (2005) Oslo Manual provides a definition of innovation that can help as a starting point for thinking about a possible working definition of digital innovation. It

defines innovation as "the implementation of a new or significantly improved product (good or service), or process, new marketing method, or new organisational method in business practices, workplace organisation or external relations" (see Box 1). The level of the improvement or newness required to qualify as innovation is context dependent though: it is typically assumed that innovation requires that it be introduced for the first time. But a later introduction of the same innovation, but in a different context, may also qualify as innovation. As Fagerberg (2006) explains "the latter arguably includes a larger dose of imitative behaviour (imitation), or what is sometimes called 'technology transfer'". However, the author also acknowledges that "introducing something in a new context often implies considerable adaptation (and hence incremental innovation) and, as history has shown, organisational changes (or innovations) that may significantly increase productivity and competitiveness". This is highly relevant for digital innovation, where the adoption and use of a particular ICT may not occur for the first time from a (global) market perspective, but may be new or a significant improvement from the perspective of a specific organisation or social group.

Box 1. The OECD and Eurostat Oslo Manual definition

The Oslo Manual defines innovation as "the implementation of a new or significantly improved product (good or service), or process, new marketing method, or new organisational method in business practices, workplace organisation or external relations". This definition, for measurement purposes, captures the following four types of innovation:

- *Product innovation* – The introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user-friendliness and other functional characteristics.
- *Process innovation* – The implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software.
- *Marketing innovation* – The implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing.
- *Organisational innovation* – The implementation of a new organisational method in the firm's business practices, workplace organisation or external relations.

Source: OECD and Eurostat (2005)

Based on the OECD and Eurostat (2005) Oslo Manual definition, and in light of the different definitions of digital innovation proposed in literature, this report suggests that digital innovation should be understood:

- in a narrow sense, as the implementation of a new or significantly improved ICT product, i.e. *ICT product innovation*;
- in a broader sense, as also including the use of ICTs for the implementation of a new or significantly improved product or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations, or simply put as *ICT-enabled innovation*.

ICT product innovation mainly occurs in the supply side (i.e. the ICT producing industries), while ICT-enabled innovation is a much broader phenomenon that captures digital innovation in the ICT demand side (across the economy). That said, ICT product innovation increasingly occurs also in non-ICT sectors including space, defence, infrastructure (e.g. power grids), automobiles, automation, robots, logistics, aviation, healthcare, environment monitoring, and toys. In particular, a growing amount of ICT product innovation ends up as an integral part of non-ICT products (e.g. embedded systems or software, and the IoT) to improve performance and efficiency.[31] This underscores the linkages between ICT product innovation and ICT-enabled innovation: ICT product innovation spill over across the economy as it leads

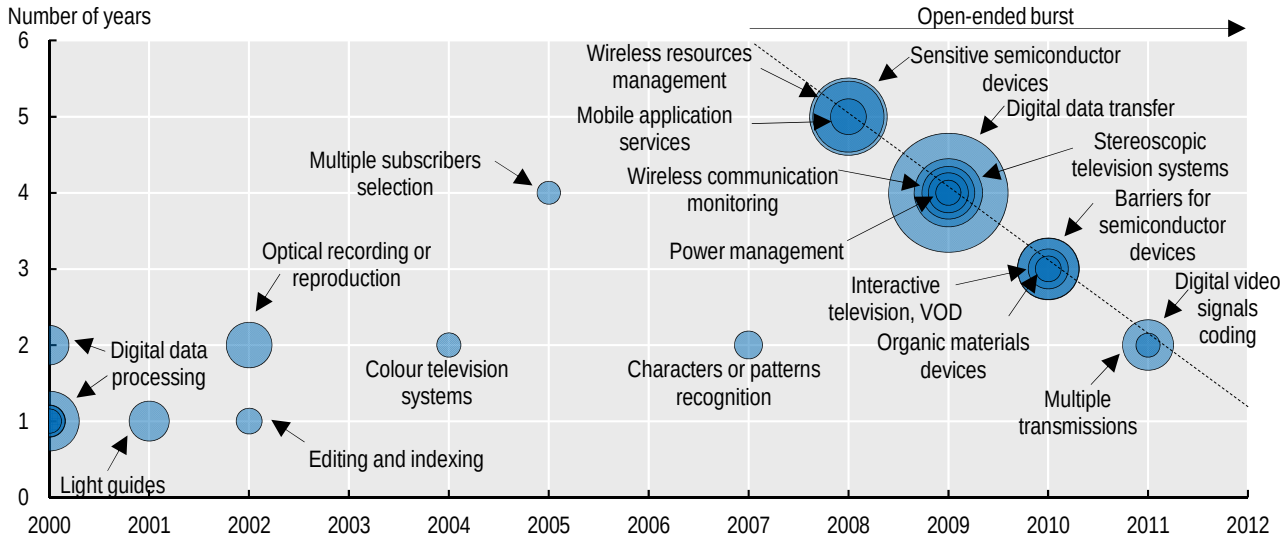
to disruptive new ICTs that displace established ones and affect production processes, the entry of new firms, and the launch of ground-breaking products and applications (ICT-enabled innovation).

ICT-product innovation spilling over across the economy

Many of the most exciting or useful products available today owe their existence, performance, efficacy and accessibility to the development of disruptive ICTs that have emerged over the last decade. Figure 8 shows the intensity and development speed in ICT-related technologies. The size of the bubble indicates the "burst" intensity, and different shades indicate the different technologies that burst. The X axis indicates the year in which the technology bursts and the Y axis indicates the number of years during which patents field are accelerating before levelling off. Bubbles located along the diagonal line on the right-hand side of the figure represent "open-ended" burst technologies (i.e. technologies still developing at an accelerated pace at the end of the sample period). Figure 8 shows, for example, that at the start of the 2000s, activities burgeoned in the field of digital data processing and editing, enabling what today is referred to as big data or data-driven innovation (DDI, see OECD, 2015b). Since 2008, technologies related to wireless communications and improved performance of ICT devices (e.g. power management, data transfer) have accelerated with unprecedented intensity, enabling the mobile revolution across society and with that for example applications that has emerged under the label of the "sharing economy".

An examination of technological fields attributed to patent applications filed under the Patent Co-operation Treaty (PCT) can function as a proxy for the cross-fertilisation between ICTs and other technological areas and their related products. In 2010-12, about a quarter of ICT-related patents also belonged to one or more other technological fields (Figure 9). Patents in medical, biotechnology or pharmaceutical technology fields added up to about 14% of this group, while transport, logistics and machine tools amounted to 8%. Many patents cover technological fields contiguous to ICTs, such as electrical machinery (14%) or audio-visual technologies (5%). Numerous examples include patents in technologies likely to be applied in the ICT field, such as basic chemistry or nano-technologies. Often ICT-related inventions in this group lie at the crossroad between several other technological fields and their potential applications also bridge different industrial domains (OECD, 2014a).

Figure 8. Intensity and development speed in ICT-related technologies, 2000-12

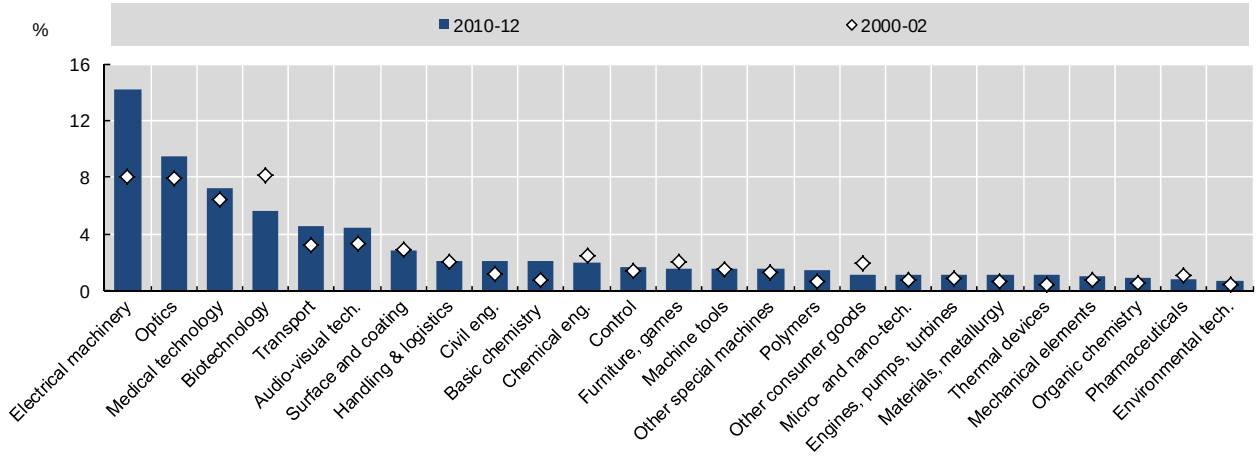


Note: Data refer to patent applications filed at the EPO or the USPTO that belong to IP5 families, by filing date, using fractional counts. ICT-related patents are defined on the basis of their International Patent Classification (IPC) codes.

Source: OECD (2015c) Science, Technology and Industry Scoreboard 2015, OECD Publishing, Paris, http://dx.doi.org/10.1787/888933273469.

Figure 9. Top 25 combinations between ICTs and other technologies in patent applications, 2000-02 and 2010-12

As a percentage of all ICT-related patent applications also belonging to other technology fields



Note: Patent counts are based on the priority date.

Source: OECD (2015a) Digital Economy Outlook, OECD Publishing, Paris, based on OECD, Patent Database, February 2015. http://dx.doi.org/10.1787/888933224483.

At this point it is important to acknowledge that innovation, including digital innovation, does not exclude cases where its purpose is malevolent. The speed at which, in particular, malware has evolved over the last 10 to 15 years suggests not only that digital innovation comes with higher risks but also that malware has become highly innovative (see Box 2). Innovation in malware has forced the IT security industry and IT security experts to keep pace, thereby providing significant incentives for further digital innovation. This "arm race" between malicious users and the IT security community has been a driving force for digital innovation in the last decade. This is for instance reflected in increasing R&D efforts to integrate security (and privacy) concerns early into the design of ICTs (*security and privacy by design*).[32]

Box 2. Increasing sophistication of cybersecurity threats

Malicious users are continuously improving malware technologies making them more and more sophisticated. This increasing sophistication is challenging IT departments, IT-security companies and law enforcement alike, who are forced to keep pace through continuous innovation themselves. Malware developers are increasingly using multiple attack vectors simultaneously including social engineering and (zero-day) vulnerability exploits of popular applications to increase the effectiveness of their attacks. Furthermore, techniques and technologies such as polymorphisms and encryption have become the standard repertoire of malware developers looking not only to thwart antimalware programmes, but also to make the analysis of the malware's functioning (through *e.g.* reverse engineering) as difficult as possible once detected (see Golovanov et al., 2008; Microsoft, 2012). Malicious users are also continuously monitoring antivirus databases in order to (automatically) update their malware when new antivirus signatures are released. *Virut*, for example, is considered among some security experts as one of the fastest-mutating viruses; generating new variants as often as once a week (see Zakorzhevsky, 2010).

The increasing complexity of malware attacks is also due to the fact that malicious users are building their malware on the "shoulders of giants", by *e.g.* exchanging innovative practices and technologies, reusing existing code or by even buying "off-the-shelf" malware kits with ready-made and continuously updated vulnerability exploits. In this context, the discovery, marketing and exploitation of zero-day-vulnerabilities remain one of the most critical success factors for malware developers and the biggest threat to software users. The *bootkit*[33], for example, uses the browser as an infection vector (*i.e.* "drive-by download") combined with rootkit technologies and migrating command and control (C&C) botnet servers among others. In particular, *bootkit* uses the *Neosploit* bundle of vulnerability exploits, which has been sold since 2007 on the black market for between USD 1 000 and USD 3 000 (see Golovanov et al., 2008).

Another example is *Operation Aurora*, which is considered one of the most sophisticated attacks targeting in particular intellectual property (IP) repositories of high-tech companies such as Google[34], Adobe Systems, Juniper Networks, and Rackspace. According to McAfee (2010), the primary goal of *Operation Aurora* was to gain access to and potentially modify IP repositories in high-tech firms. The attack involved social engineering techniques, the exploitation of a zero-day-vulnerability (of a web browser) and the usage of distributed C&C botnet servers (see Zetter, 2010). Further analysis reveals that *Operation Aurora* used hosts primarily located in United States, China, Germany, Chinese Taipei, and United Kingdom. Operation Aurora has been estimated to have effected more than 34 organisations including Yahoo, Northrop Grumman, Dow Chemical and Rand Corp. (see Damballa, 2010).

Source: OECD (2012) Internet Economy Outlook

Trends in ICT adoption and the enabled innovation

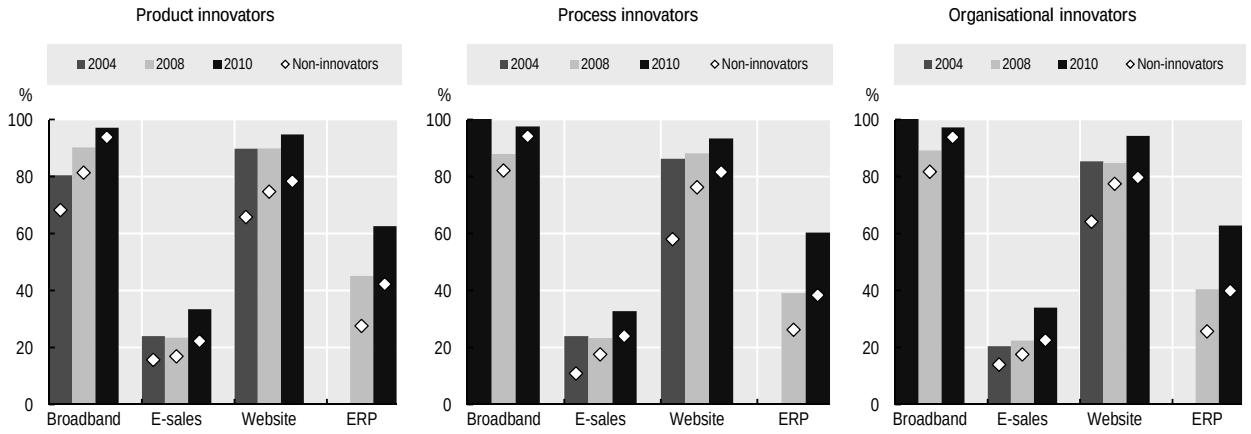
There is strong evidence that the use of ICTs drives innovation, which in turn can enhance productivity and competitiveness. ICTs help reduce transaction costs and enhance the scope of communication with the different stakeholders of an organisation. This enables, for instance, to speed up the creation and diffusion of ideas and knowledge (spillover) within an organisation, but also between organisations. This can translate into enhanced collaboration during R&D activities, and the co-production of goods and services between firms, and between firm and their customers. The use of ICTs can also enable greater product differentiation, enhance customer relationship and supply chain management through ICT enabled business processes, and accelerate time to markets across different geographical locations. In addition, ICTs enable the automation of knowledge and labour intensive tasks (see OECD, 2015b). All this ultimately can lead to an increase in productivity and higher market shares.

While there is no lack of anecdotal evidence of the positive impact of ICTs on innovation, understanding exactly how the productivity effects unfold in single firms is still difficult to disentangle. Significant progress has been made thanks to the linkage of micro-data (e.g. firm-level data), including in particular micro-data from ICT, innovation and business surveys.[35] These linkages permit researchers to look at the characteristics and the *dynamics* of the relationship between ICT use and innovation performance.[36] The analysis of linked micro-data from the EU ESSLait project, for instance, strongly

suggests that innovating enterprises are also relatively more inclined to adopt ICT, and that this characteristic does not fade over time, the opposite being rather true. Figure 10 presents four key dimensions of ICT uptake (having a broadband connection, having a website, using ERP applications and engaging in e-sales) for innovators and non-innovators, considering the three key core types of innovation, i.e. product, process, and organisational for the average of the 13 countries, from 2004 to 2010.[37]

Figure 10. ICT uptake among innovators and non-innovators in 13 European countries, 2004, 2008 and 2010

Percentage shares of adopters of the selected technologies in the two groups, all countries averages



Note: The figures show simple averages for all reporting countries across reference years in which the Community Innovation Survey (CIS) and the Community Survey on ICT Usage in Enterprises were performed. Data refer to Austria, Denmark, Finland, France, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Slovenia, Sweden and the United Kingdom. Cell values for each variable are reweighted to represent the business structure by employment size in each country. Data for ERP in 2010 are limited to Finland, France and Luxembourg.

Source: OECD (2014), Measuring the Digital Economy, OECD Publishing, Paris, based on based on the EU ESSLait project Micro Moments Database, June 2014, http://dx.doi.org/10.1787/888933148548.

The analysis of the European Union ESSLait micro-data sets shows that the share of businesses performing e-sales, having a website and using ERP solutions was higher (from 20% to 70%) among innovators, depending on the year and the type of innovation considered (de Panizza et al., 2013). Differences between the two groups are slightly diminishing over time for broadband adoption and website presence, but still increasing for ERP use. However, these figures do not show any causality. For the underlying evidence to be considered robust, further analysis including details of firm characteristics (e.g. size-class, age, and sector) are needed. Some empirical studies have provided further insights. Gago and Rubalcaba (2007) find that businesses that invest in ICT are significantly more likely to innovate in services. Van Leeuwen (2008) shows that e-sales and broadband use affect productivity significantly through their effect on innovation output. Broadband use, however, only has a direct effect on productivity if R&D is not considered as an input to innovation. This approach is further developed by Polder et al. (2010), who look at R&D and ICT investment as an input to innovation. Their study finds that ICT investment is important for all types of innovation (in particular in services), while R&D mainly drives product innovation in manufacturing and is less relevant to innovation in services. More specifically, broadband use positively affects product innovation in manufacturing, while e-commerce is positively related to process innovation. By linking the ICT and innovation surveys for 10 countries, Spiezia (2011) also finds evidence for the positive effects of ICTs on innovation, in particular product and marketing innovation.[38]

The studies presented above provide strong evidence of the positive effects of ICT use on innovation performance. At the same time they also show that there are differences in not only the effects of ICTs on

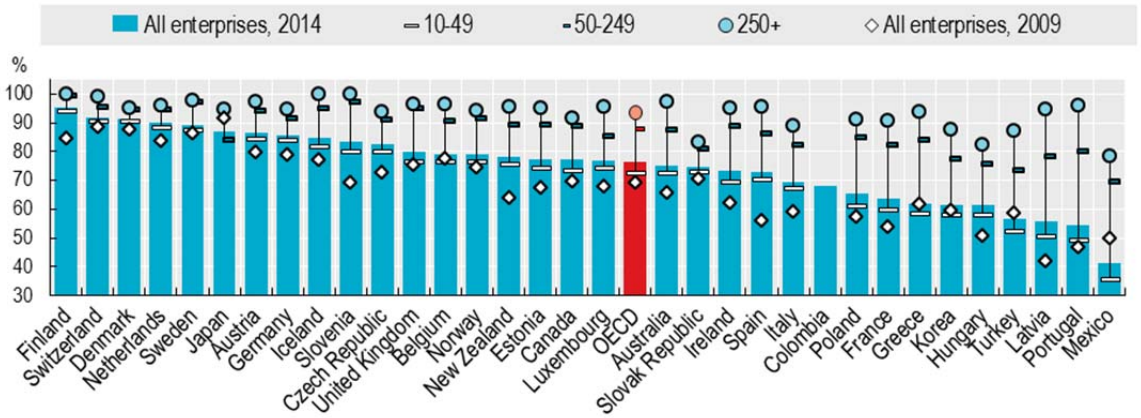
innovation across countries, sectors and firms, but also across the different types of ICTs. In particular, emerging empirical work by Garicano and Rossi-Hansberg (2006), Bloom et al (2013) and Garicano and Heaton (2010) confirm that treating ICT as a homogenous technology may disguise the likely heterogeneous effects of the different types of ICTs. The following section looks at current trends in (i) business adoption of (a selection of) the different types of ICTs for which official cross-country statistics are available. This includes: broadband, website, e-commerce, enterprise resource planning, and cloud computing adoption, and in (ii) ICT adoption by individuals and households.

Business adoption of selected ICTs

More than 76% of all OECD enterprises had a website or a homepage in 2014, up from 70% in 2009 (Figure 11). The share of enterprises with a web presence ranges from over 90% in Denmark, Finland and Switzerland to 54% in Portugal and 42% in Mexico. Progress since 2009 was particularly strong in Spain (17%), Slovenia (15%), Latvia and New Zealand (14%). As with broadband access, web presence is lower among small firms. In most OECD countries (27 out of 32), 90% or more of larger enterprises have a website, while web presence in SMEs ranges between 90% and above in Denmark, Finland and Switzerland and 50% or less in Latvia, Portugal and Mexico. The speed of adoption depends in some cases on prior uptake. It took 15 to 20 years for slightly more than three quarters of enterprises to develop a website, but only a few years for around 30% of businesses to then become active on social networks.

Figure 11. Enterprises with website or home page, by size, 2009 and 2014

As a percentage of enterprises in each employment size class



Notes: Except otherwise stated, the sector coverage consists of all activities in manufacturing and non-financial market services. For Australia, Canada, Japan, Korea and Colombia, data refer to 2013 instead of 2014. For Australia, data refer to the fiscal years 2008/2009 and 2012/2013, ending on 30 June, instead of 2009 and 2014. Data for the fiscal year 2012/2013 include Agriculture, forestry and fishing. For Canada, data refer to 2007 instead of 2009. Medium-sized enterprises have 50-299 employees. Large enterprises have 300 or more employees. For Japan, data refer to businesses with 100 or more employees. Medium-sized enterprises have 100-299 employees. Large enterprises have 300 or more employees. For Mexico, data refer to 2012. Small-sized enterprises have 10-50, medium-sized enterprises have 51-250 persons employed, and large enterprises have 251 or more persons employed. For New Zealand, data refer to the fiscal years 2007/2008 and 2011/2012, ending on 31 March, instead of 2009 and 2014. For Switzerland, data refer to 2011. For Colombia, data refer to enterprises with 10 or more persons employed in the manufacturing sector (excluding divisions 12-14, 17, 21 and 33) and enterprises with 75 or more persons employed in the non-financial market services (excluding divisions 49-51, 58, 75 and 77).

Source: OECD (2015a) Digital Economy Outlook, OECD Publishing, Paris, based on ICT Database; Eurostat, Information Society Statistics and national sources, March 2015.

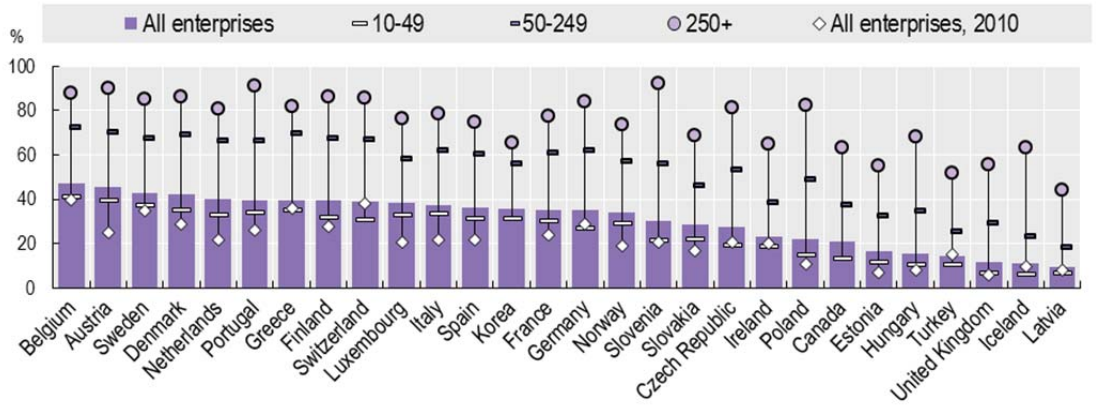
In most cases, a web presence is still used as a window to provide information on the enterprise. Figures on participation in e-commerce are much lower. On average, 21% of firms with at least ten people employed in reporting OECD countries received electronic orders (e-sales), 4 percentage points more than in 2009. Differences in e-sales among countries remain considerable. In New Zealand, the share is above

45%, while in Greece, Turkey, Italy and Mexico, it is 10% or less. These differences closely follow the differences in shares of smaller firms among countries. For enterprises with 250 or more persons employed, participation in e-commerce is 40% and the share is above 30% even in some lagging countries. Differences between large and small firms are even larger with regard to e-commerce turnover. The share of e-commerce sales in turnover stands at 16% of total turnover on average in reporting countries. Up to 90% of the value of e-commerce comes from business-to-business (B2B) transactions over EDI applications. The observed patterns are dominated by the economic weight of large enterprises, for which e-commerce sales represent, on average, 20% of turnover against 7% for small firms.

Much larger cross-country differences remain in the management of information flows within companies (Figure 12). The role of e-business processes in handling internal information flows can be seen in the diffusion of enterprise resource planning (ERP) software applications. In 2014, on average, such technologies were used to share information by 31% of enterprises, against less than 22% in 2010. ERP software was used in 75% of larger (and more complex) enterprises, but by less than 25% of small firms, for which it is only recently becoming more affordable. Adoption rates – the percentage of firms using ERP software - across countries range between 44% and 92% for larger enterprises and between 7% and 41% for smaller ones, with Belgium, Austria, Sweden and Denmark leading, and Latvia, Iceland and the United Kingdom lagging for enterprises of all sizes.

Figure 12. Use of enterprise resource planning software, by size, 2010 and 2014

Percentage of enterprises in each employment size class



Notes: Unless otherwise stated, sector coverage consists of all activities in manufacturing and non-financial market services. Only enterprises with ten or more persons employed are considered. Size classes are defined as: small (from 10 to 49 persons employed), medium (50 to 249) and large (250 and above). For Canada, medium-sized enterprises have 50 to 299 employees. Large enterprises have 300 or more employees. For Korea, data refer to 2013. For Switzerland, data refer to 2011.

Source: OECD (2015a) Digital Economy Outlook, OECD Publishing, Paris, based on ICT Database; Eurostat, Information Society Statistics and national sources, March 2015.

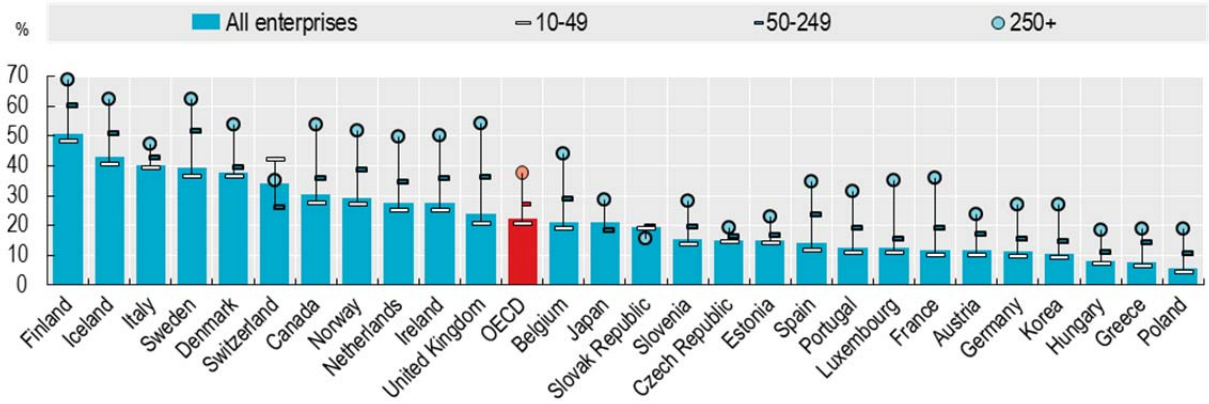
Among new ICT uses by firms, cloud computing (CC) deserves special attention. CC can be understood as a service model for computing services, based on a set of computing resources that can be accessed in a flexible, on-demand way with low management effort (OECD, 2015a; 2015b). CC services permit users to access software, computing power, storage capacity, and other services. Those services can be easily scaled up or down, be used on-demand by the user, and are paid for either per user or by capacity used. They can take the form of software or be extended to platforms or infrastructure, and may be deployed either privately (for exclusive use), publicly (open to the general public), or under a hybrid (mix of the two former) format. The main benefits from CC perceived by firms are an easy and quick deployment of solutions, higher flexibility due to scaling up or down, and a reduction of ICT-related

investment costs. However, in some countries[39] a majority of businesses still consider that benefits linked to the reduction of ICT costs are not noticeable or of a limited degree only (OECD, 2015a).

Diffusion of CC among firms has accelerated in recent years. In 2014, over 22% of businesses were using CC services. This share ranges from over 50% in Finland down to 6% in Poland. In most countries, uptake is higher among large businesses (close to 40%) compared to small or medium-sized enterprises (around 21% and 27%, respectively). By contrast, in Switzerland and the Slovak Republic, uptake is higher among small businesses than large ones (Figure 13). Businesses buy CC services with a high level of sophistication more frequently (e.g. finance and CRM software, and computing power), than less sophisticated CC services (e.g. emails, office software or storage of files). In Finland, for example, 53% of firms using CC bought high-level services and only 28% purchased low-level services.

Figure 13. Enterprises using Cloud Computing services by size, 2014

As a percentage of entreprises in each employment size class



Note: Except otherwise stated, the sector coverage consists of all activities in manufacturing and non-financial market services. Except otherwise stated, only enterprises with 10 or more persons employed are considered. Size classes are defined as: small (from 10 to 49 persons employed), medium (50 to 249), large (250 and more). For Canada, data refer to enterprises that have expenditures on "Software as a Service" (e.g. cloud computing). Medium-sized enterprises have 50-299 employees. Large enterprises have 300 or more employees. For Japan, data refer to businesses with 100 or more employees. Medium-sized enterprises have 100-299 employees. Large enterprises have 300 or more employees. For Canada and Korea, data refer to 2012 instead of 2014. For Japan and Switzerland, data refer to 2011 instead of 2014. For Switzerland, data refer to enterprises with 5 and more employees.

Source: OECD (2015a) Digital Economy Outlook, OECD Publishing, Paris, based on ICT Database; Eurostat, Information Society Statistics and national sources, January 2015.

Household and individual adoption of selected ICTs

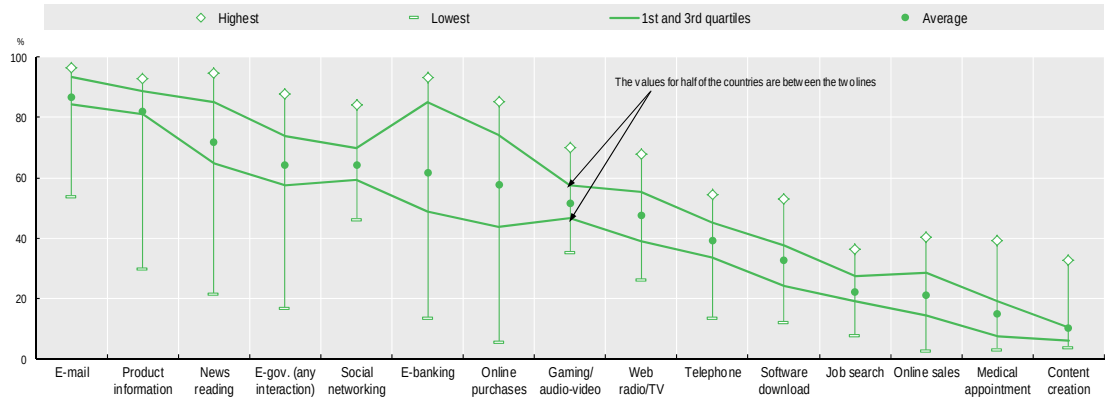
Internet usage continues to vary widely across OECD countries and among social groups. In 2014, more than 95% of the adult population accessed the Internet in Denmark, Iceland, Luxembourg and Norway, but less than 50% in Mexico and Turkey. In Iceland and Italy, the share of daily users is very similar to that of total users. In Chile, Japan and Mexico, many users access the Internet on an infrequent basis. Differences in Internet uptake are linked primarily to age and education, often intertwined with income levels. In most countries, uptake by young people is nearly universal, but there are wide differences for older generations (OECD, 2015a). Over 95% of 24 year-olds in the OECD used the Internet in 2014 while less than 49% among 65-74 year-olds.

Education appears to be a much more important factor for older people than for youth. Usage rates for 65-74 year-olds with tertiary education are generally in line with those of the overall population, and in leading countries approach the usage rates among 16-24 year-olds. Differences between high and low educational attainments among 65-74 year-olds are particularly large in Hungary, Poland and Spain

(OECD, 2014c). Over 2013-14, on average 87% of Internet users reported sending emails, 82% used the Internet to obtain information on goods and products, and 72% read online news. While 58% of Internet users ordered products online, only 21% sold products over the Internet (Figure 14). Activities such as sending emails, searching product information, or social networking show little variation across all countries. However, the shares of Internet users performing activities usually associated with a higher level of education (e.g. those with cultural elements or more sophisticated service infrastructures), tend to show larger cross-country variability. This is the case, for example, for e-banking, online purchases, news reading and e-government.

Figure 14. The diffusion of selected online activities among Internet users, 2013-14

Percentage of Internet users performing each activity



Notes: Unless otherwise stated, a recall period of three months is used for Internet users. For Australia, Canada, Chile, Japan, Korea, Mexico and New Zealand, the recall period is 12 months. For Switzerland, the recall period is six months. For the United States, no time period is specified. For web-based radio/television, data refer to 2012. For job search and software download categories, data refer to 2013. For online purchases and e-government categories, the recall period is 12 months instead of three months, and data relate to individuals who used the Internet in the last 12 months instead of three months. For countries in the European Statistical System and Mexico, data refer to 2014. For Australia, Canada and New Zealand, data refer to 2012. For Chile, Israel and Japan, data refer to 2013. For Australia, Chile and New Zealand with regard to interactions with public authorities, data refer to obtaining information from public authorities. For Japan, data refer to individuals aged 15-69. For job search, data refer to 2012.

Sources: OECD (2015a) Digital Economy Outlook, OECD Publishing, Paris, based on ICT Database; Eurostat, Information Society Statistics and national sources, April 2015, http://dx.doi.org/10.1787/888933224908

The breadth of activities performed on the Internet can be regarded as an indication of user sophistication. In 2013, the average Internet user performed 6.3 out of the 12 activities selected, up from 5.4 in 2009. This figure ranges from 7.5 to 8 activities in the Nordic countries and the Netherlands, to 5 activities or less in Greece, Italy, Korea, Poland and Turkey. Education plays a key role in shaping the range of activities on the Internet. While users with tertiary education perform on average 7.3 different activities, those with lower secondary education perform only 4.6 activities. Differences by level of education are particularly high for Belgium, Hungary, Ireland, Korea and Turkey.

The disruptive effects of digital innovation

Digital innovation can be disruptive, inducing the "creative destruction" of established businesses, markets and value networks, and challenging existing regulatory frameworks. With the global recovery still sluggish, ICT-induced structural shifts need to be facilitated to lead to a more resilient and sustainable economic future. However, the disruptive effects of digital innovation can be perceived as threatening by individuals, businesses and governments alike.

For established (traditional) businesses, the competitive environment may discourage investments in disruptive innovation in the short run for two reasons: *(i)* investments in disruptive innovation can take

scarce resources away from sustaining the most profitable business units (which are needed to compete against current competition), and *(ii)* is often highly risky compared to more incremental (evolutionary) forms of innovations, given that they may not be profitable enough in the short run. This leads to what Christensen (1997) refers to as the *innovator's dilemma*, where successful companies put too much emphasis on current success, and thus fail to innovate in the long run. This is particularly the case with disruptive innovation as it may in some cases require substantial changes of organisational structures, business processes or even business models that may involve sunk costs (that cannot be recovered).[40] In addition to economic factors, these changes may also be hard to implement in light of internal resistance due to the organisational culture and physiological resistance among management and their employees.

The fear of change and disruption combined with short-term thinking typically result in disruptive digital innovation being often first introduced by start-up companies and puts a premium on framework conditions affecting business dynamics and entrepreneurship (see next section). As shown by Criscuolo et al. (2012), new technologies and innovations are often first commercialised through start-up companies because they can leverage the advantage of starting without the legacy of an existing business and customer base to experiment, and thus can create a rich variety of presumably new business models. Christensen (1997) also highlights the controversial role of the existing customer base, arguing that disruptive innovations are often not valued by existing customers at first. As a consequence, incumbents who tend to be mainly responsive to their main customer base, will tend to ignore the markets most susceptible to disruptive innovation, and even though the incumbents may heavily invest in R&D.

That said, digital innovation is not always disruptive – even though it may be revolutionary (new and unexpected). It may involve "only" incremental (evolutionary) improvements.[41] For instance, the use of e-commerce by a retailer does not necessarily require disruptive changes and constitutes rather an evolutionary improvement of the established business model. Current business surveys confirm the evolutionary nature of digital innovation. In a study by the MIT Sloan Management Review and Capgemini Consulting (Bonnet and Westerman, 2015), for instance, 42% of the executives surveyed said that digital innovation was helping them to enhance their existing products and services and 29% said that it was helping to launch new products and services.

In some cases, however, digital innovation, even though it may be evolutionary, can reach a tipping point where it turns out to be disruptive. As Christensen (1997) explains: "Generally, disruptive innovations were technologically straightforward, consisting of off-the-shelf components put together in a product architecture that was often simpler than prior approaches." This is apparent when looking at digital disruptions that are based on established digital technologies: *(i)* digital innovations driven by data (data-driven innovation), *(ii)* digital innovation emerging under the label of the "sharing economy" that is enabled to a large extent by the diffusion of mobile smartphones and big data analytics, and maybe even *(iii)* the digitalisation of industrial production enabled in particular by the IoT and also big data analytics.

Data-driven innovation

From the turn of the century onwards patenting activities burgeoned in the field of digital data processing and editing (Figure 9). This has enabled data-driven innovation today, where the use of "big data" and analytics is driving knowledge and value creation across society; fostering new products, processes and markets; spurring entirely new business models; transforming most if not all sectors; and thereby enhancing economic competitiveness and productivity growth (OECD, 2015b). Algorithmic trading systems (ATS), for example, analyse massive amounts of market data on a millisecond basis to autonomously identify what to stock and when, and at what price to trade; this process was unheard of a decade ago. Furthermore, traditional sectors such as manufacturing and agriculture are also being disrupted through digitalisation, and are becoming more and more service-like. The German manufacturer of athletic shoes and sports equipment, Adidas, for instance, has redesigned many of its products as *data-driven*

services, which are integrated via its online *miCoach* platform. This platform enables services related to physical activities such as performance monitoring and training recommendation.

Available evidence shows that firms using data and data analytics raise labour productivity faster than non-users, by approximately 5-10%. A study of 330 companies in the United States by Brynjolfsson, Hitt and Kim (2011), for instance, estimates that the output and productivity of firms that adopt data-driven decision making are 5% to 6% higher than would be expected from their other investments in and use of ICTs. These firms also perform better in terms of asset utilisation, return on equity and market value. A similar study based on 500 firms in the United Kingdom by Bakhshi, Bravo-Biosca and Mateos-Garcia (2014) finds that businesses that make greater use of online customer and consumer data are 8% to 13% more productive as a result.[42] The analysis shows that, other things being equal, a one-standard deviation greater use of online data is associated with an 8% higher-level of total factor productivity (TFP). A more recent study by Tambe (2014), based on the analysis of 175 million LinkedIn user profiles, out of which employees with skills for big data-specific technologies have been identified, indicates that firms' investment in big data-specific technologies was associated with 3% faster productivity growth. The estimated output elasticity of 3% resulted after controlling for firms' adoption of data-driven decision making.[43]

Collective consumption and production

The use of mobile smartphones and applications (apps), combined with the analysis of big data generated, has enabled new collective consumption of private durable goods by providing access to excess capacity of these goods. These new platforms that have emerged under the label of the "sharing economy" offer short-term rental of space, mostly of homes, and shared mobility. Although home exchanges or short-term rentals are not new, nor are the technologies underlying platforms such as Airbnb, the speed and scale at which these platforms have made commercial home-sharing a common practice is unprecedented (OECD, 2015a). The diffusion of mobile devices and the use of data analytics have been key for this trend. This is also true for shared mobility options ranging from the rental of private cars (Zipcar), rides (Uber, Lyft, blablacar) and parking spaces (justpark) to the rental of free floating (Car2go, DriveNow) and station-based cars (Autolib') and bikes (Velib') (OECD, 2015a). While the growth of some of the home-sharing platforms has been spectacular over the past years, their overall economic impacts are not yet fully understood (OECD, 2015a), and the related regulatory challenges needs to be further assessed, including challenges related to consumer protection (see OECD, 2016b).

The digitalisation of industrial production

There are indications that the combination of different ICTs and their convergence with other technologies (owing in particular to embedded software and the IoT) will be a game changer that is driving a transformation of production. In manufacturing, for instance, companies are increasingly using sensors mounted on production machines and delivered products to collect and process data on the machines' and products' operation, taking advantage of the IoT – the interconnection of "real world" objects. Sensor data are not only used for incremental innovation (e.g. to monitor and analyse the efficiency of products and to optimise their operations at a system-wide level), but also used in collaboration with suppliers for disruptive innovation, in particular when commercialised as part of new services for existing and potential suppliers and customers.[44] An example of an incremental innovation is Germany-based Schmitz Cargobull, the world's largest truck body and trailer manufacturer, that uses M2M and sensors to monitor the maintenance, travelling conditions and routes travelled by any of its trailers (Chick, Netessine and Huchzermeier, 2014; see also Vennewald, 2013).[45] A more disruptive and radical innovation is the transformation of manufacturing into a more services-like business, a trend pioneered by firms such as Rolls Royce which has stopped selling its jet engines and began selling "power by the hour" thanks to ICTs (Binns, 2014).

Barriers to digital innovation and possible policy levers

The section above strongly suggests that the adoption and use of ICTs enable digital innovation and productivity growth. Despite available evidence, however, ICT investments remain below expected levels. In particular, the adoption of advanced ICTs such as cloud computing, supply chain management, and ERP applications by firms is still much below that of broadband networks or websites (Figure 4). And it is especially SMEs face the biggest challenge in ICT adoption and use. Cloud computing, for instance, plays a significant role in increasing the capacity to store and analyse data, a capacity that is crucial for instance for enabling data-driven innovation (OECD, 2015d).[46] It is expected to be particularly relevant for start-ups and SMEs as it provides supercomputing resources in a flexible manner via a pay-as-you-go model, without the need to make heavy upfront investments in ICTs. As revealed in Figure 13, however, larger enterprises (250 or more employees) are more likely to use cloud computing. In the United Kingdom, for instance, 21% of all smaller enterprises (10 to 49 employees) are using cloud computing services, compared to 54% of all larger enterprises.[47]

There are many factors that affect business' decision and ability to adopt ICTs successfully: (i) *access to digital infrastructures* at competitive prices can be considered a fundamental factor. This includes access to ICTs such as broadband, in particular mobile broadband, but also access to data which are increasingly becoming an infrastructure for data-driven innovation (DDI) (OECD, 2015b). However, even if ICTs (and data) are made available, the modalities of their provision can be as crucial as the provision itself. Evidence shows that in particular the *lack of appropriate (open) standards* and *fears of vendor lock-in*, often due to proprietary solutions, can also be strong barriers to adoption. This is particularly true for SMEs, which often lag the negotiation power and the know-how about advanced ICTs such as cloud computing, data analytics, and the IoT (see OECD, 2015b; OECD, 2016i).

For many ICTs including, but not limited to, cloud computing, (ii) *lack of trust in the digital economy* has also been raised as a potential barrier to ICT adoption (OECD, 2008; 2010; 2015; 2016y). This is to a large extent due to the increasing digital security risks perceived by potential adopters (OECD, 2015), which is partly also the result of the increasing sophistication of digital security threats (see Box 2). In addition, increasing concerns have been raised whether privacy rights (OECD, 2015b), and also intellectual property rights (OECD, 2015d), are sufficiently protected (and enforced) in the digital economy. It is true that digital security threats lead to higher risks that privacy and intellectual property rights could be violated as demonstrated by the case of Aurora discussed in Box 2. But there are also additional risk factors associated to emerging practices in the use of personal data and intellectual property that risk deteriorating trust in the digital economy, and thus reduce incentives to ICT adoption. For instance, discrimination enabled by data analytics, for example, may result in greater efficiencies and innovation, but may also limit individuals' freedom (OECD, 2015b).

As highlighted above, investment in ICTs alone do not lead to innovation and productivity gains. Their effective use requires additional investments in complementary KBC. Assessing the barriers to ICT adoption and use therefore demands also understanding the factors that shape firms' perceptions of the expected returns in investing in both, ICTs and the complementary KBCs. Besides the lack of access to cost effective ICTs and the lack of trust, which both raise the expected costs (or reduce the expected returns) of ICT adoption, two more factors are highly relevant from an investment perspective: (iii) investments in complementary assets including, in particular, ICT-related skills (see OECD, 2016z) and organisational capital, and (iv) other regulatory framework and market conditions affecting in particular the perceived flexibility of businesses, but also individuals and governments, to experiment with (disruptive) innovations, and to scale-up those that have shown successful in smaller scale experiments, and to scale them down if they turn out to be a failure. These framework and market conditions include, but are not limited to, competition and product market regulation, and finance, labour market, and bankruptcy regulation.

The following sections discuss these factors in more detail, putting them in the context of the diagnostic framework for identifying the key constraints to innovation presented in the revised OECD Innovation Strategy (Box 3).

Box 3. The potential rationale for (digital) innovation policies

The revised OECD Innovation Strategy (OECD, 2015a) presents a diagnostic framework for identifying the key constraints to innovation. These constraints include factors limiting the (expected) returns to investments in innovation, and are typically divided into two categories:

- The first category refers to **low economic returns**, encapsulating factors which create inertia in economic systems (i.e. fundamental – systemic – barriers to change and innovation, e.g. linked to barriers to competition, lack of co-operation within an innovation system, prevailing norms and habits, as well as technology lock-in) and capacity constraints, or "low social returns", that are often linked to lack of skills, infrastructure or inadequate institutions.
  - *Low economic returns due to inertia and systemic barriers* can constrain the expansion of new or innovative production techniques, technologies or other forms of innovation. In the context of digital innovation, inertia and systemic barriers emerge often due network effects acting as barrier to entry, and the bias in the market towards existing technologies and standards. Examples include barriers to the migration to a new system of Internet addresses (IPv6) from the current version (IPv4) for which addresses are essentially exhausted. But inertia and systemic barriers can also emerge due to vendor lock-in through the use of proprietary ICT solutions.
  - *"Low social returns"* implies the absence of enabling conditions for productive investments in innovation. These constraints reduce the choices of firms and other actors to invest in innovation. In the context of digital innovation, low social returns can be the result of poor ICT infrastructures or broadband availability that limit the opportunities for firms to benefit from connectivity and the associated network effects. Other barriers include insufficient human capital, in particular a lack of ICT specialist skills and ICT-savvy managerial skills that imply that firms have insufficient know-how to deploy ICTs or to adjust to them through organisational change.
- The second category refers to **low appropriability of returns**. This is where market and government failures prevent firms or other innovation actors from capturing the full value of their investments in innovation, thus leading to underinvestment. Examples include the externalities associated with investment in R&D, where a firm can never capture all the returns to its investments, due to the spill-over effects associated with investment in knowledge. Another example concerns the negative externalities related to environmental damages. These damages are often not priced by the market, which adds to the difficulties faced by private investors to fully appropriate the returns from innovation.
  - *Market failures* provide the main neo-classical rationale for innovation policies, and lead to well-recognised areas of policy such as government support for business R&D, government investments in basic R&D and knowledge infrastructure, pertinent for the support of the development of new ICTs.
  - *Government failures* that contribute to a low appropriability of returns can affect many areas of the innovation systems. These include for example the preference to incumbents that can sometimes characterise policy making related to innovation, the lack of policy predictability and stability that often characterise innovation policies; and regulatory barriers that affect innovation.

The importance of constraints to innovation will vary according to level of development, socio-economic context, and existing economic and environmental policy settings. Low human capital, inadequate infrastructure and poor institutional quality will often tend to be associated with lower levels of economic development (though not exclusively). Rectifying these constraints will be of high priority and perhaps a precondition to resolving many other constraints. Where human capital and infrastructure are relatively well supplied, the focus often first shifts to resolving government and market failures. However, for innovation to have an impact, attention also needs to be paid to some of the disadvantages that new firms and technologies may have relative to incumbents and existing technologies and policies that can help advance these. Sequencing of reforms may be important in this context, in particular in areas where market failures are important.

Source: Drawn from OECD (2015e).

Access to cost effective and interoperable digital infrastructures

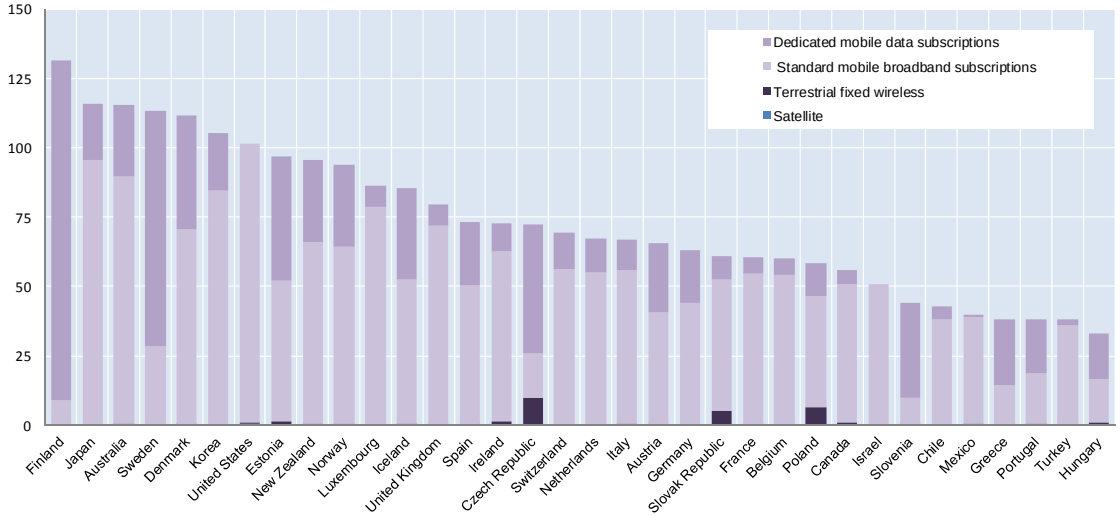
Broadband networks

The rapid diffusion of broadband is one of the fundamental enablers of digital innovation. High-speed broadband is the underlying infrastructure for the exchange and free flow of data that are collected remotely through, and used by, digital services. It enables digital "innovation 'at the edges' without affecting the system's overall (core) functionality or performance" (OECD, 2016h). Mobile broadband is essential, as mobile devices are becoming a key platform for digital innovation. Moreover, high-speed mobile broadband is especially important to further improve connectivity in remote and less developed regions, where digital innovation could bring much needed (regional) growth and development (see OECD, 2015d). In China, for instance, less than a third of rural residents have access to the Internet, compared to 64% of the urban population (see Annex).

Within 10 years, between 2003 and 2013, fixed broadband penetration rates (subscribers per 100 inhabitants) in the OECD area have almost tripled, to reach around 30% of the OECD populations, but mobile broadband penetration rates have been more dynamic since surpassing fixed broadband penetration rates in 2008. Since then, mobile broadband penetration rates have more than doubled, currently reaching around 70% in the OECD area.

The drop in mobile access prices, mainly thanks to enhanced competition, is the prime factor behind the explosion of mobile subscriptions, and calls for continuous efforts to strengthen competition in the telecommunication services markets (OECD, 2014b). In Finland, Japan, Australia, Sweden, Denmark, Korea, and the United States, mobile penetration rates exceeded 100% in 2014 (Figure 15). Australia, which edged into first place after a 13% surge in smartphone subscriptions in the first half of 2013 – as well as Estonia, New Zealand, the Netherlands, the Czech Republic, and Canada – has experienced a boost in mobile subscriptions since 2009. Penetration is still at 40% or less in Mexico, Greece, Portugal, Turkey, and Hungary; however, considering progress to date and the universal diffusion of standard mobile subscriptions, mobile broadband could well catch up in lagging economies as well (OECD, 2014b).

Figure 15. OECD wireless broadband penetration, by technology, June 2014



Note: Standard mobile broadband subscriptions may include dedicated mobile data subscriptions when breakdowns are not available. Israel: data for June 2010 instead of 2009.

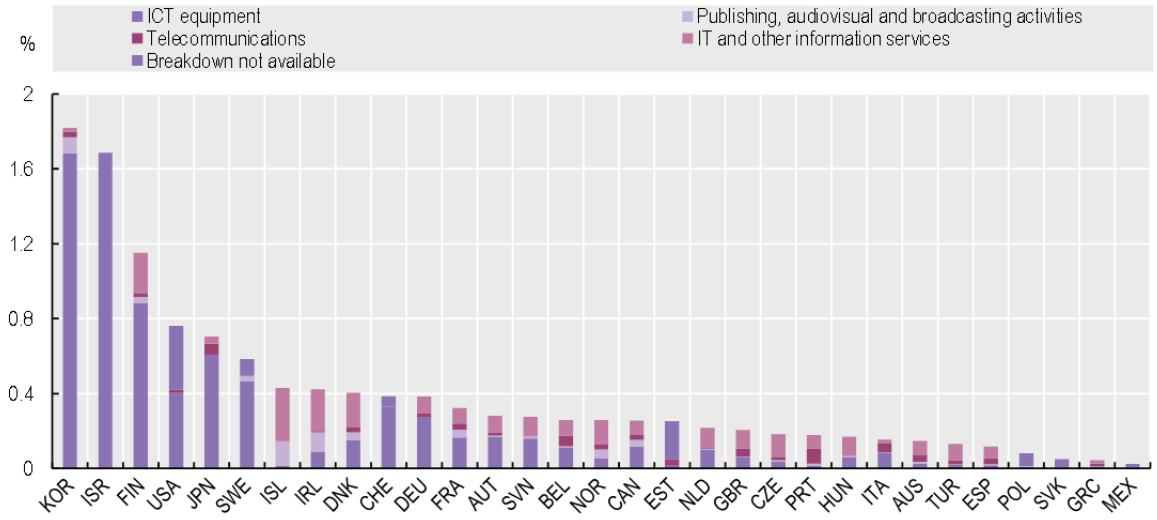
Source: OECD (2015a), Digital Economy Outlook, OECD Publishing, Paris, based on *OECD Broadband Portal*, www.oecd.org/sti/broadband/oecdbroadbandportal.htm, May 2014, http://dx.doi.org/10.1787/888933224593.

New emerging ICTs

In many countries even if rural residents have Internet access, they often cannot afford the technology needed for actually using it. In China, for example, less than 30% of rural residents owned a smartphone in 2014, compared to 60% of the urban population. Access to cost-effective ICTs beyond broadband are therefore also a key enabler of digital innovation, and ICT-product innovation has been a crucial factor. The development of ICT products (goods and services) mainly occurs in the ICT sector. Still today, the ICT sector remains one of, if not the most, innovative sectors in national economies. In 2012, computers and electronics saw the largest number of top research and development (R&D) investors, accounting for about 30% of both the top 100 and the top 250 R&D corporate investors (Figure 6).[48] The top corporate R&D investors are mainly ICT companies, which also tend to be technology and market leaders. In 2014, Samsung (with USD 13 133 million in R&D investment), Intel (USD 11 537 million) and Microsoft (USD 12 046 million) were the top global corporate R&D spenders after Volkswagen (USD 14 041 million). In most OECD countries, the ICT sector accounts for the largest share of business expenditures on research and development (BERD), amounting to about 25% of total BERD and 0.2% to 0.4% of GDP (Figure 16). In Finland, Israel, Korea and the United States, the ICT sector accounts for 40% to over 50% of BERD, and ICT BERD alone represents between about 0.6% to more than 1.8% of GDP, reflecting the high research intensity of these economies and the sector itself.[49]

Figure 16. R&D expenditure in information industries, 2013

As a percentage of GDP



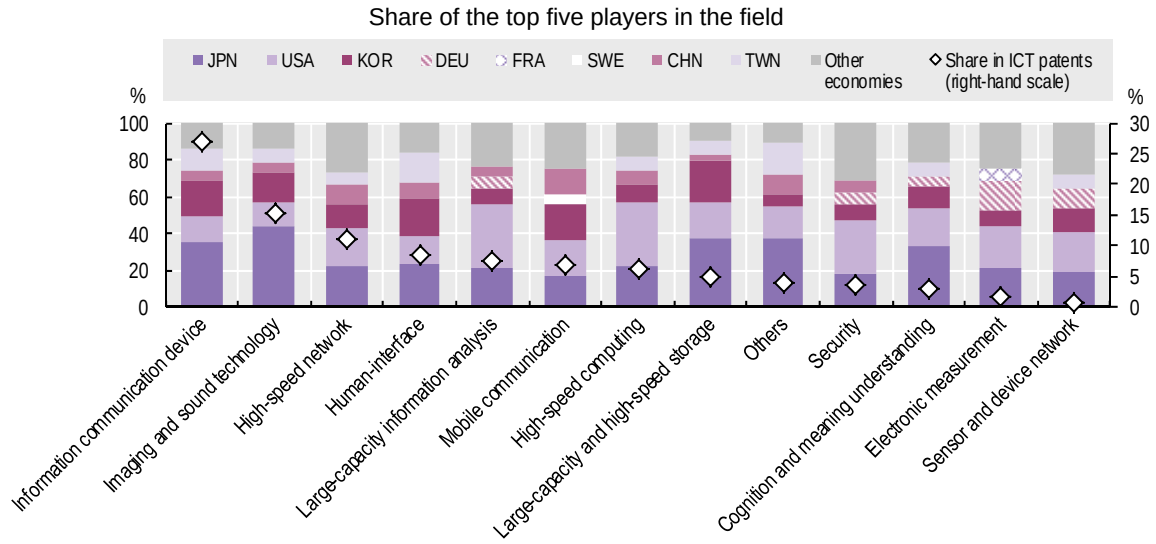
Note: The "information industries" aggregate comprises ISIC Rev. 4 Divisions 26 and 58-63. The terms "ICT equipment", "Publishing, audio-visual and broadcasting activities", "Telecommunications" and "IT and other information services" refer to ISIC Rev. 4 Divisions 26, 58-60, 61 and 62-63 respectively. For Australia, Austria, Belgium, Greece, Ireland and Mexico, data refer to 2011. For Denmark, France, Germany, Hungary, Iceland, Israel, Italy, Portugal, Switzerland, the United Kingdom and the United States, data refer to 2012. R&D ratios are normalised using official GDP figures. These are compiled according to the System of National Accounts (SNA) 2008 except for Japan and Turkey, where figures are available on the basis of SNA 1993.

Source: OECD (2015e) Science, Technology and Industry Scoreboard, based on OECD, ANBERD Database, www.oecd.org/sti/anberd, and Research and Development Statistics Database, www.oecd.org/sti/rds, June 2015. http://dx.doi.org/10.1787/888933274169.

While R&D provides a measure of innovation input, inventive output is often reflected in patents. Patenting activities in ICT-related technologies grew by 66% between 2000-03 and 2010-13, with marked changes observed in the relative importance of different sub-fields (Figure 17).

In particular, technologies related to high-speed networks, and large capacity and high-speed storage, decreased in relative importance (from 17% to 11% and from 11% to 5%, respectively). Technologies related to mobile communication and human interface (i.e. enhancing operability by human beings) increased their share from 4% to 7% and from 4% to 8%, respectively. These dynamics mirror the growing importance of mobile devices and the development of the Internet of Things. Out of the total number of patents held by the top 250 R&D players, 55% relate to ICTs, corresponding to almost 80% of all ICT-related patents owned by the top 2 000 corporate R&D investors. While top R&D corporations located in Korea tend to specialise in ICT-related technologies in general, US-headquartered corporations lead in IT methods, whereas Chinese corporations are extremely specialised in digital communications and telecommunications (Figure 17).[50]

Figure 17. Patents in ICT-related technologies and major players, 2010-13



Note: Data refer to IP5 patent families with members filed at the EPO or at the USPTO, by first filing date, the applicant's residence using fractional counts. Patents in ICT are identified following a new experimental classification based on their International Patent Classification (IPC) codes. Data from 2012 are estimates.

Source: OECD (2015e) Science, Technology and Industry Scoreboard, based on OECD, STI Micro-data Lab: Intellectual Property Database, http://oe.cd/ipstats, June 2015, http://dx.doi.org/10.1787/888933274171.

Based on work by the UK Intellectual Property Office (IPO), the OECD (2015c) has published figures on technologies identified as potential sources of future growth. Among the identified technologies were a number of enabling technologies that form the basis of the new generation of ICTs and that could enable and drive digital innovation in the broader sense. These ICTs include in particular:

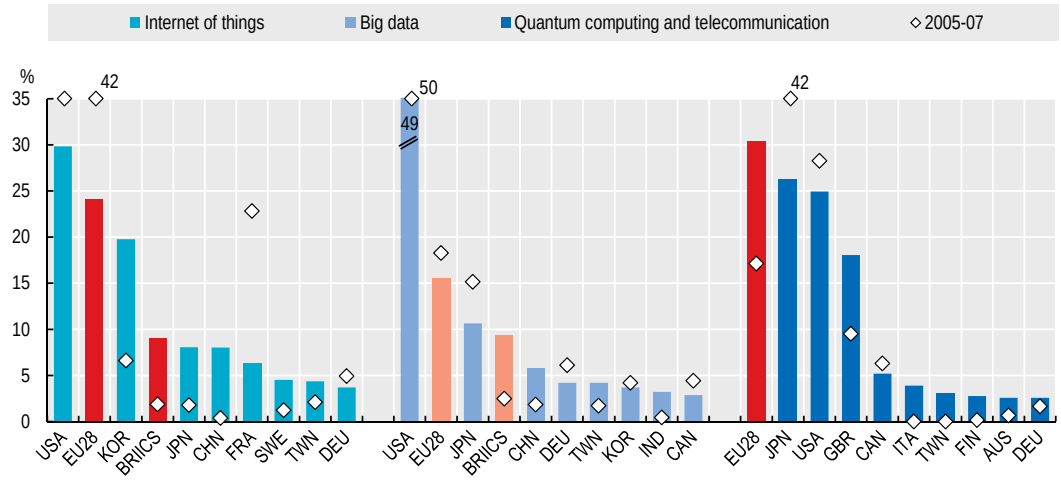
- *Quantum computing and telecommunication* – Quantum computation technologies are information-processing methods that promote more effective computation by harnessing quantum physics to acquire functionalities or improve the performance of existing technologies (e.g. microprocessors). Similarly, quantum telecommunications technologies offer secure communication channels and lead to patents related to encryption, as well as transmission systems and components.
- *The Internet of Things* (IoT) – The IoT refers to networks of everyday physical objects that can be accessed through the Internet, are able to automatically identify themselves to other devices, and to communicate with them via machine-to-machine communication (M2M). Examples include: patents related to remote control appliances, traffic congestion optimisation, e-health and industrial auto-diagnosis.

- *Big data* – This refers to the storage and processing (analysis) of large volume of data (typically several petabytes) that also require high processing speed to handling and manipulation. These technologies are typically used for data-driven innovation (DDI) (see OECD, 2015d).

As with many other technologies, these advanced ICTs have developed in a wave-like fashion. Rapid growth is followed by periods of slower activity and subsequent phases of rapid development (OECD, 2015e). Inventive activities related to big data dramatically increased around 2010, while developments related to the IoT grew throughout 2006-12, ranging from rates of 23% to 126% a year, reaching a peak in 2010. Activities in quantum computing and telecommunications seemingly established the basis for the development of other ICT-related technologies: patenting in the field peaked around 2006 and slowed down thereafter before stabilising. EU countries, especially the United Kingdom, led developments in quantum computing, whereas the United States led developments in both IoT and big data-related technologies (Figure 18). While European economies have played an increasingly important role in quantum technologies, both the European Union and the United States saw their relative share of IoT inventions diminish as Asian countries, in particular China and Korea, gained ground.[51]

Figure 18. Top players in IoT, big data and quantum computing technologies, 2005-07 and 2010-12

Share of IP5 patent families filed at USPTO and EPO, selected ICT technologies



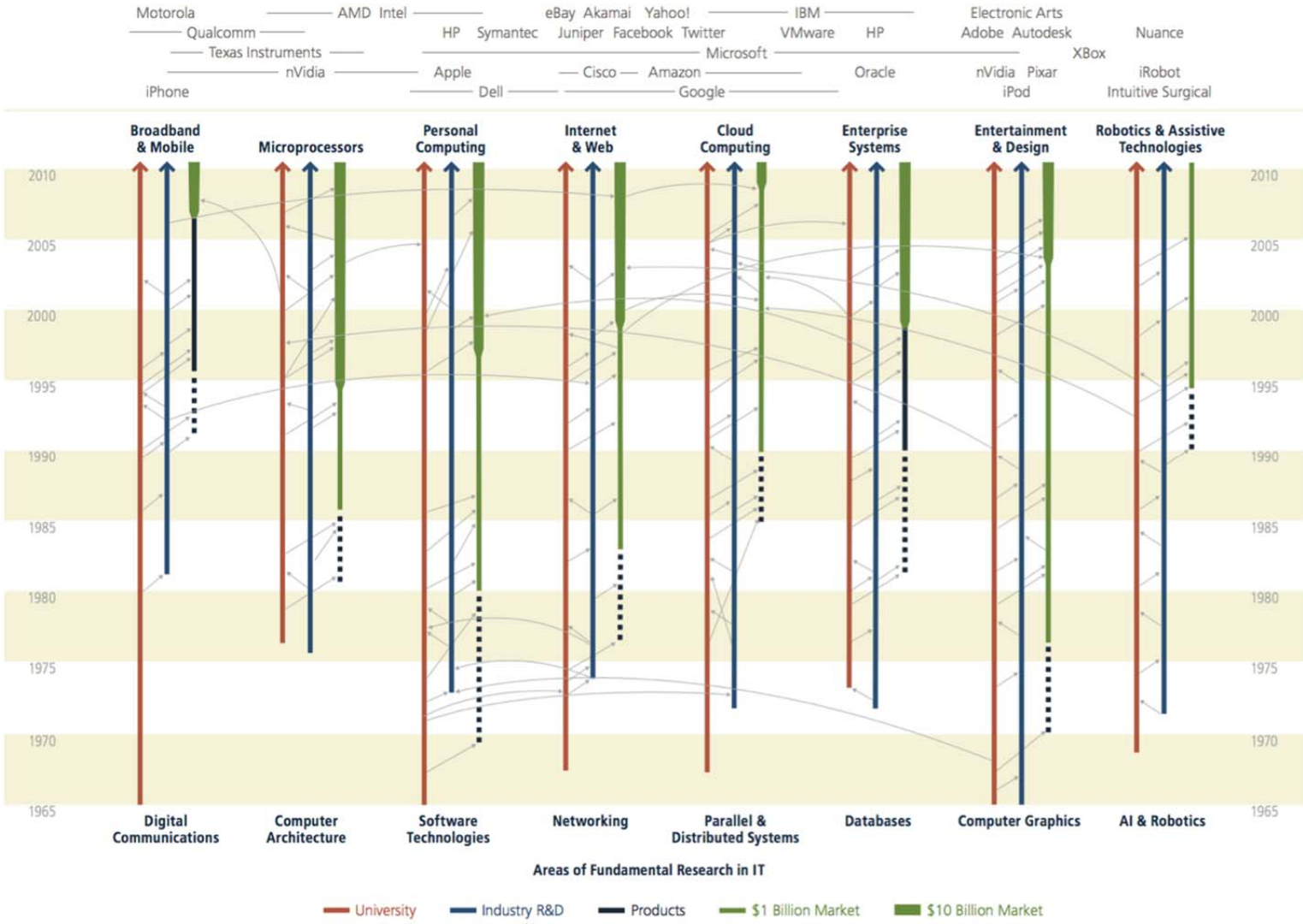
Note: Data refer to IP5 patent families with members filed at the EPO or the USPTO, by first filing date and according to the applicant's residence using fractional counts. The Intellectual Property Office (IPO) of the United Kingdom has allocated patent documents to technology fields. For further details on IPO's patent landscape reports on Eight Great Technologies (October 2014), see www.gov.uk/government/publications/eight-great-technologies-the-patent-landscapes.

Source: OECD Science, Technology and Industry Scoreboard 2015. OECD calculations based on IPO (2014), Eight Great Technologies: the Patent Landscapes and STI Micro-data Lab: Intellectual Property Database, June 2015. http://dx.doi.org/10.1787/888933273495

Investment in ICT-related R&D is constrained by several factors, such as: high capital intensity, specific risks related to the dynamics of technological change and uncertain adoption. The role of government has therefore been instrumental for the development of ICTs.

Figure 19, often called the "tire tracks" diagram because of its appearance, shows how government investments in academic and industrial research led to the ultimate creation of new ICT industries with more than USD 1 billion in annual revenue. It shows in particular that government support has been instrumental for the successful development and commercialisation of major ICT applications. For instance, university research in robotics and assistive technologies has been a key enabler for many cloud computing services today.

Figure 19. IT sectors with large economic impact



Source: National Academy of Sciences (2012)

Data, including public sector data

Data are an infrastructural resource – a form of capital that cannot be depleted and that can be used for a theoretically unlimited range of purposes (OECD, 2015b). Physical infrastructure such as roads and bridges enables benefits to 'spill over', for instance, by fostering trade and social exchanges. In the same way, greater access to data also has beneficial spill-overs, where data can be used and re-used to open up significant growth opportunities, or to generate benefits across society in ways that could not be foreseen when the data were created. But some of the spill-overs of data cannot be easily observed or quantified (e.g. socialisation and behavioural change, cultural and scientific exchange, or greater levels of trust induced by transparency). Organisations may not always be able to capture the private benefits of their investment in data – often due to unclear ownership structures – and also do not yet always see the larger benefits that the data can bring across society (see the case of Scania in the Annex). As a result, countries – and governments in particular – risk under-investing in data and may end up giving access to data for a narrower range of uses than socially optimal. This risks undermining countries' capacity to innovate, as data and its analysis have become a fundamental input to innovation, akin to R&D.

In this sense, data are the new "R&D" for 21st century innovation systems. Data and R&D share a number of common properties: both are intangible assets that can be combined with other innovation investments like training, software, organisational change, etc.; both enable the creation of knowledge with positive externalities or spill-overs across society; and both face the challenge of these externalities possibly negatively impacting on incentives to invest. Although successful innovation requires a bundle of investments in addition to R&D, innovation policy all too often focuses most prominently on R&D, for example, through R&D tax credits, or government investments in basic R&D. Governments are thereby not yet sufficiently considering the crucial role of data in shaping or strengthening innovation performance. This could also have ramifications on the role of the public sector not only as key user of data and analytics, but also as key producer of data.

Furthermore, the public sector is one of the most data-intensive sectors, and public sector data can benefit governments (e.g. in terms of public sector productivity and internal costs savings, improved policy development, more effective service delivery, transparency), citizens (e.g. through public participation and engagement, people's empowerment) and businesses (e.g. through product and process innovation). The potential of public sector data for the private sector is significant. The OECD market for public sector information (including data) was estimated to be around USD 97 billion in 2008, and could have grown to around USD 111 billion by 2010. Aggregate OECD economic impacts of PSI-related applications and use were estimated to be around USD 500 billion, and there could be close to USD 200 billion of additional gains if barriers to use are removed, skills enhanced and the data infrastructure improved. There is also firm-level evidence that there are significant cross-country benefits from free or marginal cost pricing, with SMEs benefitting the most.

The main barriers to open access to public sector data are not technical but *i*) policy challenges (e.g. the lack of procedures and standards for dealing with open data in governments), *ii)* funding challenges (e.g. cost recovery), and *iii)* organisational and cultural challenges (e.g. ensuring accountability, the quality of data and responsibility in the context of collaboration). Funding challenges are often seen as a critical challenge at times of budget cuts and financial constraints. Some governments therefore feel the need to clearly articulate a "business case" and identify funding models. Available evidence suggests that where revenues are collected from the use of public sector data, they are in most cases less than 1% of expenditures, with a maximum of one-fifth of expenditures in a few cases. This suggests that revenue collection models have restricted use without collecting significant revenues. That said, there is a need to establish a clear measure of the potential costs and benefits of opening up public sector data, and to help governments build a better "business case" for open access in the public sector.

Interoperability and (open) standards

Despite the widely agreed benefits that interoperable systems enable, there are still significant (non-legal) issues limiting interoperability between systems (including data exchange). In the case of cloud computing, for example, recent surveys among potential cloud users have highlighted a lack of standards and of open standards as one of the biggest barriers to the use of advanced ICTs such as cloud computing (OECD, 2014b) and the IoT. Fear of potential vendor lock-in is often a consequence. The lack of open standards for cloud computing is a key problem especially when it comes to the model of "platform as a service" (PaaS). In this service model, application programming interfaces (APIs) are generally proprietary. Applications developed for one platform therefore cannot easily be migrated to another cloud host.[52] Consequently, once an organisation has chosen a PaaS cloud provider, it is – at least at the current stage – locked in (OECD, 2014b).[53] Another concern linked to this is that users can become extremely vulnerable to providers' price increases. This is the more relevant as some IT infrastructure providers may be able to observe and profile their users to apply price discrimination to maximise profit (see OECD, 2015b).[54] In the case of the IoT, as another example, an executive survey by the World Economic Forum (WEF, 2015) indicates that lack of interoperability ranks after security concerns, but before uncertain return on investments (ROI), among the top three barriers to IoT adoption. Furthermore, there is evidence that the large majority of the data generated by sensors do not reach operational decision makers due to interoperability issues (McKinsey, 2015).

APIs, which can be seen as the "gateway" between different systems in the digital economy, are a key enabler for interoperability. This however also means that APIs can be exploited as strategic point of control, for example by limiting users' choice in the applications used on top of a service provided over an API (see the example of Twitter in Box 4). Trends towards more closed APIs are therefore raising concerns among some actors that rely on open API for their innovative services. This is particularly relevant in view of the recent debate on the ability for legal entities to copyright APIs. This debate has gained significant momentum after a recent petition by the Electronic Frontier Foundation (EFF, 2014) to the United States Supreme Court in November 2014. The petition follows a court finding earlier in May 2012 that Google had infringed on Oracle's copyright on Java APIs in Android, "but the jury could not agree on whether it constituted fair use" (Duckett, 2014).

Open standards, inspired by open internet standards such as TCP/IP and HTML5, are therefore often presented as a key enabler of "permissionless innovation". In the cloud computing, attempts have been made to extend general programming models with cloud capabilities in order to enhance interoperability, in particular for PaaS (Schubert et. al., 2010). However, these attempts have not met with success. Promoting open standards for APIs and further work on interoperability are therefore seen as the appropriate response to this problem. As a result, many initiatives are under way, covering the full spectrum from infrastructure standards – such as virtualisation formats and open APIs for management – to standards for web applications and services, security, identity management, trust, privacy, and linked data.[55]

As digital services become more and more data-intensive, the reuse of data not only requires interoperable APIs, but also more open standards for data formats (including the metadata), to reduce risks of vendor lock-in and vendors' exploitation. Furthermore, data portability becomes a means to empower users (including consumers) and further their active participation in the data driven economy, while promoting the free flow of their own (personal) data across organisations (see OECD, 2015b).[56] Data portability may however involve significant costs to those that need, want, or must implement portability in their (existing) data-driven services. These include, costs both for developing and maintaining the mechanisms for enhanced data access, and for complying with relevant regulations (OECD, 2015b). This may reduce incentives to provide data portability in existing services and raise questions about who should bear the costs for developing and maintaining these mechanisms.[57]

Box 4. Competitive effects of Twitter's vertical integration

Twitter's application programming interface (API) allows outside developers to build apps that can pull in information directly from Twitter to display in their own apps. The availability and openness of proprietary API's have been instrumental for the rapid expansion of apps and the growth of platforms such as Twitter.

Twitter has been pursuing a vertical integration strategy by acquiring and building a portfolio of apps. The company purchased apps such as TweetDeck (2011), Tweetie (2010) and Summize (2008) intending to later transform them into brand extensions that serve different platforms and services, e.g. search engines.

The result of this integration is that Twitter wants developers to start building apps that use Twitter, rather than Twitter apps. Twitter has been discouraging developers from using their APIs to make apps that compete directly with their platform, by rejecting apps that rely on tweet feeds via its API and by revoking API access. The risk of such an approach for Twitter or other growing platforms is that the uncertainty of future access to the API will stifle investment and innovation.

In August 2012, Twitter restricted the number of individual user tokens for an app that could access their APIs to 100 000. This essentially means that app developers are limited to 100 000 app installs on users' devices without special permission from Twitter to increase the number. Some developers were forced to require all members to re-login to free up unused keys for new users.

Source: OECD, 2013d, based on Musil, 2011; Mashable;[58] Twitter, 2012; and Yahoo News, 2013.

Government initiatives promoting *data portability* may therefore be needed. In 2011, a government-backed initiative called "midata" was launched in the United Kingdom to help individuals access their transaction and consumption data in the energy, finance, telecommunications and retail sectors. Under the programme, businesses are encouraged to provide their customers with their consumption and transaction data in a portable, preferably machine readable format. A similar initiative has been launched in France by Fing (Fondation Internet Nouvelle Génération), which provides a web-based platform MesInfos,[59] for consumers to access their financial, communication, health, insurance and energy data that are being held by businesses. Both initiatives, in the United Kingdom and France, are outgrowths of ProjectVRM,[60] a United States initiative launched in 2006 that provides a model for Vendor Relationship Management by individual consumers. Finally, the right to data portability suggested by the European Commission (EC) in the current proposal for reform of their data protection legislation, aims at stimulating innovation through a more efficient and diversified use of personal data, by allowing users "to give their data to third parties offering different value-added services" (EDPS, 2014).

Trust in the digital economy

Critical to reaping the substantial economic benefits of digital innovation is the key element of trust. Trust is a complex issue, and yet there is consensus that it plays a central, if not vital, role in social and economic interactions and institutions (Putnam et al., 1993; Morrone, et al., 2009; OECD, 2011a). In reducing transaction costs and frictions, trust generates efficiency gains, and is considered by some to be a determinant of economic growth, development, and well-being. The OECD (2011a) provides quantitative evidence that high trust is strongly associated with high household income levels. In relation to the digital economy, the main components of trust are security and privacy, and consumer protection. Another aspect of trust that will be discussed here is that of intellectual property rights (IPRs), which play a key role for enabling trust in the digital economy as well. The following sections will illustrate how the different aspects of trust can affect digital innovation. It should be noted that these sections only briefly discuss the issue of digital security and privacy, and consumer protection, given that they are discussed in more details in OECD (2016b; 2016c) respectively.

Cybersecurity risks

The intricate, hyper-connected digital environment, on which digital innovation relies, is increasingly filled with security threats that have changed in both scale and kind (see Box 2). They include organised crime groups, "hacktivists", foreign governments, terrorists, individual "hackers" – and sometimes, business competitors. There are, in addition non-intentional digital threats, such as hardware failure and natural disasters.

Many stakeholders continue to adopt a *traditional security approach* that not only falls short of appropriately protecting assets in the current digital environment, but is also likely to stifle digital innovation and growth. That traditional approach aims to create a digital environment secure from threats that can undermine the "AIC triad": digital environment's availability (accessibility and usability upon demand by an authorised entity); integrity (quality in terms of accuracy and completeness); and/or confidentiality (prevention of data disclosure to unauthorised individuals, entities or processes). To preserve each of these dimensions, security experts put in place "controls", "mechanisms" or "safeguards", generally based on technologies that form a perimeter around the protected assets to secure them.

The problem today is that digital innovation introduces a level of complexity to the point where the traditional security approach cannot scale up. First, these digital innovations rely on information systems and networks to become more open and interconnected, enabling data flows to be exchanged easily, flexibly and cheaply, with a potentially unlimited number of partners outside the perimeter. Second, digital innovation relies on the capacity to exploit the dynamic nature of the digital environment, e.g. rapidly connecting, matching and analysing what was previously not related in order to create new assets. Third, in the particular context of data-driven innovation (DDI), traditional security can deal with increased volumes and diversity of data, if the data are located within that defined perimeter and their processing is not subject to continuously unpredictable uses and flows. However, the uncertainty already introduced by the open and dynamic nature of digital innovation grows, sometimes exponentially, with these increases. As a result, the traditional security approach, which can only operate at the cost of reducing complexity and increasing stability, will inevitably slow digital innovative usage and, ultimately, undermine the economic and social benefits of interoperable ICTs.

With the risk-based management approach, the objective is to increase the likelihood of economic and social benefits from digital innovation by minimising potential adverse effects of uncertainty related to the availability, integrity and confidentiality of digital services (the AIC triad). Unlike the traditional security approach, digital security risk management does not aim to create a secure digital environment to eliminate risk. Instead, it creates a framework to select proportionate and efficient AIC security measures in light of the benefits expected from digital innovation. That raises the key question of responsibility. Traditional security focuses on securing the digital environment. Therefore, in most cases, the party responsible for the provision of the environment (generally the IT department) takes responsibility for its security, and users of the environment do not have to be concerned with it. In contrast, from a digital security risk management perspective, responsibility cannot be delegated to a separate party. Managing risk means accepting a certain level of risk – or deciding not to accept it, and therefore not to realise the benefits. The primary responsibility for managing risk should therefore mirror the responsibility for achieving the objectives and realising the benefits (leadership).

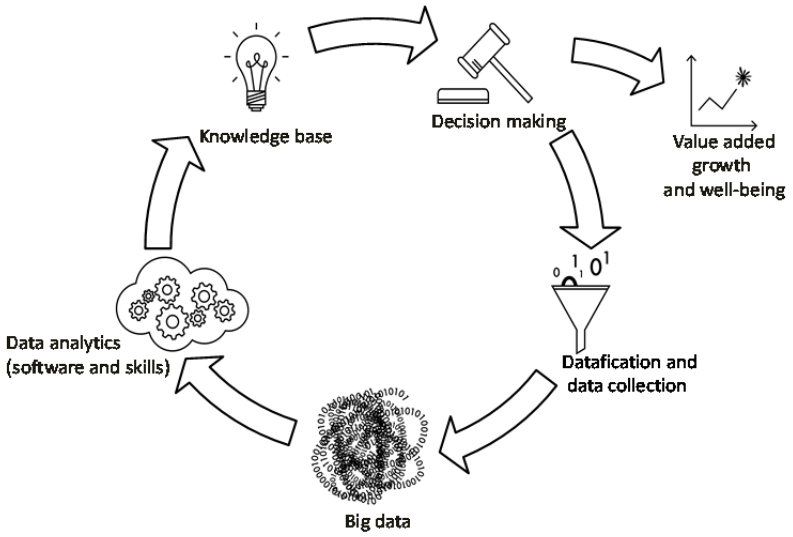
The complexity of applying digital security risk management to digital innovation should thus not be underestimated. It requires a high degree of systematisation and significant management efforts, bundled with business operation. Notably however, this is the same risk management approach routinely applied by many businesses in other spheres of their activities to increase their likelihood of success. The *2015 OECD Recommendation on Digital Security Risk Management for Economic and Social Prosperity* offers an

opportunity to elevate the need for attention to digital security risks to the highest levels in organisations – a key to progress in this area.

Privacy in a data-driven economy

As digital innovation becomes more data-driven, privacy will be more of a key factor. Understanding the risk factors related to privacy require understanding the data value cycle (Figure 20) on which data-driven innovation relies and can raise privacy concerns. *Step 1* is the initial data collection, which is becoming increasingly comprehensive, diminishing an individual's private space. Some of the data collected is *volunteered* and thus knowingly and willingly provided by the individual as it is often essential to the completion of an online transaction. An increasing share of data in contrast is *observed*, based on the online tracking of individuals and the collection and analysis of related personal information.

Figure 20. The data value cycle



Step 2 is the massive storage of data, which increases the potential of data theft or misuse by malicious actors and other consequences of a data security breach, the risks of which may not be easy to ascertain. Where personal data are collected, stored or processed, security incidents can heavily affect individuals' privacy – as high-profile *data breaches*[61] have demonstrated. Cyber-attacks still remain the most frequent cause for data breaches in terms of records stolen but not in terms of number of incidents. These incidents come along with significant costs to individuals but also to the firms suffering the data breaches.

Steps 3 and 4 involve inferences of information and knowledge enabled by data analytics, which often go well beyond the data knowingly provided by a data subject – diminishing an individual's control and creating information asymmetry. Advances in data analytics make it increasingly easy to generate *interferences* from data collected in different contexts, even if individuals never directly shared this information with anyone. Once *linked* with sufficient other information, data analysts can predict, with varying degrees of certainty, the likelihood that an individual will possess certain characteristics. This increased capacity of data analytics is illustrated by Duhigg (2012) and Hill (2012), who describe how the United States based retailing company Target "figured out a teen girl was pregnant before her father did" based on specific signals in historical buying data.[62]

Finally, data-driven decision making (*Step 5*) can lead to a real-world (discriminatory) impact on individuals and other harms. Concerns have been raised that the information inferred through data analytics

could be used to exploit the vulnerabilities and receptiveness of individuals in a way that not only induces them to undertake certain actions (e.g. purchase products), but that alters their preferences for these actions. In addition, private actors increasingly rely on the predictive capabilities of data analytics in their search for competitive advantage. While these predictive analyses may result in greater efficiencies, they may also perpetuate existing stereotypes, limiting an individual's ability to escape the impact of pre-existing socio-economic indicators. A well-known example in this regard is "price discrimination" where firms are selling the same good to different customers for different prices, even though the cost of producing for the two customers is the same. Certain uses of data analytics may also have more serious implications for individuals by affecting their ability to secure employment, insurance or credit – this is more severe when decision-making processes are fully automated.

Intellectual property rights[63]

Intellectual property rights (IPRs) are exclusive rights held by the owners of a variety of knowledge-based assets that qualify for legal protection under applicable IP laws (OECD, 2015d). IPRs support (digital) innovation by making it a more worthwhile investment and encouraging knowledge diffusion. The economic rationale for IPRs is that it is in everyone's long-term interest for people and businesses that create knowledge, to have well-defined, enforceable rights to exclude third parties from appropriating their ideas, or the expression of their ideas, without permission. Failing to put restrictions on appropriating others' inventions and creations could dilute the rewards for investing in innovation, thereby reducing the incentives for making such investments. In addition, both *i)* disclosure requirements and time limits for exclusivity that are built into IPR laws, and *ii)* IPRs' facilitation of licensing and other knowledge transfers, contribute to knowledge diffusion and thus to innovation.[64]

IPR's overall role in economies has evolved from a policy area that was mainly relevant to a handful of industries to a force that influences a wide swath of demand and sectors (OECD, 2015d). Consequently, IPR policy has become a more influential framework condition that affects not only innovation, but trade, competition, taxes, consumer protection, and other areas. Investment in IPR-protected capital is growing faster than investment in tangible capital, and salaries in IPR-intensive sectors are higher than in non-IP-intensive sectors (OECD, 2015d). The available evidence on IPR's aggregate role also shows that IPR's economic importance has grown over time and that it remained resilient during the recent recession. The context in which IPR operates has been changing substantially in particular due to the growth of the digital economy. IPR frameworks and stakeholders have been and continue to be affected by a number of developments, including the rise of cloud computing, the growth of the Internet, digitalisation and globalisation. These have created both new challenges for IPRs, including the facilitation of piracy and industrial espionage, and new opportunities for it to stimulate inventions and creativity as well as to facilitate greater access to information and creative works.

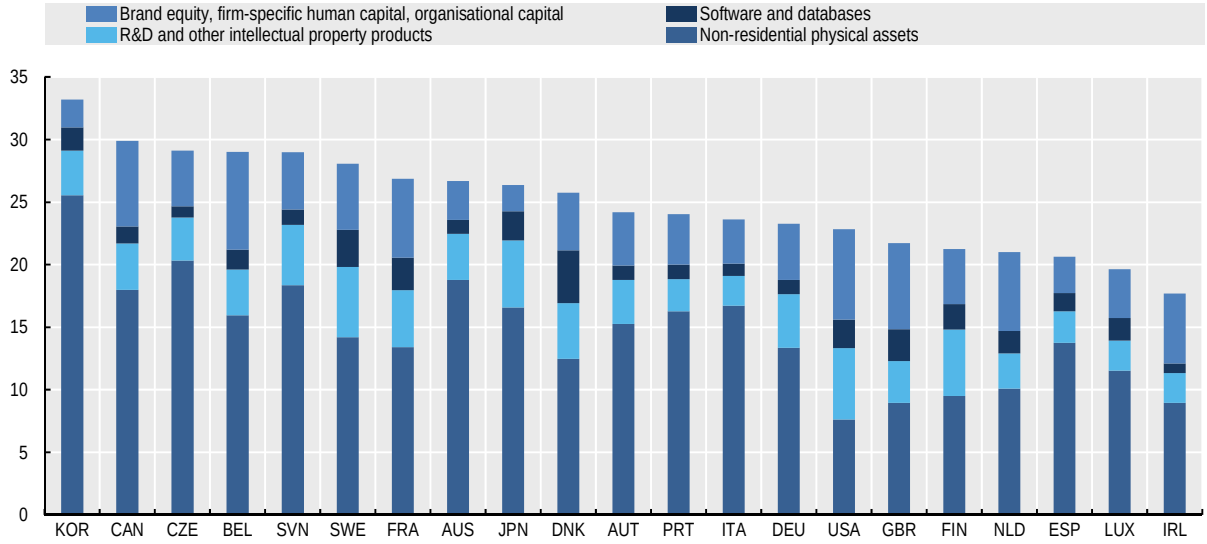
Among the different types of IPRs, copyright's performance excels in terms of the magnitude of investment it attracts, the growth rate of that investment, and job growth (OECD, 2015d). Copyright's role in economies appears to be growing larger and faster, in particular as the digital economy continue to grow. In particular, in much of the world, copyright protects a significant amount of software investment – sometimes more than in the rest of the "creative industries". Furthermore, user generated content is now also a significant source of entertainment and information. When it comes to the role of patents for stimulating innovation, the evidence is mixed (OECD, 2015d). Several surveys have shown that patents are not considered to be very effective in protecting innovations outside a small number of sectors. However, other reports indicate that growth in patent-intensive industries following the 2008-09 recession outpaced growth in non-IPR-intensive industries. In any event, studies still have not definitively concluded that stronger and broader patent rights are necessarily resulting in more innovation. Despite this mixed evidence, over the past 20 years or so, patent rights have generally become broader and stronger, and there has been a surge in the number of patents granted.

Investments in complementary knowledge-based capital

In 2010, the OECD launched a horizontal project on *New Sources of Growth: Knowledge-Based Capital*, which provides evidence of the impact on growth and the associated policy implications of three main types of knowledge-based capital (KBC): i) computerised information (e.g. software and databases); ii) innovative property (e.g. patents, copyrights, designs and trademarks); and iii) economic competencies (e.g. brand equity, firm-specific human capital, networks of people and institutions, and organisational know-how) (OECD, 2013a).[65] The work highlighted that in some countries – such as Sweden, the United Kingdom and the United States – investment in KBC matches or exceeds investment in physical capital such as machinery, equipment and buildings (Figure 21). In many countries, such as Denmark, Ireland and Italy, business investment in KBC also rose higher as a share of GDP, or declined less, than investment in physical capital during the 2008-09 financial and economic crisis (OECD, 2013a). Brand equity, firm-specific human capital and organisational capital represent a significant share of the investments in KBC intensive economies.

Figure 21. Investment in physical and knowledge-based capital, 2010

As a percentage of value added of the business sector



Sources: *OECD Science, Technology and Industry Scoreboard 2013*, based on INTAN-Invest Database, www.intan-invest.net, and national estimates by researchers. Estimates of physical investment are based on OECD Annual System of National Accounts (SNA) and the INTAN-Invest Database, May 2013, http://dx.doi.org/10.1787/888932889820

Evidence shows that the effective use of ICTs typically depends on additional complementary investments in KBC, in particular firm-specific skills and know-how, and organisational change including new business processes and business models (see Pilat, 2004; van Ark et al., 2008; Bloom 2012; Corrado et al., 2014). This is confirmed by business surveys showing that insufficient knowledge and barriers to organisational change are often indicated as barriers to the effective use of ICTs, besides concerns of lock-ins and security breaches discussed above. In particular smaller firms which too often do not have internal IT departments or in-house know-how are the most effected.

This section discusses the role of organisational change and ICT-related skills for effective use of ICTs, which seems in particular a challenge for traditional and old SMEs. The discussion on ICT-related skills will focus on how these skills enable digital innovation, without however going into much detail about current trends in ICT-related skills and jobs which are discussed further in OECD (2016d and 2016e).

Organisational change and business model transformation

"Organisational capital consists of knowledge, know-how and business practices" that are firm specific (Squicciarini and Le Mouel, 2012). It includes a wide range of internal and external processes such as production processes (quality management, lean production, business re-engineering), management approaches (teamwork, training, flexible work and compensation) and external relations (outsourcing, customer relations, networking) (Murphy, 2002). It may be summarised as the combination of a firm's business model and its corporate culture (see Squicciarini and Le Mouel, 2012).

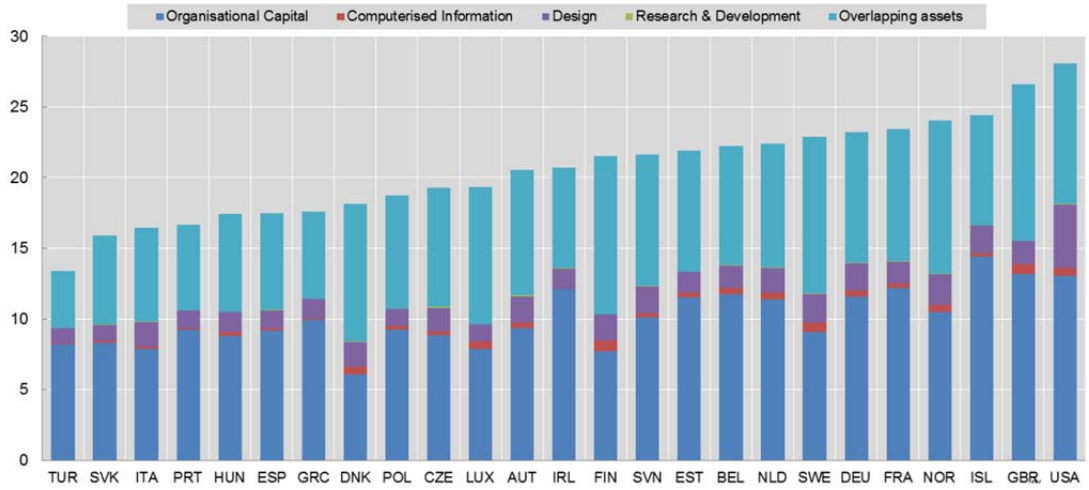
The effective use of ICTs will typically require organisational changes to various degrees and thus additional investments in organisational capital.[66] Complementary investments in organisational capital have been highlighted as crucial in many empirical studies on the effective use of ICTs. The recent study by Corrado et al. (2014) was already highlighted in the introduction, as it presented strong evidence at the macroeconomic level for complementarities between ICT and KBC investments, and in particular organisational capital. Findings by Polder et al. (2010) confirm the importance of organisational change: "Organizational innovation is the only innovation type that leads to higher contemporaneous TFP levels. Product and process innovation only lead to higher TFP when performed in combination with an organisational innovation." (Polder et al., 2010) These findings are in line with previous research by Brynjolfsson and Hitt (2000), Black and Lynch (2001), Basu et al. (2003), Pilat (2004), Brynjolfsson et al. (2006), van Ark et al. (2008), and Bloom (2012), all pointing to poor investments in organisational capital or poor managerial skills as one major factor behind productivity differences between firms, including also between the United States and Europe. Brynjolfsson and Hitt (2000), Brynjolfsson et al. (2002) and more recently Abramovsky and Griffith (2009), for example, provide a review of this literature confirming that firms become more productive when they both adopt ICTs *and* restructure.

Complementarities between investments in data analytics and organisational change have also been highlighted as a necessity to enable data-driven innovation (DDI). A study by Bakhshi et al. (2014) based on 500 firms in the United Kingdom show that complementary changes in organisational processes are a potential factor explaining the significant difference in productivity between firms. As Bakhshi et al. (2014) explain: "The disconnect between the levels of online data activity and the benefits that we estimate may in part be explained by our other finding that firms need to introduce complementary changes in order to reap the full returns from their online data activity".

Complementarities between ICTs and organisational change are also suggested after the analysis of KBC-related occupations – many of which involve working activities related to "overlapping assets" including those involving computerised information (CI) *and* organisation capital (OC) (Figure 22). These occupations are selected on the basis of the tasks workers perform on the job, the skills they apply, and the level of knowledge of the subject area they rely on (Squicciarini, and Le Mouel, 2012). KBC-related workers account for 13% to 28% of total employment in many OECD countries. Of these workers, between 30% and 54% contribute to more than one type of KBC asset, and, of these, 30% to 50% are involved in tasks related to the combination of R&D and CI. In particular, workers involved in CI, i.e. those dealing with software and databases, are to various extents, involved in tasks related to all other KBC types considered.

Figure 22. Knowledge-based capital related workers, 2012

Percentage of total employed persons



Source: OECD Science, Technology and Industry Scoreboard 2013. *http://dx.doi.org/10.1787/888932890618*

Organisational change does not need to be radical or disruptive though; it can be incremental (evolutionary innovation). A survey by Donnet and Westerman (2015), for example, shows that revolutionary business model transformation remains elusive. Only 7% of the executives surveyed said that their company's digital initiatives were helping them to launch new businesses, and only 15% indicated that their initiative was helping them create new business models. What seems more pertinent is an incremental (evolutionary) transformation of organisation processes and business models. This is in particular the case when ICTs are used to i) *enhance traditional business models*, often by increasing the efficiency of business processes. Examples include financial and insurance services, where software was introduced to improve prediction models. Today, the use of "big data" analytics, cloud computing and the IoT has led to further opportunities (Box 5). Examples include the use of ICTs in retail to link data on supply chains and thereby increase operational efficiency. Furthermore, the use of ICTs can enable firms to ii) *extend traditional business models*. This is for instance the case when businesses introduce e-commerce solutions to create new revenue channels in addition to their existing traditional shops. In the survey by Donnet and Westerman (2015), 42% of the executives said that digital technologies were helping them to enhance their existing goods and services and 29% said that digital was helping launch new goods and services.

Box 5. Steps towards the digital transformation of traditional business models

The analysis of successful digital business models suggest a number of steps through which traditional business models could be digitally transformed by taking advantage of current ICT trends such as big data, cloud computing and the IoT. These steps include:

- **The digitisation of physical assets** is one of the most straightforward steps to digitally transform businesses. One early example is the entertainment and content industry, where books, music, and videos were digitised to provide them electronically and over the Internet. Thanks to the deployment of 3D scanners and 3D printing, digitisation is no more limited to content, but can now include real-life objects. 3D printing promises, for instance, to shorten industrial design processes, owing to rapid prototyping, and in some cases raise productivity by reducing material waste (OECD, 2016f). Boeing, for instance, has already replaced machining with 3D printing for over 20 000 units of 300 distinct parts (Davidson, 2012).

Box 5. Steps towards the digital transformation of traditional business models (cont.)

- **The "datafication" of business relevant processes** refers to data generation, not only through the digitisation of content, but through the monitoring of activities, including real-world (offline) activities and phenomena, through sensors. "Datafication" is a portmanteau for "data" and "quantification" and should not be not be confused with *digitisation*, which refers to the process of encoding information into *binary digits* (i.e. bits) so it can be processed by computers (OECD, 2015b).[67] Datafication is used by many platforms which can monitor the activities of their users. And thanks to the IoT, this approach is no longer limited to Internet firms. Data collected on agriculture machines such as provided by Monsanto, John Deere and DuPont Pioneer, for example, are being used as an important data source for optimising the distribution but also genetic modification of crops (GMC).

- **The interconnection of physical objects** via the IoT enables product and process innovation. Scania AB, a major Swedish automotive industry manufacturer of commercial vehicles, is now generating one sixth of its revenues thanks to new services enabled by the wireless communication built into its vehicles. This allows the company to transition towards a service firm increasingly specialised in logistic, repair and other services. For instance, thanks to the interconnection of its vehicle, Scania can better offer fleet management services. The interconnection of physical objects also enables the generation and analysis of big data, which can then be used for the creation of even more new services. Scania, for instance, offers a set of new "ecolution" services, which aim at increasing driving efficiency and thus resource efficiency. This includes for example coaching of the drivers based on driving data collected via the data connection. Another example includes "remote diagnostics" based on predictive data analytics providing the possibility to make the right diagnosis earlier and efficiently remove multiple on-call visits, and also to enhance just-in-time storage of repair parts in the repair shops (see Annex).

- **The codification and automation of business relevant processes via software and AI**: Software provides incentives and enables businesses to standardise their processes, and where these processes are not central to the business model, to sell codified process via software to other businesses. "Cloud computing has put such opportunities within even closer reach because it allows companies to easily distribute software, simplify version control, and offer customers 'pay as you go' pricing" (Parmar et al., 2014). An example is IBM's Global Expenses Reporting Solutions, which was originally developed to automate the company's internal travel related reporting processes. IBM turned the in-house system into a service, which "it has since sold to organisations worldwide, effectively giving birth to a new business" (Parmar et al., 2014). Another example is Google's Gmail, which was originally used as an in-house email client, before it was announced to the public as a limited beta release in April 2004 (McCracken, 2014).

- **The trading of data** (**as a service**) is made possible as soon as physical assets have been digitised or processes "datafied". The data generated as a by-product during a business operation can have huge value for other businesses (in other sectors). The French mobile communication services firm, Orange, for instance, uses its Floating Mobile Data (FMD) technology to collect mobile telephone traffic data that are anonymised and sold to third parties, including government agencies and traffic information service providers. In addition, businesses can take advantage of the non-rivalrous nature of data to create multi-sided markets, where activities on one side of the market go hand in hand with the collection of data, which is exploited and used on the other side of the market. Very often, however, it will be difficult to anticipate the value that the data will bring to third parties. This has encouraged as a result some businesses to move towards a more open data centric model (see OECD, 2015b).

- **The (re-)combination of data within and across industries** creates business opportunities for those firms that play a central role in their supply chain. Walmart and Dell are well-known to have successfully integrated data across their supply chains. But as manufacturing becomes smarter thanks to the IoT, this approach is becoming very attractive to manufacturing companies as well. Sensor data, for instance, can be used to monitor and analyse the efficiency of products, to optimise operations at a system-wide level, and for after-sale services, including preventive maintenance operations. The data can then be used in collaboration with suppliers, and in some cases even commercialised as part of new services for existing and potential suppliers and customers.[68] For example, Germany-based Schmitz Cargobull, the world's largest truck body and trailer manufacturer, uses sensors to monitor the maintenance, travelling conditions and routes travelled by any of its trailers, and to provide additional services to its customers (Chick, Netessine and Huchzermeier, 2014; see also Vennewald, 2013).

As Kushida and Zysma (2013) highlight, the digital transformation of organisations (incl. business models) is often a continuous (evolutionary) process: "existing firms often progress from one step to the next; they first enhance their traditional business model to improve efficiency, then move to extending the business model in new ways". The successive transformation can then organically lead to a revolutionary transformation that can be disruptive. This is in line with Christensen (1997), according to which evolutionary innovation can reach a tipping point where it turns out to be disruptive. Box 5 illustrates how current trends in ICTs such as in particular (big) data analytics and the IoT provide huge opportunities for the digital transformation of traditional business models.[69]

It is important at this point to acknowledge the challenges of successfully investing in organisational change and to digitally transform traditional business models. As Bakhshi et al. (2014) explains: organisational change "may include disruptive – and therefore possible controversial – changes to [firms'] organisational structures and business processes".[70] These controversial changes can lead to what Christensen (1997) refers to as the "innovator's dilemma", where successful companies put too much emphasis on current success and in particular the (short-term) pursuit of profit, and thus fail to adopt new technology, business models or markets in fear of cannibalising or disrupting their own most profitable business units. As a result, these firms may fall behind and eventually vanish entirely as disruptive innovation is introduced by competitors. One way proposed to overcome the innovator's dilemma is "setting up a separate company that eventually goes on to defeat the parent" (Allworth, 2011).

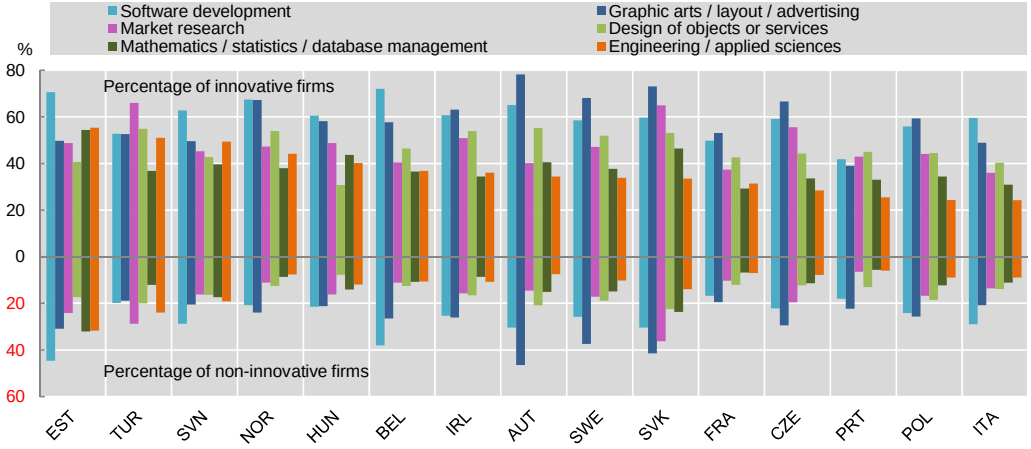
Business surveys confirm that digital transformation is perceived as a highly risky undertaking. Among the businesses surveyed by Kane et al. (2015), more than half of the less digitally mature businesses indicated their organisations' fear of risk as a major barrier, compared to only 36% of the more digitally mature businesses. This suggests that policy makers and business leaders must enable a culture of digital transformation that encourage risk-taking to support digital innovation. This highlights the fundamental importance of management skills as pointed out by many researchers like Bloom and van Reenan (2010), and leads to questions related to the favourable conditions for entrepreneurship, the creations of businesses and competition, discussed in the following section.

Skills and awareness

ICT-related skills are a key enabler of digital innovation. This is confirmed by business innovation surveys showing that firms using (internal or external) skills related to ICTs (i.e. software) and data (i.e. mathematics, statistics and database management skills) are more likely to innovate (Figure 23).[71] In most countries, for which data is available, around 60% of the innovative firms employ software developers, and around 40% employ mathematicians, statisticians and database managers (compared to around to 30% of non-innovative firms that employ software developers and 20% that employ mathematicians, statisticians and database managers). In terms of data specialists, in particular, evidence suggests that firms with better access to data specialist skills are more likely to gain faster productivity growth through data-driven innovation (DDI). A recent study by Tambe (2014) was based on an analysis of 175 million LinkedIn user profiles, out of which employees with skills on big data-specific technologies were identified. The study indicates that firms' investments in big data-specific technologies were associated with 3 percentage points faster productivity growth, but only for firms that i) already had access to significant data sets and ii) were well connected to labour networks with sufficient expertise in big data-specific technologies.

Figure 23. Firms using innovation-relevant skills, 2008-10

As a percentage of innovative and non-innovative firms



Source: OECD Science, Technology and Industry Scoreboard 2013, http://dx.doi.org/10.1787/888932890770.

The study by Tambe (2014) is also highly pertinent because it strongly suggests that geography matters for unleashing labour market spillovers, and because its provides an explanation for the systematic cross-regional firm-level variations in IT returns observed by many authors, such as Brynjolfsson and Hitt (2000), Dewan and Kraemer (2000), and Bloom and Van Reenen (2007). Most of the big data technologies studied by Tambe (2014) are so new that few experts have sufficient knowledge or the expertise to work with them, and those with high levels of skills tend to concentrate in specific regions. His analysis of LinkedIn profiles shows that expertise in Hadoop, a major big data-related technology, is concentrated in certain regions in the United States, with the San Francisco Bay area being the most Hadoop-intensive region. These findings call for a cautious interpretation of country-level employment and skills statistics, as they do not always reflect (sub-)regional labour market concentrations and dynamics, and thus may not reveal existing skill gaps that may be a barrier to ICT adoption and use in certain regions.

OECD (2016w) shows that the skills needed to unleash the potential of ICTs are not limited to (the technical) ICT specialist skills, but also include other skills and competencies such as communication skills, problem solving skills and domain-specific skills. This is also confirmed by the OECD (2015b) study on data-driven innovation showing that data specialists will typically be required to have a mix of different skill sets. These include: (i) computer science skills such as software engineering, database management, and machine learning (ML), as well as (ii) skills in statistics, but also (iii) domain-specific skills such as business management, marketing, finance and health, in addition to (iv) "soft skills" such as communication, creative thinking and problem solving skills, which are also often increasingly highlighted as skill requirements in current job posting.

Very often barriers to adoption will not only be due to lack of available skills in the (regional) labour market, but more a lack of awareness about the potential of ICTs for innovation and productivity growth. This is particularly true for firms that face challenges in transforming their organisations. A recent study (Hammermann and Stettes, 2016) on the impact of digital change on skills and employment in Germany suggests that the "ability to plan and organise, to act autonomously", combined with firm-specific and occupational-specific working experience, is crucial for the successful digital transformation of businesses. However, surveys also show that the ability to articulate the value of digitalisation to the organisation's future is too often missing in businesses. This translates to a lack of a business strategy for the digital transformation. Kane et al. (2015), for instance, find that "early-stage companies are often falling into the trap of focusing on technology" and thus only focus on using ICTs for improving their operations if at all.

Only 52% of the less-intensive ICT using businesses surveyed (early-stage adopters) say that transforming their business is part of their digital agenda.

In particular, SMEs have a deficit of knowledge and awareness of the chances and new business opportunities offered by digitised business and work, which then leads to a poor ability to change, and competitive disadvantages. A 2014 survey among 1 000 SMEs in Germany revealed that for 70% of enterprises with an annual revenue below EUR 500 million, digitalisation of processes was still seen irrelevant. What is making the situation worse, is that many of the currently available ICT products and information do not take the specific needs of SMEs into account. A study funded by the German Federal Ministry of Economic Affairs and Energy (2015), for instance, confirms that current research and projects on "Industrie 4.0" are too often not presenting their results in a format and language that is appropriate to SMEs and skilled crafts.

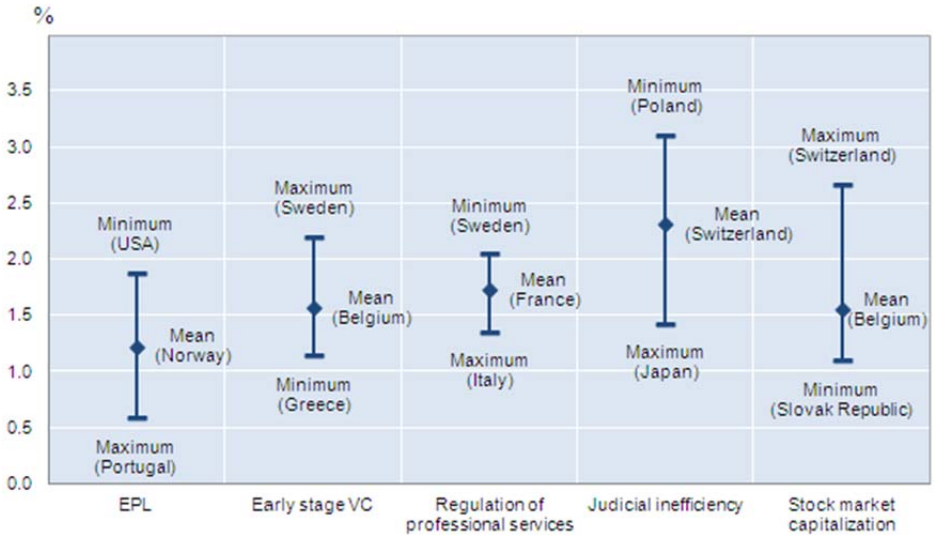
Other regulatory framework and market conditions[72]

Regulatory framework and market conditions (framework conditions) play an important role for the successful adoption of ICTs, in particular in cases where the adoption requires substantive investments (including in organisational changes) that are perceived as highly risky or disruptive. By shaping the perceived flexibility (cost) of businesses to experiment with (disruptive) innovations, framework conditions affect, for instance, the ability of businesses to scale-up those innovations that have shown successful in smaller scale experiments, and to scale them down if they turn out to be a failure. At a macro level, framework conditions thereby affect the ability of economies to reallocate scarce resources needed for digital innovation (such as ICT-related skills) to more successful firms, and are thus an important determinant for business dynamics. Findings by Andrews and Criscuolo (2013) strongly suggest that countries that are more successful at channelling resources to the most productive firms also tend to invest more in KBC, the very complementary assets needed to successfully leverage ICT investments.[73]

While firm entry is important, the extent to which young firms can scale is even more critical (Andrews and Criscuolo, 2013). Evidence shows that there are significant differences in the ability of firms to scale across countries. For instance, "on average an older manufacturing business in France is half the size [in terms of employment] of one in the United States, even though start-ups in France are larger than in the United States" (OECD, 2015e). In particular, Andrews and Criscuolo (2013) reveal important cross-country differences in the extent to which capital and labour flow to innovative firms.[74] Estimates are available for how resources flow to patenting firms depending on different public policy settings (Figure 25). It suggests, for example, that a policy reform, which would reduce the stringency of regulations affecting business services from the OECD average (i.e. France) to the low level in Sweden, is associated with an increase in the size of innovative firms by around 20% in terms of employment and 30% in terms of capital stock. A significant body of literature indeed suggests that differences in institutional factors that affect the costs of reallocating resources may best explain the relative sluggishness of some countries to capitalise on the digital revolution (Conway et al., 2006; Aghion et al., 2008; Bartelsman et al., 2010).

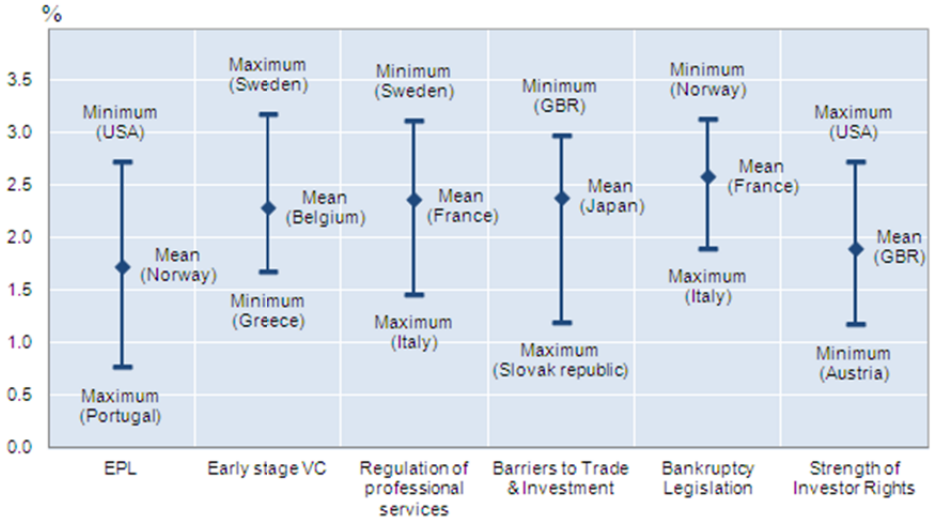
Figure 24. Framework policies and resource flows to patenting firms, 2002-10

A: Additional labour attracted by a firm that increases its patent stock by 10%



The estimated impact of different framework policies on the responsiveness of the firm employment to patenting

B: Additional capital attracted by a firm that increases its patent stock by 10%



The estimated impact of different framework policies on the responsiveness of the firm capital stock to patenting

Note: The chart shows that the sensitivity of firm employment and capital to changes in the patent stock varies according to the policy and institutional environment. All policy terms are statistically significant at least at the 10% level. Panel A shows that the sensitivity of firm employment to patenting is three times larger when EPL is at the sample minimum (i.e. the United States), compared with the when EPL is at the sample maximum (i.e. Portugal).

The chart is based on matched ORBIS-PATSTAT data. See Andrews et al. (2013) for details. EPL is the OECD Employment Protection Legislation (EPL) sub-index of restrictions on individual dismissal of workers with regular contracts; Regulation of professional services and Barriers to Trade and Investment are sourced from the OECD Product Market Regulation (PMR) Index; Stock market capitalisation is expressed as a percent of GDP and is sourced from the World Bank along with Judicial Efficiency and Strength of Investor Rights. Judicial Inefficiency refers to the cost of enforcing contracts, which measures the court costs and attorney fees as a per cent of the debt value. Strength of Investor Rights takes into account the extent of corporate disclosure, director liability and ease with which shareholder can sue company officers.

Source: Andrews and Criscuolo (2013)

The following section presents evidence on the effects of *(i)* competition and product market regulation, *(ii)* job protection regulation, *(iii)* bankruptcy legislation, and *(iv)* access to finance on the innovation capacity of economies. It should be noted at this point that this section does not further discusses the role of entrepreneurship for digital innovation. Although entrepreneurship is essential for the development and adoption of ICT for digital innovation, this section will only focus on some framework conditions which affect business dynamics more generally. A more detailed discussion on entrepreneurship and ICTs is provided in the context of job creation in OECD (2016d). Similarly, this section will also not discuss the importance of trade and global value chains (GVC) for digital innovation, which is discussed in the context of Internet Openness in OECD (2016g). And finally, although the framework conditions discussed here clearly affect ICT investment climate, there are other dimensions of the OECD (2015i) *Policy Framework for Investment* such as taxation and corporate governance that are not discussed here.

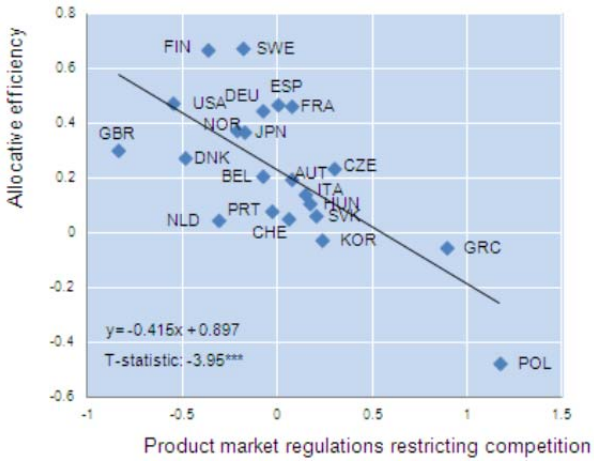
Competition and product market regulation

There is evidence that the adoption of ICTs have been largely driven via heightened competitive pressure in ICT-using sectors (see Conway et al., 2006; Aghion et al., 2008). When comparing Japan to the United States, for example, Kushida and Zysman (2013) observe that ICT adoption rates remained lower in ICT intensive sectors such as finance, retail, and healthcare in Japan, despite higher broadband penetration rate. The authors argue that the ICT revolution developed largely in the United States instead thanks to "lead users of ICT tools [that] faced newly liberalized environments, pressuring them into intense competition".[75] Lower entry regulations increase the supply of new ideas by raising firm entry rates, which in turn increase the pressure on incumbent firms to innovate via heightened competitive pressure (Andrews and Criscuolo, 2013). A good illustration of this phenomenon is the entry of firms such as Uber in the taxi market, which has incentivised the adoption of mobile applications (apps) for taxi hailing in many countries (King, 2015). Since the emergence of firms such as Uber and Airbnb, travel and mobility apps have ranked high among the most frequently downloaded apps (TechCrunch, 2014).[76] This means that regulatory barriers can prevent the effective diffusion of digital innovation. For example, large-scale IoT users such as car manufacturers, who need to control their own devices with their own SIM cards, cannot do so in many countries (see OECD, 2012b; OECD, 2015a).

A large number of empirical studies have confirmed the effects of product market regulations (PMR) on innovation (Aghion et al., 2004; Bourles et al., 2010; Bouis et al., 2011; Andrews and Criscuolo, 2013). Evidence shows, for instance, that "a modest reduction in PMR in the energy, transport and communications sectors – corresponding to the difference in regulation between Australia and Austria in 2008 – could result in a 5% increase in the stock of business enterprise R&D and a 3% rise in patents per capita in the long run" (Andrews and Criscuolo, 2013; citing Westmore, 2013). Furthermore, PMR influence the ability of economies to capitalise of innovation and to scale faster in case of a success. Less stringent regulations affecting product markets tend to be associated with higher allocative efficiency in manufacturing sectors across OECD countries (Figure 25; see also Figure 24 on the stringency of PMR affecting business services). Finally, there is also evidence that pro-competitive product market reforms can lead to improved managerial performance and thus, more effective organisational change, a requirement for the successful adoption and use of ICTs. Andrews and Criscuolo (2013), for instance, present evidence according to which the tail of poorly managed firms is smaller in countries where PMR are less stringent (in the United States) compared to where PMR are on average more cumbersome.

It is important to note that pro-competitive regulation is not enough, but requires in addition that other barriers for labour and capital (to flow to their most productive use) are also addressed (see Andrews and Cingano, 2012). This is in line with Kushida and Zysman (2013) concluding that "government policy driving liberalization of [ICT intensive] sectors was […] critical, as well as the labour and other institutional environmental factors that facilitated firms to reorganize how they competed".

Figure 25. Product market regulations restricting competition, 2005



Note: Allocative efficiency measures the contribution of the allocation of employment across firms to manufacturing labour productivity in 2005. Product market regulation refers to the overall index from of the OECD PMR for 2003.

Source: Andrews and Cingano (2012)

Labour market regulation

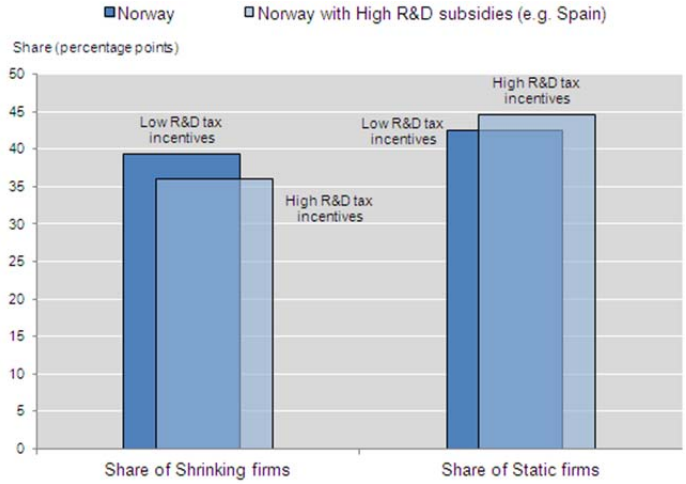
A significant number of studies present evidence on the impact of strict employment protection legislation (EPL) on the adoption of new ICTs and digital innovation (see Bartelsman and Hinloopen, 2005; Haltiwanger et al., 2006; Bartelsman et al., 2010). These studies show in particular that stringent EPL can raise labour adjustment costs to a point where the reallocation process is significantly slowed down. This can have negative effects on (digital) innovation, as it raises the expected cost for scaling down (or exit) innovation that turn out to be a failure, and thus discourage experimentation with uncertain technologies and organisational changes. In other words, stringent EPL can raise the expected cost of failure and thus discourage digital innovation when in particular the innovation is perceived as risky or disruptive. This explains why, for instance, countries with stringent EPL tend to have smaller ICT intensive sectors (see Bartelsman et al., 2010), an observation confirmed by recent OECD empirical evidence showing that "higher EPL lowers productivity growth by handicapping firms that operate in environment subject to greater technological change" (Andrews and Criscuolo, 2013). Furthermore, there is also evidence showing that multinational firms tend to concentrate their more radical and disruptive innovative activities in countries with low EPL where resource reallocation is easier (Griffith and Macartney, 2014).

While stringent EPL can raise (expected) exit costs, it can also discourage high-risk or disruptive innovation by slowing the allocation of scarce resources (such as ICT skilled work force) to high-performing firms, thus decreasing the expected returns on (ICT-related) investments. Evidence shows, for instance, that "stringent EPL stunts the development of venture capital (VC) financing in highly volatile sectors in Europe" (Andrews and Criscuolo, 2013; citing Bozkaya and Kerr, 2013). This is because stringent EPL hinders the aggressive reallocation of critical labour force from failing to high-performing ventures. This is also illustrated by noting that less stringent EPL is associated with a more dynamic firm growth distribution – with a lower share of static firms and a higher share of growing and shrinking firms (Bravo-Biosca et al., 2013) (Figure 27).

The effects of EPL on innovation are more ambiguous than the discussion so far may suggest, although empirical evidence for the beneficial effects of stringent EPL on innovation is still rather scarce (see Andrews and Criscuolo, 2013; Griffith and Macartney, 2014). EPL increases job security and the greater enforceability of job contracts can increase worker investment in innovative activity. This is relevant for firm-specific investment in human capital, where employment protection might raise workers'

commitment and firms' incentives to invest in firm specific skills and competences (Autor, 2003; Wasmer, 2006). This is in line with evidence showing that "stringent EPL is less detrimental in industries characterised by cumulative innovation processes, where innovation-driven labour adjustment are more likely to be accommodated through the skill-upgrading of existing employees than worker turnover" (Andrews and Criscuolo, 2013). In other words, while stringent EPL may have adverse effects on more disruptive and radical innovation, in particular in sectors characterised by this type of innovation (e.g. the ICT industries), this is not the case for cumulative patterns of (evolutionary) innovation and the sectors characterised by this type of innovation (e.g. the chemicals industries).

Figure 26. The differential impact of EPL on firms' growth dynamics



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

Source: Bravo-Biosca et al. (2013)

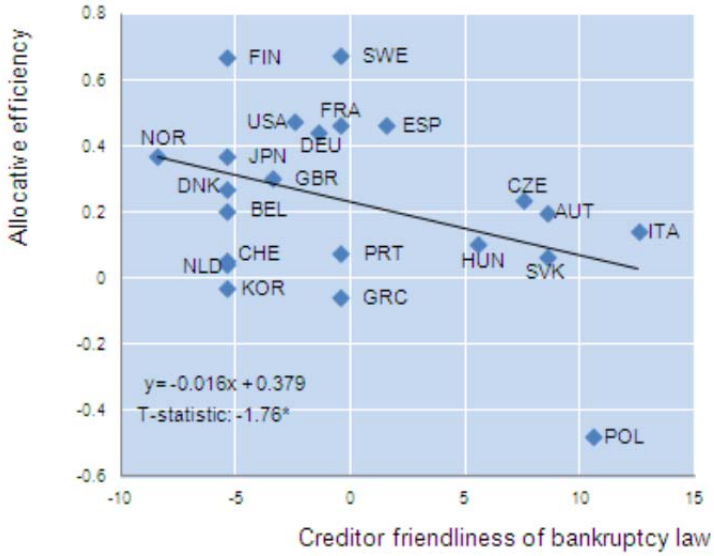
Andrews and Criscuolo (2013) therefore conclude that "the asymmetric liberalisation of employment protection for temporary contracts while leaving in place stringent regulations on permanent contracts – which took place in many European countries – may have adverse effects on the accumulation of firm specific human capital, to the extent that firms substitute temporary for regular workers and temporary workers are less likely to participate in job related training" (see also Martin and Scarpetta, 2012). Furthermore, their work suggests that that there is no such trade-off between innovation and social protection in countries more reliant on labour market expenditures (e.g. unemployment insurance benefits) than EPL to insure workers against labour market risks. They therefore conclude that "well-designed social safety nets and the portability of health and pension benefits can help workers who are displaced by reallocation without imposing significant costs to resource flexibility and innovation" (Andrews and Criscuolo, 2013).

Bankruptcy legislation

Similarly to stringent EPL, bankruptcy regimes can raise the (expected) costs of failure, and thus discourage (digital) innovation, in particular when the innovation is perceived as risky or disruptive. This is in particular the case when bankruptcy regimes "severely penalise failed entrepreneurs, whether by forcing liquidation more often or limiting entrepreneurs' ability to restart new businesses in the future" (Andrews and Criscuolo, 2013). As a consequence, entrepreneurs will be less willing to take risks, which will reduce incentives for more radical and disruptive innovation. Evidence shows that more debtor-friendly bankruptcy regimes

are associated with a higher intensity in patent registration, patent citation, and faster growth, in countries with more innovative industries (Acharya and Subramanian, 2009). Furthermore, bankruptcy regimes increase the likelihood of rapid technological diffusion when they are more debtor-friendly (Westmore, 2013). As Figure 24 shows, bankruptcy legislation that does not excessively penalise failure – measured in terms of the cost to close a business – are associated with more capital flowing to more innovative firms (see also Figure 27).

Figure 27. Creditor friendliness of bankruptcy law, 2005



Note: Allocative efficiency measures the contribution of the allocation of employment across firms to manufacturing labour productivity in 2005. Data on bankruptcy law are provided by the World Bank and refer to the cost to close a business.

Source: Andrews and Cingano (2012)

Similarly to EPL, there are also some trade-offs to be considered when it comes to bankruptcy legislation. Bankruptcy regimes that do not provide safeguards for creditors may reduce incentives to supply debt finance to businesses (see next section). The right balance between leniency and protection of creditors is therefore crucial.

Access to finance

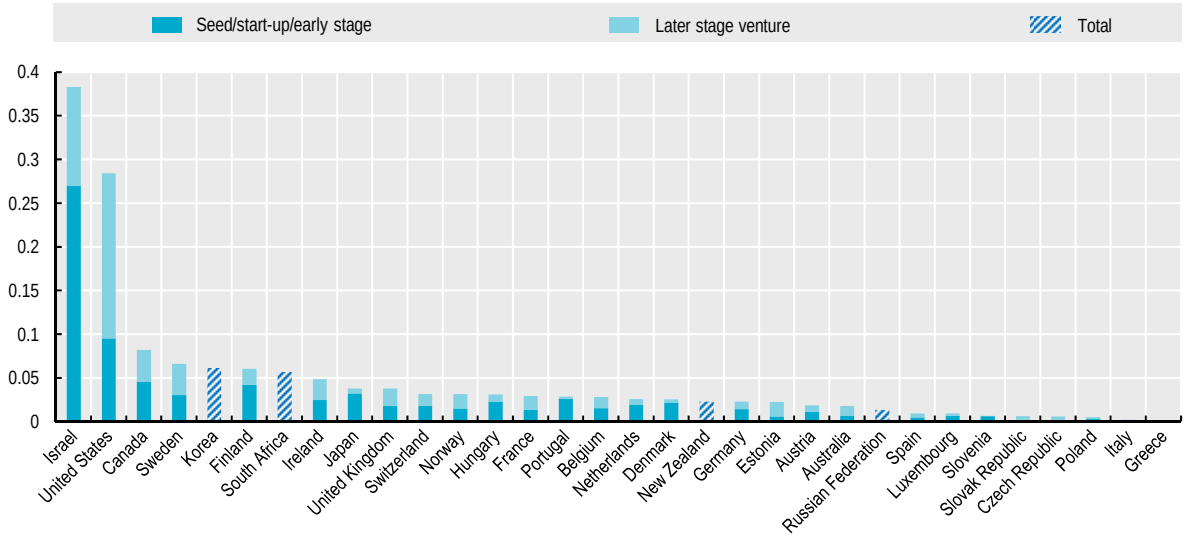
Challenges related to financing often rank among the top barriers faced by businesses looking to invest in digital innovation. Well-functioning financial markets are crucial for firms to implement and commercialise innovation (Andrews and Criscuolo, 2013). Figure 24 suggests that resources tend to flow more strongly to innovative firms in countries with higher stock market capitalisation to GDP. Bravo-Biosca et al. (2013) also confirm that deeper financial markets are associated with a more dynamic distribution of firm growth, in particular in industries more dependent on external finance (such as pharmaceuticals, electronic equipment and energy sectors).While access to financial market matters a lot for innovation, there are still a number of challenges faced by young, small and innovative firms, that are mainly due to the firms' characteristics.

First, "traditional debt and equity markets are primarily designed to fund tangible assets that have well defined market prices and can serve as collateral" (Andrews and Criscuolo, 2013). KBC, however, are intangibles that are often to such an extent firm-specific that they are *non-separable* and *non-transferable*. This is limiting their secondary use across third parties and the monetarisation of their full salvage value in the event of firm bankruptcy. Value attribution of KBC, in particular, is still challenging because of lack of measurement standards and current limitations in fully disclosing KBC (and their value) via corporate reporting.[77] The challenge of value attribution has been well documented in the context of data-driven innovation (DDI) (see OECD,

2015b). In many cases, the context dependency of data challenges the applicability of market-based value attribution, since this assumes that markets can converge towards a price at which demand and offer meet. That is not always the case. As "Exploring the Economics of Personal Data: A Survey of Methodologies for Measuring Monetary Value" (OECD, 2013a) shows, the monetary valuation of the same dataset can diverge significantly among market participants. Furthermore, where data are collected or generated and no market exists to set a price, businesses may have no means to objectively evaluate their data assets.[78]

Furthermore, young firms often lack the necessary track record to signal their prospects to potential investors. As Andrews and Criscuolo (2013) highlight, a "missing market" problem may emerge due to information asymmetries, leading many of the innovations associated with young firms not to be introduced or commercialised at larger scale. Private equity investors, particularly venture capital (VC) investors and business angels, can address the problem caused by information asymmetries by "intensively scrutinising firms before providing capital and monitoring them afterwards" (Andrews and Criscuolo; 2013). As a result, these investors have been able to partly bridge the financing gap by providing new financing opportunities to innovative young firms, in particular in high-tech sectors. A large share of private equity investments is, therefore, ICT-related. In 2014, for instance, about 70% of VC in the United States went to the ICT sector (OECD, 2015a). In most countries, however, VC investments remain low and still below their pre-crisis level (see Figure 28, see also OECD, 2015c). This can be a serious barrier to digital innovation. As empirical studies suggest, countries with more developed seed and early stage VC markets tend to invest more heavily in KBC, and are more effective at channelling capital and labour to young innovative firms (see Figure 28; see also Kortum and Lerner, 2000; Samila and Sorenson, 2011).

Figure 28. Venture capital investments as a percentage of GDP, 2014

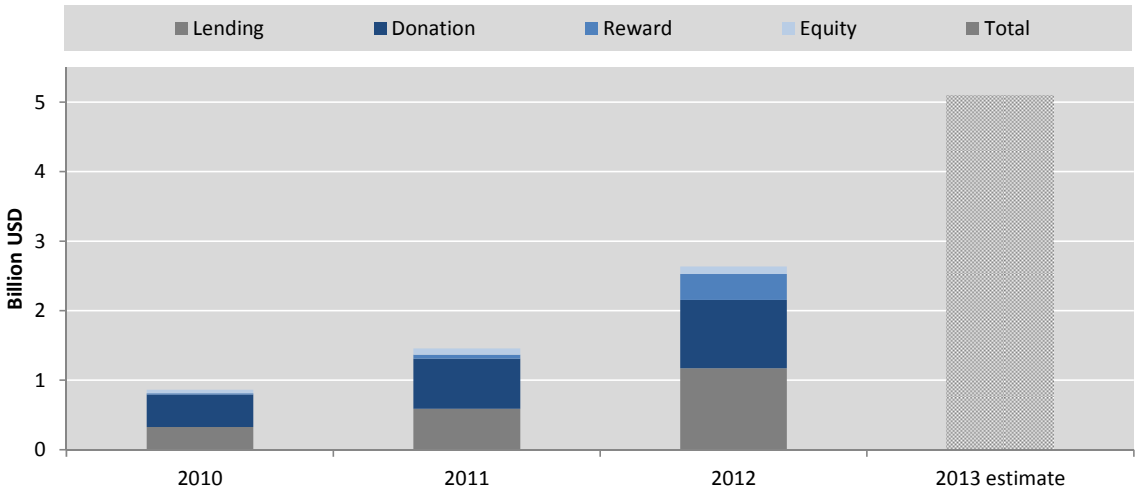


Source: OECD (2015h), *Entrepreneurship at a Glance 2015*, OECD Publishing, Paris, http://dx.doi.org/10.1787/entrepreneur_aag-2015-graph85-en

At this point, it is interesting to note, that ICTs are enabling new means to reduce some of the pressing finance-related obstacles. The Internet, for instance, can help to bring together small young firms and potential investors by reducing information asymmetries and increasing transparency. For instance, data brokers with loan-level information can help investors to better assess risks in small firms and identify investment opportunities. More reliable information about risk may also help to reduce the financing costs, which are typically higher for small than for larger firms. Start-ups public listing on dedicated platforms can increase their visibility and facilitate match-making with investors. In addition, online platforms can provide training, mentoring and coaching for potential entrepreneurs and help them to improve the quality of their business plans and investment projects.

Most prominently, crowdfunding platforms have emerged that provide new sources of finance for businesses (Figure 29). Peer-to-peer lending can be attractive in particular for small and young firms that lack collateral or a credit history to access traditional bank lending. Equity crowdfunding, in particular, can provide a complement or substitute for seed financing for firms that have difficulties in raising capital from traditional sources. However, although crowdfunding has grown rapidly since the mid-2000s, it still represents only a very minor share of financing for businesses. Donations, rewards and pre-selling are still dominant given that regulation has limited the diffusion of crowdfunding, especially for securities-based crowdfunding, which is not legal in some countries (OECD, 2015a). Crowdfunding is most developed in the United States and Europe, which accounted for 60% and 35%, respectively, of the market in 2012 (Massolution, 2013). There is a need to better understand the scalability of crowdfunding to lending and equity finance, to assess its risk for borrowers and lenders, and to design appropriate regulations to support its development while reducing financial risks.

Figure 29. Crowdfunding markets, 2010-13



Source: OECD (2015a) Digital Economy Outlook, OECD Publishing, Paris, based on Massolution, 2013.

The role of national strategies for leveraging digital innovation

National digital economy strategies[79]

Most OECD countries and partner economies have established or are close to adopting national strategies addressing policy priorities related to the digital economy. Out of the 34 countries[80] that responded to the *OECD Digital Economy Outlook 2015* questionnaire, 27[81] have an overarching national digital strategy, many of which were established or revised between 2013 and 2014 (OECD, 2015a). A few countries do not have an overall strategy, either because it is under development or under review (e.g. Austria and Switzerland), or because their digital economy policy comprises several strategies and policies associated with specific issues and/or sectors, which collectively form a national digital economy framework (e.g. the Russian Federation and the United States).

National digital strategies are cross-sectoral by nature and in many instances are designed explicitly to boost countries' competitiveness, economic growth and social well-being. Germany's Digital Agenda 2014-2017 highlights "the increased exploitation of the potential of innovation in order to achieve further growth and employment"[82] as its primary objective (in addition to enhancing high speed networks and trust). Italy's Strategy for the Digital Agenda 2014-2020 aims to "ensure economic and social growth, through the development of skills in business and the dissemination of digital culture among citizens".[83] Mexico's National Digital Strategy (2013) aims to make Mexico to "the leading country in digitization in Latin America … with a similar level of digitisation to the OECD average by 2018".[84] Some national strategies, such as that

of Australia, plan to make the country "a leading digital economy by 2020".[85] The Plan France Numérique also aims to build a more competitive digital economy in addition to targeting youth and preserving and reinforcing social values.[86] Japan's ambitious Declaration to be the World's Most Advanced IT Nation aims to achieve its goal by 2020,[87] while the Information Economy Strategy of the United Kingdom intends to "help the UK accelerate in the global race, focusing on [its] strengths".[88] Last, but not least, Columbia's "Vive Digital" strategy, introduced in 2010, aims at making the country a regional leader in the digital economy and changing its productive base to make it less dependent on commodities and raw materials to become an economy focused on digital creation (see Annex). The tendency to focus on a country's strength emerges as a characteristic of national digital strategies across many OECD countries.

The various national digital economy strategies of EU member countries reflect the objectives set out in the Digital Agenda for Europe (EC, 2010), the first of seven flagship initiatives established under the "Europe 2020" strategy for smart, sustainable and inclusive growth. The aim of the Digital Agenda is "to maximise the social and economic potential of ICT, most notably the Internet, a vital medium of economic and societal activity". To help EU member states achieve this objective, the Digital Agenda contains 132 "actions",[89] grouped around seven challenging priority areas including: *(i)* achieving the digital single market; *(ii)* enhancing interoperability and standards; *(iii)* strengthening online trust and security; *(iv)* promoting fast and ultra-fast Internet access for all; *(v)* investing in research and innovation; *(vi)* promoting digital literacy, skills and inclusion; and *(vii)* promoting ICT-enabled benefits for EU society.

Typically, national digital economy strategies build on and sometimes integrate pre-existing national strategies related to ICTs, for example, national broadband strategies, e-government strategies and cybersecurity strategies. They often co-exist with other complementary national strategies such as national strategies for science, technology and innovation (STI, see section below) or development strategies. The forthcoming Digital Agenda for Austria, for example, is building on existing national strategies such as Broadband Austria, e-Health in Austria,[90] eFit 21 – Digital Agenda for Education[91] and e-Accessibility in Austria[92] among others. Sweden's ICT for Everyone – A Digital Agenda for Sweden[93] builds on a number of ICT-specific strategies including the national Broadband Strategy,[94] the E-Government strategy,[95] ICT for a greener administration[96] and the e-Health Strategy.[97] In addition, Sweden's national digital strategy is complemented by the National Strategy for Regional Growth and Attractiveness[98] and the Swedish Innovation Strategy.[99]

Besides traditional ICT policy areas such as (i) further developing telecommunications infrastructure (e.g. access to broadband and telecommunication services) and preserving the open Internet or (ii) promoting the ICT sector including its internationalisation, many present national digital strategies put significant emphasis on ICT demand-side objectives. These objectives which are discussed further below include, but are not limited to:

- Encouraging the adoption of ICTs by businesses and SMEs in particular, with a focus on key sectors such as *(i)* healthcare, *(ii)* transportation and *(iii)* education;
- Advancing e-inclusion with a focus on the aging population and disadvantaged social groups;
- Promoting digital skills and competences including basic ICT skills and ICT specialist skills; and
- Leading by example with the use of ICTs in the public sector.

ICT adoption across the economy, with a focus on education, healthcare and transport

Many national digital strategies aim to promote adoption of ICTs by businesses and SMEs in particular (Box 6). In addition, governments are promoting ICT adoption in key areas such as education, healthcare and transport to fulfill key public policy objectives.

Box 6. Selected government initiatives promoting ICT adoption by SMEs

Many governments have initiatives to promote ICT adoption by SMEs, some as part of their national digital strategies, others through specific strategies and programmes. These initiatives are often motivated by the recognition that insufficient knowledge and financial resources, but also barriers to organisational change are often inhibiting the effective use of ICTs, in particular by smaller firms which too often do not have internal IT departments or in-house know-how, or the financial resources needed to invest in ICTs or to engage with external ICT services firms. This is why most initiatives targeting SMEs focus on*: (i)* awareness raising and training, often with a focus on enhancing ICT-related and sometimes also organisational know-how, *(ii)* financial support, and *(iii)* social networking.

In Canada, for example, the Business Development Bank of Canada (BDC) realigned its existing support to SMEs in 2011 to focus on ICT adoption. Its support is designed around the following three stages: (i) *awareness raising* in particular via the provision of eBooks and articles, success stories and testimonials, and free ICT assessment describing a company's technology situation in relation to other Canadian SMEs; (ii) *consideration and engagement* through financial support for consulting services to help SMEs tailor ICT solutions to their business, and to address financial challenges more specifically (iii) loans to purchase hardware, software and consulting services (with a budget of CAD 200 million). Interest in and use of these offerings has been stronger than expected. In the first 18 months of the initiative's existence from October 2011 to May 2013, the BDC SmartTech website had almost 220 000 visitors; the two e-books were downloaded over 10 000 times; and BDC undertook over 35 000 online web assessments, around 900 ICT assessments, and over 300 consulting mandates. In addition, BDC averaged 130 ICT loans per month, but provided nearly 1 800 loans. However, the BDC only serves a small and specific segment of Canada's SMEs, and there are many firms not captured by these offerings who would benefit from increased adoption.

Another example, is the initiative "Mittelstand-Digital" (EN „SMEs digital") of the German Federal Ministry of Economic Affairs and Energy (Bundesministerium für Wirtschaft und Energie, BMWi) that aims at showing SMEs and skilled crafts the importance of using software for business processes and to support these enterprises in digitalising their business processes. The initiative builds on three pillars including:

1. *German Mittelstand 4.0 – Digital Production and Work Processes* which aims at supporting SMEs and skilled crafts in the digitilisation of their business processes and the deploying Industrie 4.0 applications. Focus is put – among other things – on raising awareness on the opportunities and challenges, and enhancing technological and organisational competences, and providing opportunities for demonstrations and testing;
2. *Simply intuitive – Usability for SMEs* which aims at providing development and testing support mechanisms for SMEs to increase quality and usability of business and production software used in SMEs. This pillar is motivated by the recognition that software for SMEs have mostly ignored the aspects of usability, which however has become an important aspect for end-user software, and thus an important competitive factor.
3. *eStandards – Standardising Business Processes, Securing Success*, which aims at developing a "common language" for SMEs and skilled crafts of different fields of business to enable efficient data exchange. This pillar is motivated by findings according to which SMEs face considerable initial costs if they want to use and implement e-standards.

The initiative "Mittelstand-Digital" so far proves that trust is a very important factor for SMEs. Unbiased, official information by the Federal Government has therefore found a lot of acceptance, while information provided by commercial IT consultants is rather seen skeptically. This is why creating networks between many different participants and stakeholders with opportunities where entrepreneurs can learn from each other has proven very helpful to get the most acceptance from SMEs. Finally, the initiative confirms that the challenges brought about by digitalisation vary significantly between regions, sectors and businesses. Addressing these regional and sectoral differences has therefore proven to be very important for the success of the initiative.

Source: See Annex

E-Health care is another prominent area targeted by many national digital strategies. As with education, some measures focus on ensuring high-quality broadband connectivity across the healthcare system. But in most cases, measures aim to further the development of tele-medicine or the deployment and better use of electronic medical healthcare records. Italy's Strategy for the Digital Agenda 2014–2020,

for example, has allotted investments worth EUR 750 million to improve the cost-quality ratio of health-related services by reducing waste and inefficiency. Measures include electronic health records for all citizens, electronic pharmaceutical prescriptions, and online booking with a view to optimising health-related resources and reducing waiting times.

Some measures also target specific social groups, especially the elderly population. Australia's National Digital Economy Strategy, for example, aims to increase the share of high-priority consumers able to access individual electronic health records to 90% by 2020. These include older people, mothers and babies, and those with a chronic disease as well as their caretakers. The main steps include: *(i)* expanding the Medicare Benefits Schedule (MBS) for tele-health items; *(ii)* implementing video consultations for the after-hours GP Helpline and Pregnancy, Birth and Baby Helpline; and *(iii)* evaluating outcomes from tele-health trials and developing action plans to address challenges. In Austria, the initiative e-Health in Austria aims to address key challenges related to e-health financing, interoperability, and co-ordination among health institutions and stakeholders. Similarly, Germany's Digital Agenda 2014-2017 aims to improve co-ordination and interoperability between key stakeholders and their IT systems, and to address emerging IT security risks related to increasing digitalisation of the healthcare system.

Lastly, some national digital strategies target transportation and logistics. Japan's national digital economy strategy plans to use ICTs to create a safe, economic and environmentally friendly road traffic system. It also aims to further internationalise and expand Japan's agriculture-related IT industry. Other national digital strategies emphasise the use of R&D or other policy measures to target sectors of strategic economic importance. Germany's Digital Agenda 2014-2017, for example, includes initiatives to increase digitalisation and automation in manufacturing, and measures to promote information on best practices for industry and smart service applications.

E-inclusion: ICT adoption by households

The promotion of ICT adoption by households and individuals aims to advance social policy objectives such as e-inclusion. This objective still requires ICT supply-side policies, such as expanding broadband access to underserved areas, especially those home to disadvantaged social groups. However, supply-side measures are often supplemented by initiatives to increase the level of digital literacy and raise awareness about risks and opportunities online. One example of an initiative to further e-inclusion at multiple levels is the Low Income/Lifeline Programme in the United States, which was approved for a comprehensive overhaul in 2012. A key objective in the modernisation process will be to ensure broadband availability for all low-income Americans. Lifeline builds on efforts by the FCC to close the broadband adoption gap and address digital literacy. The Commission aims to establish a Broadband Adoption Pilot Programme using USD 13.8 million in savings from other reforms to test and determine how Lifeline can be used to increase broadband adoption among Lifeline-eligible consumers.

The Digital Agenda for Europe anticipates a multifaceted approach to e-inclusion. Under its activity "inclusive digital services", the Agenda calls for the European Commission to examine "how best to meet demand for basic telecom services in today's competitive markets, what role universal service could play in achieving the objective of broadband for all, and how universal service should be financed" (EC, 2010). It also calls for "concerted actions to make sure that new electronic content is also fully available to persons with disabilities". To promote accessibility, the Agenda calls, for instance, for the systematic evaluation of "accessibility in revisions of legislation undertaken under the Digital Agenda […] following the UN Convention on the Rights of Persons with Disabilities".

Australia's National Digital Economy Strategy also includes supply and demand-side considerations, for example, under Action 24, to provide "free Wi-Fi access to remote Indigenous communities". At the same time, the strategy targets the aging population with measures to boost the Keeping Seniors Connected

programme. Similar measures are found in a significant number of national digital strategies. For example, Germany's Digital Agenda 2014-2017 recognises the lack of confidence exhibited among elderly people in ICTs and has called for an examination into ways to increase their skills and trust.

Digital skills and competences

All national digital strategies recognise improvement of skills and competences as a means to further e-inclusion. Key actions identified by the Digital Agenda for Europe to further e-inclusion relate to the development of skills and competences essential for the digital economy. Action 10 proposes "digital literacy and competences as a priority for the European Social Fund regulation (2014-2020)". Other measures include "promot[ing] a higher participation of young women and women returners in the ICT workforce through support for web-based training resources, game based eLearning and social networking". Digital Slovenia 2020[100] aims to ensure inclusiveness by raising awareness of the importance of ICT for the development of all segments of society. Ireland's National Digital Strategy[101] aims to reduce by half the number of "non-liners" (people who have not yet engaged with the Internet) by 2016. One measure envisioned in the strategy is "awareness raising campaigns with industry stakeholders to convey to 'non-liners' what they could do online, and to highlight to existing users other ways they could use and benefit from further digital engagement". Ireland's strategy also foresees the introduction of a new training grants scheme (BenefIT) to fund digital skills training for citizens, and the development of an online mapping resource to identify digital skills learning opportunities.

A number of countries have identified ICT-related skills as the key to increasing job creation opportunities. The Czech Republic describes a number of measures in Digital Czech v 2.0 to increase ICT-related skills levels. These include collaboration between the Ministry of Labour and Social Affairs and the Ministry of Education, Youth and Sports on a strategy to increase digital literacy and develop e-skills among citizens. The goal is to ensure that new employees have adequate ICT skills and to support current employees during periods of transition due to ICT-related activities or the effects of globalisation. In Spain, the Digital Agenda[102] aims to promote digital inclusion and literacy, and to ensure the training of new ICT professionals. In Italy, the Strategy for the Digital Agenda 2014–2020 plans to invest EUR 12 million to promote digital skills and increase digital literacy levels, widen the curricula of topics related to digital skills, increase the number of ICT skills training courses, boost the number of graduates in fields related to ICT and raise the level of digital skills among civil servants. In Australia, e-inclusion is supported via measures that directly target the labour market. The National Digital Economy Strategy aims to double the level of telework[103] to 12% of Australian employees and implement measures to raise awareness of telework in the labour market, such as organising an annual National Telework Week.

Governments leading by example with the use of ICTs in the public sector

The role of governments as active contributors in digital economy developments cannot be underestimated. Over one third of countries responding to the questionnaire placed government use of digital technologies and public sector information high on their future digital agenda. The need for governments to take an active role in the digital economy is reflected both in the OECD Recommendation of the Council on Public Sector Information, which was adopted in 2008 and reviewed in 2014, and the OECD Council Recommendation on Digital Government Strategies, adopted in 2014 (OECD, 2008, 2014f).

Open data and e-government

Some national digital strategies highlight the use of open data citing improved interoperability as a main benefit. The Digital Agenda 2020 for Estonia,[104] for example, aims to open up public sector data for business innovation and promote the joint use of technologies and data (including cloud computing). It also

aims to ensure cross-border interoperability of Estonian service infrastructure to facilitate the use and provision of cross-border services for both citizens and enterprises. In Japan, the Declaration to be the World's Most Advanced IT Nation highlights the key role of ICTs in enabling public service delivery at any time, by anyone, anywhere, via a one-stop e-government portal through which public sector data can be accessed. Promotion of open data usage ranks high in Japan's government.

Today's national digital strategies recognise that governments can act as catalyst for the digital economy. This is noticeable in the case of open data initiatives, where the public sector can stimulate data-driven innovation by opening up public sector information, including data. E-government initiatives are also used to stimulate the adoption of a wide range of applications needed for e-health and e-commerce. In this respect, a major trend in the current set of national digital economy strategies is the ongoing effort to promote trust in the digital economy through the establishment of *(i)* digital identities for all citizens, and *(ii)* electronic document verification systems (including e-billing systems).

Digital identities and e-authentication

A number of national digital strategies have prioritised the creation of national digital identities for citizens. The Digital Agenda 2020 for Estonia, for example, plans to develop existing national electronic identity cards (including mobile IDs) and promote their use in Estonia and across borders. Italy's Strategy for the Digital Agenda 2014-2020 also highlights the issue of digital identity with government spending of EUR 50 million foreseen to guarantee safe and secure access to digital services provided by the public administration and private entities. Japan has also launched a large-scale initiative to establish a national digital identity for all citizens, with significant government investments linked to introduction of the "Number System", which will provide an infrastructure for IT utilisation in the future. The system aggregates information to provide individual numbers and corporate numbers designed to enable accurate and rapid identity verification.

While not all national digital strategies aim to provide government digital identity management services, some support the deployment of secure authentication services. Canada's Digital Economy Strategy, for instance, foresees the creation of "new authentication services for consumers, including the Credential Broker Service and GCKey, to make it easier to manage and secure online usernames, identities and passwords". In the United Kingdom, the Information Economy Strategy anticipates the government "work[ing] closely with industry, privacy advocates and consumer groups to develop an Identity Assurance solution for HMG [Her Majesty's Government] services that leverages existing capabilities and sets informed industry standards". It is expected that "knowledge and skills applied during the development of this IDA [identity assurance] solution will create a centre of excellence within HMG across a range of digital, technology and service sector disciplines (e.g. identity and authentication technology, design, cyber security, research, business transformation, mobile communications, digital service and platform development)."

A complementary measure consists of promoting international interoperability by aligning the United Kingdom's IDA approach with that of other national governments, international standards bodies and major industry associations. Finally, some national digital strategies also promote document verification services, including digital signatures. Australia, for example, plans to expand the use of the Document Verification Service and investigate the use of trusted third-party credentials by the government. In Hungary, the National Infocommunications Strategy plans to boost the electronic commerce market not only by reinforcing electronic payments, but also by promoting electronic invoicing and e-signatures. These efforts are consistent with a key objective of many national digital strategies – to increase trust in the digital economy (see Box 7).

Box 7. Trust: Digital privacy and security

The protection of privacy is seen as critical for trust, however effective implementation still raises challenges. The "Protecting Canadians" pillar of Canada's Digital Economy Strategy details existing forms of protection "in place for families and businesses through some of the most modern and effective privacy and anti-spam laws in the world". In the Czech Republic, the national digital strategy calls for the Office for Personal Data Protection to monitor the development and application of new forms of technology, and propose solutions in the event that self-regulatory mechanisms fail. The strategy also calls for the modification of existing legislation if necessary. Mexico's National Development Plan calls for measures to ensure personal data protection, while also encouraging accountability in the use of these data. Finally, the United Kingdom's Information Economy Strategy calls for the government to continue efforts "to drive and influence EU [European Union] and international discussions in key areas such as privacy and data protection and the digital single market to ensure that growth opportunities are not inhibited by new or existing levels of regulation, while providing a proper balance of protection and security for citizens".

Although protection of privacy features prominently in many national digital strategies, this is not reflected in budget allocations – no country has yet allotted funding for privacy-related measures. This may be linked to the persistent perception that privacy is a legal matter under the purview of specialised enforcement authorities rather than a strategic horizontal objective. In some cases, however (e.g. Luxembourg's Digital Lëtzebuerg), dedicated R&D funding for ICT security and cryptology may provide spillover benefits for privacy-enhancing technologies.

Measures linked to cybersecurity appear frequently in national digital economy strategies, including references to R&D support measures and national cybersecurity strategies. Cybersecurity measures may include public information on cyber risk and measures to combat cybercrime. Australia's national digital strategy, for instance, describes a number of actions to address digital security concerns including the development of a "National Plan to Combat Cybercrime" and the release of "Digital Citizenship Best Practice Principles" to address security risks. In Hungary, the National Infocommunications Strategy has allocated EUR 17 million to IT security with the aim of maximising protection of networks, IT infrastructure and public administration e-services, as well as disseminating information on digital risk management. Korea and Japan have also highlighted cyber security in their respective strategies, with the former earmarking government funds worth KRW 246 billion.

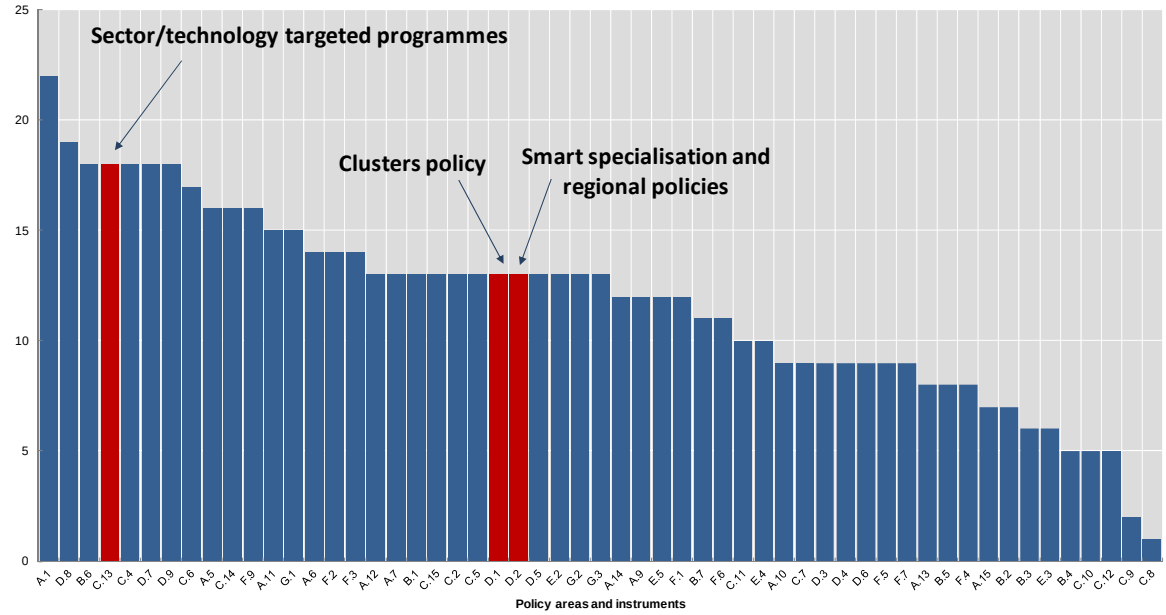
Some national digital strategies also aim to strengthen the national cybersecurity industry. The United Kingdom's Information Economy Strategy reiterates commitments made in the National Cyber Security Strategy to award 11 leading universities the status of Academic Centre of Excellence for Cyber Security Research, sponsor 78 PhDs and fund two Research Institutes. In addition, the strategy calls for the development of new routes to transfer cyber expertise between research institutions, industry and Government Communications Headquarters (GCHQ), otherwise known as the Cyber Growth Partnership. It also calls for collaboration with the Information Economy Council on areas of mutual interest, including R&D and skills, and for renewed commitment to develop and exploit innovations in cyber security. In Germany, the Digital Agenda 2014-2017 anticipates efforts to strengthen the security of online services via secured ICT infrastructures and to reinforce the IT security industry.

National strategies for science, technology and innovation[105]

Besides national digital economy strategies, many countries have also developed *national science, technology and innovation (STI) strategies,* in which digital innovation is highlighted as a key pillar.[106] Country responses to the OECD (2014d) STI Outlook policy questionnaire 2014 reveal that STI policy initiatives are becoming more strategic and more sector and technology focused. Out of the 22 countries that have reported that their national STI strategies or plans have substantially changed, 18 have seen these changes in sector and technology-oriented programmes, many of which related to ICTs (Figure 30). Furthermore, many OECD countries (and regions) have also developed new industrial policies, cluster policies and smart specialisation strategies, in which digital innovation also ranks prominently high, also in terms of recent policy changes.

Figure 30. National STI strategy and plans among other areas of STI policy change, 2012-14

Countries reporting a substantial change in the policy area, compared with other STI policy areas



Note: The x-axis presents all areas of STI policy covered in the OECD STI Outlook policy questionnaire 2014 (the codes presented in the chart refer to the question code in the 2014 questionnaire). The y-axis shows the number of countries reporting that the situation has substantially changed in each policy area. Simple counts do not account for the magnitude and impact of policy changes. Responses are provided by Delegates to the OECD Committee for Scientific and Technological Policy.

Source: Country responses to the OECD STI Outlook policy questionnaire 2014, http://dx.doi.org/10.1787/888933151897.

The STI Outlook policy questionnaire 2014 also reveals a number of similarities and differences in goals and policy priorities across countries' STI strategies, some of which related to digital innovation (OECD, 2014d). A first similarity is that almost all countries have given high priority to business innovation and innovative entrepreneurship, with a significant share focusing on ICTs. Second, most countries aim at consolidating the innovation ecosystem by strengthening public R&D capacity and infrastructures, improving overall human resources, skills and capacity building, and improving framework conditions for innovation (including competitiveness). Third, the degree to which STI policies focus on specific technologies such as ICTs may vary as a function of the stage of socioeconomic development, and is also reflected in the relative concentration of countries in strategic STI policy fields as measured in terms of the intensity of their gross domestic expenditure on R&D (GERD). Typically, for countries that already rank high in terms of business R&D and innovation, there is a focus on investing in the science base, both public research and human resources, to strengthen the basis for future innovation (OECD, 2010c).

In the case of ICTs, this means that high-performing countries in terms of ICT-related R&D are also prioritising their research and innovation support to gain competitive advantage for future growth areas in ICTs. In Finland, Israel, Korea and the United States, for instance, the ICT sector accounts for 40% to over 50% of BERD, and ICT BERD alone represents between about 0.6% to more than 1.8% of GDP, reflecting the high research intensity of these economies and the sector itself.[107] These countries are among the top countries that spend the most (more than 3.5% of GDP) on R&D overall. These countries also put a strong emphasis on cluster and smart specialisation policies that focus on ICTs (see section below).

For certain countries with a high focus on ICTs, it is also no surprise that the use of ICTs ranks prominently high in many STI strategies that aim at addressing major societal challenges such as climate

change, health care, and energy. Korea, for instance, earmarked USD 2.4 billion for green technology in its 2nd S&T Basic Plan and confirmed its ambition to become a hub for global green growth in its recently adopted 3rd S&T Basic Plan. Israel has shown a growing interest in the development of cleantech sectors and has allocated new resources to water and oil-substitute technologies since 2012. Although not focusing on ICTs, these initiatives have put the use of ICTs as a major aspect.

OECD (2014d) has identified a number of new STI policy trends. Some of these trends are very closely related to digital innovation and include in particular: (i) new industrial policy and targeting of strategic technologies/sectors, (ii) system innovation, (iii) strategic public/private partnerships, and (iv) cluster policies and smart specialisation. These trends are discussed in the following sections in more details, given their importance for understanding current policy trends in governments' promotion of digital lead markets around smart cities and smart manufacturing.

New industrial policy and targeting of strategic technologies/sectors

A number of STI strategies include industrial policy in their innovation policies. Besides their support for general purpose technologies such as nanotechnology, biotechnology and ICTs, these policies are emphasising support for innovation in strategic technologies or sectors, including traditional ones (e.g. manufacturing and agriculture) and services. The renewed interest in industrial policies follows the recent economic crisis, after which many policy makers were looking for new sources of economic growth. Concerns in particular about a loss of manufacturing capabilities and growing competition from emerging economies have significantly contributed to this surge in interest, as have the prospects for a "new industrial revolution". Indeed, industrial policy has traditionally been specific to manufacturing industry. However, new industrial policies today include "any type of intervention or government policy that attempts to improve the business environment or to alter the structure of economic activity toward sectors, technologies or tasks that are expected to offer better prospects for economic growth or societal welfare than would occur in the absence of such intervention" (Warwick, 2013).

Industrial policy had fallen into disfavour because it was considered to prevent competition by allowing governments to "pick winners" and favour incumbents to the detriment of young innovative firms. However, there is now a growing consensus that the risks associated with selective industrial policy can be minimised through a new approach to government's facilitating and co-ordinating role and through new ways for governments and industries to work together to avoid undue influence from vested interests (Warwick, 2013). This new approach tends in particular to reconcile industrial policy and competition policy (Aghion, 2011). New industrial policies therefore often have the following features:

- *A focus on improving framework conditions*: innovation is driven by business, and for innovation to occur, businesses must operate in favourable conditions: enforcement of competition rules, trade openness, availability of skills (education and vocational training), etc.

- *Supporting linkages*: innovation activities rely on various types of links between actors (firms, universities, individuals, intermediaries). Many of these do not operate efficiently and lead to market or systemic failures, thereby motivating government intervention to support research co-operation, knowledge sharing between firms or between firms and universities. As linkages can have a geographical or a sectoral dimension, cluster policies can be effective (see section on "cluster policy and smart specialisation").

- *Supporting technologies upstream*: government support is provided more at the upstream stage and for generic technologies, so as not to impede downstream competition or infringe the state aid rules embodied in international treaties (WTO, EU). This approach contrasts with the "picking winners" focus of the previous period.

- *Using a variety of instruments and attempting to optimise the policy mix*: some countries give public procurement a specific role in fostering innovation. As lead user, governments can influence the diffusion of innovation. Demand-side initiatives are considered particularly effective in stimulating issue-oriented or mission-oriented innovation by creating a market for technology in areas where it is needed to meet environmental and societal challenges (e.g. health and healthcare).

- *Supporting entrepreneurship*: in many technology fields new companies are essential for developing innovations, and they maintain a fruitful competitive pressure on established firms. But they face various barriers (e.g. access to finance, markets, skills) that government can help address.

- *Attracting foreign multinationals and strengthening the role of domestic companies in global value chains*: governments recognise that international linkages are essential to modern industry and that technology flows are global.

- *Evaluation and monitoring are essential*: it should be independent and effective, so that failing programmes are terminated or reoriented (the inability to do so was a major failure of previous industrial policies).

A number of OECD countries have launched industrial policy initiatives in recent years, and some of these countries have implemented major initiatives in new industrial policy that are related to digital innovation. The United Kingdom, for example, launched its Industrial Strategy in 2012. It focuses on technologies, skills, access to finance, partnerships with sectors and procurement. 11 sectors were identified and strategies developed in partnership with industry with a view to building confidence and investment over the longer term. United Kingdom's Information Economy Strategy, presented in the section on national digital economy strategies above, is one of the strategies dedicated to these 11 sectors.[108] In addition, the government has committed a significant budget (USD 870 million PPP, GBP 600 million) to eight emerging technologies with potential cross-sectoral applications in which the United Kingdom has research expertise and business capability. The digital innovation related technologies identified include in particular: (i) big data analytics and (ii) robotics and autonomous systems.[109]

Many countries have also adopted a sector-oriented approach in their national strategy or plan for STI and, in some cases, have implemented sector-oriented initiatives combining direct funding (e.g. subsidies, equity funding) and indirect funding (e.g. tax incentives) instruments. One example is France's initiatives *New Industrial France in 2013*, which defines 34 strategic areas many of which being ICT-related such as electric planes, digital hospitals, e-education, green cars, big data, robotics, and cybersecurity. These areas have been identified based on their potential in terms of value added and job creation. Another example is Turkey's National Science, Technology and Innovation Strategy (UBTYS) (2011-16), which defines the ICT sector as a priority sector for R&D, besides automotive, machinery and manufacturing technologies, energy, water, food, defence and aerospace. The Scientific and Technological Research Council of Turkey (TUBITAK) is expected to subsidise investments in the manufacturing of these high-technology products and parts developed through related R&D projects.

A number of emerging economies have also implemented industrial policies where ICTs and digital innovation rank prominently. Examples include China's *2012 Plan for National Strategic Emerging Industries* to increase these industries share in GDP by 8 percentage points by 2015 and by 15 percentage points by 2020. Seven strategic emerging industries have been identified including (i) new generation information technology industries (i.e. next generation information network, fundamental core electronics, and high-end software and new information service industries) and (ii) high-end equipment manufacturing industries (i.e. aviation, satellite, rail transportation, marine engineering, intelligent equipment industries)

besides (iii) new energy auto industries, (iv) energy-saving and environmental protection industries, (v) biology industries, (vi) new energy industries, and (vii) new material industries. Another example is Brazil's *Plano Brasil Maior* launched in 2011, which includes tax breaks for labour-intensive industries including software besides clothing, footwear, and furniture. Finance and investments are supported by the National Economic and Social Development Bank (BNDES).

System innovation

System innovation is a horizontal policy approach to combine technologies and social innovations to tackle problems that are systemic in nature such as sustainable housing, e-mobility, health care; it involves many actors outside of government (as well as different levels of governments) and takes a longer term view. Interest in system innovation is motivated by the realisation that system-wide change is necessary to make economies socially, economically and environmentally sustainable. Ensuring that socio-technical systems move towards greater sustainability is a major challenge for governments but also for civil society. At the core of the transition is a shift in governance structures that not only allow change to occur, but also directs and orchestrates some of the changes. The "smart city" initiatives that mobilise technological and social innovations to make the production and consumption of a city's goods and services more sustainable illustrate this point.

A key leitmotiv is that socio-technical systems, whether local, national or sectoral, are not responding swiftly enough to global challenges in areas such as climate, energy, food, transport and health to avoid bleak scenarios. The economic rationale for policies in a system innovation context is the market and system failures, including the need to internalise externalities that dampen the incentive to invest in innovation and to foster co-ordination within the system to improve synergies. These imply changes in framework conditions to shift incentives in the desired direction (laws, regulations) and changes in the price structure. System innovation also raises issues of vertical and horizontal co-ordination and requires governments to challenge existing governance structures or to build new ones.

Some of the defining characteristics of system innovation are:

- *A fundamentally different knowledge base and technical capabilities that either disrupt or complement existing competencies and technologies, resulting in new combinations*. However, innovation based on the technology is limited by a range of systemic factors such as regulatory barriers or a lack of coherence between research funding policies and product and safety regulations and technical and market risks (e.g. scale, financing).

- *Changes in consumer practices and markets*. The digitalisation of commerce is an example of a change brought about by technology and changing consumer behaviour that results in companies' potential loss of control over consumers, increased competition, and the need to engage digitally with suppliers, partners and employees and consumers/citizens.

- *Changes in infrastructure and other elements, including policy and culture*. An example is modern mobility systems (i.e. e-mobility) that are evolving as a result of underlying changes in ICTs, ownership structure, consumer preferences, and related changes in energy systems and their linkages to other systems through interoperable interfaces and standards for data exchange.

A number of OECD countries have launched system innovation policy initiatives in recent years, some of which being strongly related to digital innovation, in particular in the area of smart cities, smart energy, smart transportation, and smart health. Major stakeholders in this process are often city administrations, research institutes, companies and the central but also regional government.

In Sweden, for instance, challenges are identified at the city level, with "Sustainable smart cities" featuring prominently among projects funded by the Challenge Driven Innovation (CDI) programme. In the more specific case of the Smart Grid project in Gotland, an island in Sweden, a reference group has been put together consisting of representatives from a number of governmental agencies and interest groups. The rationale of the reference group is twofold: (i) to ensure that the business community and society in general is kept informed about project activities, and (ii) to act as an advisory body so that the project can benefit from the reference group's knowledge and experience (see Annex).

In Japan, the increasing rate of aging of the population, in particular in the urban areas, combined with the increase in medical spending and a decrease in the workforce, has led to the creation of the "Smart Platinum Society" initiative, with the objective to help the population to (i) live independently by maintaining health for a long time, (ii) work with motivation and participate in social activities, and (iii) create and globally expand new industries in response to super-aged society. To achieve these objectives, the initiative is combining different policy levers such as (i) the deployment of an Electronic Health Records (EHR) infrastructure for linking medical and nursing care data, and promoting home care and long-term nursing, (ii) the creation of ICT health models (for disease prevention) based on the analysis of medical examination and receipt data, and (iii) the creation of life support business. These measures will be complemented by measures to improve in ICT literacy, to realise new work styles, and the deployment of ICT-enabled robots (see Annex).

Similarly, in Norway, smart health-care related innovation is facing a number of challenges related to system innovation. In the municipality of Oslo, for instance, health care service is organised at the level of city districts, each district being responsible for providing health care services to its citizens. Four of these districts (Gamle Oslo, Grünerløkka, Sagene and St. Hanshaugen) take part in the Norwegian National Programme for Personal Connected Health & Care, piloting tele-health and tele-care technologies as part of their services. Following a shift in strategy of health care and rehabilitation activities towards the goal rehabilitation, the districts have changed the way they deliver health and care services to citizens living at home. As part of this strategy, they offer assistive technologies to the elderly (most common medical dispensers and pendants) and remote care to citizens with chronic diseases (including a questionnaire and medical measurements such as blood pressure, weight, blood sugar levels etc.).

Strategic public/private partnerships

For governments, public-private partnerships (PPPs) have been highlighted as means to help make research and innovation policy more responsive to the changing nature of innovation and to social and global challenges. For business, partnering with public research can help solve problems, develop new markets or generate value through co-operation and co-production. For practical purposes, the OECD defines PPPs in STI as "any formal relationship or arrangement over fixed-term/indefinite period of time, between public and private actors, where both sides interact in the decision-making process, and co-invest scarce resources such as money, personnel, facility, and information in order to achieve specific objectives in the area of science, technology, and innovation" (OECD, 2005e).

PPPs may combine both hard and soft elements (e.g. creation of a joint research centre and provision of training). Traditionally used for physical infrastructure, PPPs are increasingly popular in R&D and innovation policy because they are better adapted to some innovation goals or challenges than policy instruments such as subsidies or tax credits. Partnerships can take many forms, from a partnership between a single company and a single university on a research project with specific short-term goals to the creation of physical research centres with a specific mission (e.g. development of vaccines) and long-term mandates, to large infrastructure projects with a longer-term horizon and broad networks.

PPPs can also help improve governance mechanisms and better means of engaging a range of stakeholders which is needed to facilitate system innovation (see previous section). A number of countries therefore have PPPs to promote system innovation. Finland and the Netherlands, for example, have PPPs to foster co-ordination and alignment [Strategic Centres for Science, Technology and Innovation (SHOKs) in Finland and the Top Sectors approach in the Netherlands]. Others have used PPPs in their industrial policy strategy, often in the context of R&D support. Malaysia's mission-oriented innovation policy and its R&D programmes use PPPs in the life sciences, ICTs, agriculture sciences or engineering, environmental sciences and advanced materials science.

Mexico's initiative "Creative Digital City (CCD)", which aims at strengthening Mexico's position within the creative economy, also builds on PPPs to support the development of major infrastructure services. Three potential technology partners have been identified: Accenture, IBM, and CISCO. Services provided will include the integration of large scale of urban systems, the deployment of network solutions, public services operations, assets management and cybersecurity solutions, videoconferences, dynamic management of transport, and automation solutions. PPPs will also help for the development and deployment of services such as platforms for distance education, software based on the cloud for registered teachers, the deployment of public digital screens, smart public lighting, and smart parking solutions (see Annex).

In China, PPPs play a crucial role for promoting digital innovation and in particular e-commerce in rural china. The Ministries of Agriculture, of Commerce, and of Transport are respectively implementing policies to improve Internet access and logistics in rural areas, and to set up around 200 comprehensive demonstration counties on e-commerce – each supported with around USD 3 million. These measures are complemented by the initiative of China's biggest e-commerce platform Alibaba to invest USD 1.6 billion over the next 3 to 5 years in order to build 1 000 e-commerce operating centres in counties to supply services such as storage and logistic, and 100 000 service stations in villages, which will serve as agents for online sales of agricultural products and provide training to the shopkeepers (see Annex).

Cluster policies and smart specialisation

Clusters are geographic concentrations of firms, higher education and research institutions, and other public and private entities that facilitate collaboration on complementary economic activities. While some of the world's leading clusters specialise in high-technology industries such as ICTs (e.g. Silicon Valley, Bangalore), they are also found in sectors ranging from wine making to automobiles to biotechnology. By promoting "smart specialisation" strategies, national and regional governments are attempting to enhance the competitiveness of firms and clusters. Smart specialisation is an evidence-based policy framework that uses indicators, technology foresight and other priority-setting tools to help entrepreneurs and firms strengthen existing scientific, technological and industrial specialisation patterns, while identifying and encouraging the emergence of new domains of economic and technological activity.

As clusters are increasingly exposed to global competition, many OECD governments are keen to enhance their competitive advantage and to help firms and entrepreneurs in clusters move up the value chain through innovation and greater specialisation. The main rationale for public policies to promote clusters, through infrastructure and knowledge-based investments, networking activities and training, is an increase in knowledge spillovers among actors in clusters. This generates a collective pool of knowledge that results in higher productivity, more innovation and increased competitiveness. Furthermore, clusters can leverage labour market spillovers which are often mainly regional. For instance, expertise in Hadoop, a major big data-related technology, is concentrated in certain regions in the United States, with the San Francisco Bay area being the most Hadoop-intensive region (see section above on skills and awareness).

Some of the defining characteristics of cluster and smart specialisation policies are:

- *Technology specialisation:* There is often a growing effort to foster cluster development around enabling technologies (including in particular ICTs, but also biotechnology and nanotechnology) and emerging industries (OECD, 2014c). Indeed, cluster dynamics are a force for the economic, industrial and technological specialisation of a region or country. The revealed technological advantage (RTA) index for 2008-10 reveals a strong specialisation in ICT in Finland, the People's Republic of China, Korea, Japan, Canada, Israel, Sweden, Ireland, United States, and the Netherlands as the top 10 countries.

- *Networking platforms:* Most OECD countries and regions have policies to promote the creation of networking platforms and collaboration among cluster members. These networks facilitate science-science interactions (between research centres and universities), science-industry interactions and industry-industry interactions. These networks are increasingly used to support cluster-to-cluster collaboration, including across regions and countries.

- *Internationalisation of clusters:* Globalisation and competition have fostered both the internationalisation and the specialisation of clusters. This has implications for public support policies. The EC European Cluster Excellence Initiative (2009-12), for example, aimed to improve European clusters' capabilities by developing methodologies and tools to support cluster organisations and providing cluster managers with practical advice and training in the management of clusters and networks. A set of cluster management quality indicators have been developed, as well as a quality labelling system for professional cluster management.

Several governments have seen globalisation as an opportunity for developing clusters while others have seen this as an opportunity for regional development. The empowerment of regions is, for instance, one of the most important issues in Japan, especially for recently devastated areas. In 2011, a new strategic regional innovation support programme was launched for regional revitalisation through knowledge transfer between universities and industry. It capitalised on prior cluster initiatives such as the Knowledge Cluster Initiative, which ended in 2010 and had as objective to strengthen the competitiveness of Japanese industry, such as IT, biotechnology, the environment, and manufacturing. The Reconstruction Agency is also contributing to invigorate local industry.

In Korea, the Seoul Metropolitan Area is the focus of much science, technology and innovation activities and this has led to quite unbalanced regional growth. In response, the government has introduced a number of schemes over the years. As a result, Korea had 105 regional innovation centres and 18 techno-parks in 2010, as well as seven programmes to strengthen the competitiveness of industrial cluster programmes, many of which focusing on ICTs. More specifically on digital innovation, 17 *Creative Economy & Innovation Centres* have been deployed nationwide to promote digital innovation while taking advantage of the regional specificities (see Annex). Local governments and big Korean corporations (e.g. SKT, Hyundai-Kia, GS, Doosan, LG, Samsung and Lotte) are jointly operating the regional centres. The task of these centres include: supporting start-ups and SMEs in each specialty area, organising the partnership or ecological relations between the relevant big corporation and regional enterprises, arranging funds for them to overcome financial difficulties, encouraging managerial and technological innovation and advisory services (called mentoring), promoting communications and cooperative works among participants, and exploring new markets at home and overseas in a concerted manner.

Conclusion

This report argued that the use of ICT fosters productivity, green and inclusive growth mainly through digital innovation. It presented evidence strongly suggesting that adopters of ICTs, and in particular of advanced ICTs such as cloud computing, are more likely to innovate. However, there is also strong evidence that the diffusion of advanced ICTs, in particular towards SMEs, still remains short of its potential. The report also acknowledged that insights are still limited in regards to the characteristics (e.g. age and sector) of the firms (not) adopting ICTs and, and in regards to the processes, through which the effects of ICT investments are mediated so to lead to aggregate productivity growth. The report therefore called for further (micro data) studies.

The report looked at a number of key barriers to ICT diffusion and discussed some policy approaches for overcoming these barriers. It showed that although major challenges such as access to cost effective and interoperable digital infrastructure and trust in the digital economy are being addressed, for instance via national digital economy strategies, many of these national strategies still do not sufficiently take into account the complementarities between investments in ICTs and KBCs, and in particular organisational change. Furthermore, there is still a strong need to better coordinate ICT-related policies with the policies affecting the framework conditions, in particular in sectors of high public policy interest such as energy, healthcare and transport. This calls for further considerations of regulatory reforms, to foster competition not only in ICT-producing industries, but also in ICT-using industries.

Finally, the analysis of the countries' case studies (presented in the Annex) revealed a number of interesting lessons learned for the implementation of policy initiatives stimulating digital innovation:

1. *ICT adoption for digital innovation is neither a pure ICT sectorial issue nor even a "high tech" issue.* This means that a whole-of-society approach (with good co-ordination among the different authorities and a clear division of tasks) is essential to grasp the benefits of digitalisation.

2. *SMEs are key actors for leveraging digital innovation for aggregate productivity growth*, and there is a strong demand by SMEs for solutions to support their ICT adoption. Awareness raising and capacity building, including organisational competences, are essential as well as the creation of networks where SMEs can learn from each other.

3. *Regions matter for digital innovation*. The challenges brought about by digitalisation vary significantly between regions and cultures. Addressing these regional and cultural differences has therefore proven to be very important for the success of government initiatives.

4. *Public private partnerships can help foster digital innovation*, in particular when they enable knowledge and technology diffusion between multinational and regional firms, for instance through regional clusters.

5. *The success of policy initiatives that focus on infrastructure sectors such as energy and transportation depend on overall public acceptance*. Policy initiatives should therefore be complemented by measures to foster public acceptance. Active multi-stakeholder involvement is also crucial, and in some cases establishing a separate and dedicated entity can be more appropriate to coordinate policy measures and to better satisfy the needs of the different stakeholders.

Overall, the report provides evidence for more holistic and whole-of-society approaches that encompass coherent evidence-based policies to stimulate digital innovation for economic growth and social prosperity across society.

NOTES

1 Digitalisation should not be confused with digitisation, which refers to the process of encoding information into binary digits (i.e. bits) so it can be processed by computers. Digitalisation in contrast refers to the transformation of the economy and society as induced by the use of information and communication technologies (ICTs).

2 As Andreessen (2011) wrote, "software is eating the world", and the world will be served in big chunks of data (TNO, 2013).

3 In the OECD area, labour force participation rates (LFPR) has declined since the crisis (from 60.6% in 2008 to 60% in 2014), while labour productivity growth has dropped from 1.5% in 2007 to 0.4% in 2014 (OECD, 2016a). Given this demographic trend, "the onus for future growth will be on productivity" (Labaye and Remes, 2015).

4 Other challenges put forward as risk factors leading to a further slowing down of productivity growth are: (i) the deterioration of education, growing inequality, climate change, the overhang of consumer and government debt, and last but not least the increasing costs of innovation as technology advances (see Jones, 2009; Cowen, 2011; Gordon, 2012; see also Teulings and Baldwin, 2014).

5 The broad patterns depicted here are robust to: *(i)* using different measures of productivity (e.g. MFP); *(ii)* following a fixed group of frontier firms over time; and *(iii)* excluding firms that are part of a multi-national group (i.e. headquarters or subsidiaries) where profit shifting activity may be relevant.

6 ICT investment across OECD countries varied from just below 4% of GDP in Switzerland and the Czech Republic to less than 2% in Greece and Ireland. These differences tend to reflect differences in the specialisation of each country and its position in the business cycle.

7 For studies at the macro level, see Colecchia and Schreyer (2001), and Jorgenson et al. (2002); at the sectoral level see Stiroh (2002); and at the firm level see Pilat (2005), Bresnaha et al. (2002), Hubbard (2003), Bartel et al. (2011) and Brynjolsson et al. (2008).

8 Kretschmer (2012) argues that "while growth accounting exercises show different ICT effects for the United States and Europe, with a lower impact in the latter, econometric estimations provide no significant country differences. Moreover, there is broad evidence that over the last two decades an increase of ICT by 10% translated into higher productivity growth of 0.5 to 0.6%."

9 This was a significant extent due to a decrease in prices for ICT equipment, but also due to the fact that an increasing proportion of business ICT expenditures might not be capitalised. Indeed, detailed information available for the United States reveals that about one third of total business expenditure in ICTs is non-capitalised and that the ICT sector itself is responsible for 40% of capitalised expenditure (OECD, 2014c).

10 The ICT capital coefficient in 2013 was higher than in 2001 in countries the following countries for which Annual National Account data (SNA 2008) were available, including Israel (by +2.3 percentage points compared to 2001), the Netherlands (+1.3), France (+0.8), Finland (+0.7), Ireland and Denmark (+0.6), and the Czech Republic (+0.3).

[11] For instance, while almost 95% of enterprises in the OECD had a broadband connection in 2014, only 21% use ICTs to conduct e-sales. For enterprises in the OECD area with 250 or more persons employed, participation in e-sales is 40% (compared to only 20% of SMEs).

[12] By subdividing the ICT contribution into the separate contributions of capital deepening and TFP growth in both the ICT-producing and ICT-using industries, for instance, a study by Bryne et al. (2013) suggests that the driving force behind these contributions was the unprecedented decline in the ratio of price to output of ICT equipment. In the United States, "the rate of price decline of the ICT deflator in the national income accounts fluctuated between zero and minus five% between 1973 and 1996 and then plummeted to a record rate of decline of 14% in 1999-2000 before returning back nearly to zero in 2014" (Gordon, 2015).

[13] As Flamm (2014) described: "The reason improvement in computer performance grew much more slowly after 2003 is that maximum clock speed in computer microprocessor chips hit fundamental technical limits related to heat dissipation requirements, which grow with power and clock rate and clock speed has basically been near-stationary ever since." See also Kumar (2015) for further arguments on the "Fundamental Limits to Moore's Law". This strongly suggests that the slowing decrease in the ICT relative price could have been the results of fundamental physical limits of microprocessors as argued for instance by Gordon (2015).

[14] For more information see for instance ScienceDaily (2008).

[15] This is for example reflected in the evolution of the DNA gene sequencing cost per genome, which continues to drop at higher rates than Moore's Law would predict, from USD 100 million in 2001 to less than USD 6 000 in 2013, thanks to the availability of massive computing power via cloud computing combined with "smart" algorithms and heuristic methods (OECD, 2015b).

[16] Net income of the average top 10 ICT firm was five times higher than that of the average top 250 ICT firm.

[17] Lock-ins and high switching costs are sometimes indicated to be the result of complex (incomparable and intransparent) pricing structures.

[18] The increasing importance of big data has created new means through which competition could be restricted (OECD, 2015b). This is because the data ecosystem contains a rich mix of points of control the exploitation of which can raise serious competition and consumer protection concerns when they lead to the reduction of consumer choice, and anticompetitive behaviour. Lack of interoperability and vendor lock-in are two major risks through which points of controls can be exploited. In the area of cloud computing, the lack of open standards is still a huge problem, in particular in the area of platform as a service (PaaS). Other points of control include, for example, data and walled gardens (i.e. closed proprietary platforms) based on multi-sided markets.

[19] The OECD is currently working on the development of new approaches to measuring broadband service prices including, in the longer term, work on hedonic deflators for different broadband services bundles. In particular, the OECD is looking at the feasibility of hedonic prices as an approach to measuring quality changes in communication services across countries.

[20] As Bloom, et al. (2007) put it: "It ain't what you do, it's the way you do IT".

[21] The other factors contributing to the productivity paradox are discussed in Pilat (2005). They include: "First, some of the benefits of ICT were not picked up in the productivity statistics (Triplett, 1999 [cited in Pilat, 2005]). A key problem is measuring productivity in the service sector, the part of the economy where most ICT investment occurs. […] A second reason for the difficulty in finding hard evidence on ICT's impacts is that the benefits of ICT use took a considerable time to emerge, as did the impacts of other key technologies, such as electricity. […] A third reason is that many early studies that attempted to capture the impact of ICT at the firm level were based on relatively small samples of firms, drawn from private

sources. If the initial impact of ICT on performance was small, such studies might find little evidence, as it would easily get lost in the econometric 'noise'."

22 The differences remained even despite substantive increase in ICT investments in Europe.

23 See in particular the illustration of the KBC-innovation-reallocation nexus.

24 It should be noted that digital innovation includes both the use of ICTs for production (process innovation) and for innovation activities (e.g. research & development).

25 As noted in Bravo-Biosca et al. (2013): "The European countries included in the sample have a larger share of stable firms (those in the middle 3 intervals, growing between -5 and 5% a year) relative to the United States where firms that grow more than 5% or shrink more than 5% a year are more prevalent". This results are also robust to controlling for differences in the industrial and size structure of the economies considered, and it also holds for most European countries when considered individually.

26 As Mandel (2012) highlights: "[…] economic and regulatory policymakers around the world are not getting the data they need to understand the importance of data for the economy. Consider this: The Bureau of Economic Analysis […] will tell you how much Americans increased their consumption of jewellery and watches in 2011, but offers no information about the growing use of mobile apps or online tax preparation programmes. Eurostat […] reports how much European businesses invested in buildings and equipment in 2010, but not how much those same businesses spent on consumer or business databases. And the World Trade Organization publishes figures on the flow of clothing from Asia to the United States, but no official agency tracks the very valuable flow of data back and forth across the Pacific".

27 In the United States, where data on working activities are available via the United States Department of Labor's O*NET system, almost 30% of the total employment in health care and social assistance, for instance, is in occupations largely involving information collection and analysis (e.g. records of patient medical histories, and test data or image analysis to inform diagnosis or treatment), but at the same time also involving a relatively low level of computer interaction. Working activities from the O*NET database considered for identifying potential occupations included: i) "getting information", ii) "processing information", and iii) "analysing data or information", with the level and importance of all three activities above the 75th percentile, and iv) "interacting with computers" at a level and importance below the 75th percentile. In the health care sector, potential occupations included, for instance, registered nurses, physicians and surgeons, and radiologists.

28 In the area of science, the advent of new instruments and methods of data-intensive exploration could signal the arrival of new "data-intensive scientific discoveries", with new opportunities for knowledge creation. New instruments such as super colliders or telescopes, but also the Internet as a data collection tool, have been instrumental in these new developments in science, as they have changed the scale and granularity of the data being collected (see OECD, 2015b). In the health sector, the efficient reuse of medical health record data promises to improve the efficiency and quality of health care. In Finland for example, the content, quality and cost-effectiveness of treatment of a set of selected diseases are analysed by linking patient data across the whole cycle of care from admission to hospital, to care by their community doctor, to the medications prescribed and deaths (OECD, 2013b). The results of the analysis are made publicly available and have empowered patients and led to improvement in the quality of hospitals in Finland. In the particular case of the US health care system, MGI (2011) estimates that the use of data analytics throughout the system (clinical operations, payment and pricing of services, and R&D) could bring savings of more than USD 300 billion, two-thirds of which would come from reducing health care expenditures by 8%.

29 "Civic entrepreneurs" increasingly use available open data as promoted by the OECD (2008) *Council Recommendation on Enhanced Access and More Effective Use of Public Sector Information* (PSI), in combination with other publicly available data sources, to develop apps that facilitate access to existing

public services. Estimates on the economic impact of PSI (EUR 509 billion in 2008 for the reuse of PSI in the OECD area) focus on the commercial reuse of PSI and thus do not cover the full range of (social) benefits.

30 By digitalization, Yoo at al. (2010) "mean the transformation of socio-technical structures that were previously mediated by non-digital artefacts or relationships into ones that are mediated by digitized artefacts and relationships. Digitalization goes beyond a mere technical process of encoding diverse types of analogue information in digital format (i.e., 'digitization') and involves organizing new socio-technical structures with digitized artefacts as well as the changes in artefacts themselves."

31 Most embedded systems are still mainly developed in the ICT sector although embedded systems are increasingly used outside the ICT sector even if generated in the sector.

32 According to OECD (2008), R&D activities focussing on cyber security put "significant impetus for improving the integrity, availability and confidentiality of digital information as well as the privacy of individuals comes from natural processes (*e.g.* quantum cryptography, self-healing computing systems, and intrusion detection inspired by immunology). Technological solutions to prevent and tackle criminal activity such as online fraud and identity theft and terrorist activities are being sought, including digital investigation and retaliation".

33 Kaspersky estimated in 2008 that developing *Bootkit* must have taken "several months" requiring "several groups of cyber criminals who are working closely together, each taking responsibility for separate areas of the project" (Golovanov et al., 2008).

34 Google was the first company to publicly disclose the attack, which it did in its official blog in January 2010 (see Google, 2010).

35 In this context the micro-data-based work by Eurostat should be highlighted, including the *feasibility study on linking data from different sources* (Eurostat, 2008), the projects *ESSLimit on Linking Microdata on ICT Usage*, which links ICT, innovation and business surveys from 15 European countries (Eurostat, 2012), and the *ESSLait on Linking of Microdata to Analyse ICT Impact* (Eurostat, 2013), which also covers other variables such as exports and ICT skills, and offers a wealth of information on ICT usage linked to other behavioural and performance variables as shows the following figure.

36 However, one should acknowledge that the analysis of micro-data do not account for the potential impacts of firm behaviour on other firms. For example, an increase in the market share of one firm may occur at the expense of another. For these effects to be captured it is essential that micro-data be related in a statistically and economically significant way to sectoral and macro data, a process of aggregation sometimes referred to as meso data.

37 Data refer to Austria, Denmark, Finland, France, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Slovenia, Sweden and the United Kingdom.

38 The study shows that these positive effects are large both in manufacturing and services. However, the study does not support the hypothesis that "ICT use increases the capability of a firm to co-operate with other firms/institutions nor that ICT intensive firms have higher capacity to develop innovation in-house or to introduce more 'innovative' (new-to-the-market) products." But the author also admits that these results are based on imperfect measures of ICT use in firms (web presence and automatic IT links), which are most likely "biased towards the use of ICTs for e-commerce and e-business but they may be a poorer proxy for other ICT-enabled activities relevant for innovation, e.g. communication" (Spiezia, 2011).

39 Austria, Iceland, the Netherlands and Norway.

[40] A firm that invest USD 1 million on a large scale enterprise software installation faces a one-time expense that cannot be recovered once spent.

[41] One example often provided is the automobile, which when first introduced was a revolutionary (radical) innovation compared to the horse-drawn vehicle market, but which did not disrupt this market until the mass-produced automobile (e.g. Ford Model T), which created a new market and disrupted that of horse-drawn vehicles.

[42] The study is based on a survey by Bakhshi and Mateos-Garcia (2012), but extended by "matching survey responses about data activities with historical performance measures taken from respondents' company accounts, and by conducting an econometric analysis of the link between business performance and data activity while controlling for other characteristics of the business".

[43] The OLS (ordinary least squares) estimate on the Hadoop measure indicated an output of 10%, which Tambe (2014) attributed to other omitted variable bias, including firms' adoption of data-driven decision making.

[44] For example to analyse and predict potentially vulnerable components; the resulting analysis is further used to optimise product design and production control.

[45] Similar services are observed in the energy production equipment sector, where M2M and sensor data are used to optimise contingencies in complex project planning activities for instance (Chick, Netessine and Huchzermeier, 2014).

[46] Cloud computing has been described as "a service model for computing services based on a set of computing resources that can be accessed in a flexible, elastic, on-demand way with low management effort" (OECD, 2014d). Super computing power and data analytics are complementary resources needed to make sense of "big data", as analysis of large volumes of data requires huge computational resources – especially if the analysis needs to be performed in real time.

[47] Similar trends can be observed across countries with other advanced ICTs such as ERP systems, and supply chain management applications.

[48] It should be noted, however, all R&D corporations, taken individually, tend to diversify their subsidiaries' structure both in terms of industrial activity and location of affiliates.

[49] But innovation encompasses a broader array of activities than R&D and patents as innovative firms aim to improve their competitiveness by also enhancing existing products and creating new ones, as well as by marketing and selling products more effectively. ICT firms are also among the most innovative when looking at overall innovation performance. On average, 74% of firms in ICT manufacturing introduced innovations, against an average of 51% for total manufacturing according to the results of the 2012 Community Innovation Survey. ICT services also account for a larger share of innovative firms than innovation core services (63% against 47%).

[50] In April 2015, Alibaba Group and China Telecom launched a joint venture to promote low-priced smartphones in rural areas. Alibaba Group presents data traffic and offers cheaper goods for the buyers. Since then, several smartphone manufacturers, including Coolpad, Hisense, TCL, Uniscope, Ctyon, Kingsun, have joined the programme. The cheapest smartphone in China is currently available at USD 48.

[51] Furthermore, the analysis of non-patent literature (NPL), which reflects prior knowledge on which patented inventions rely (including not scientific literature, conference proceedings, databases and other relevant literature), shows that almost half of all NPL cited in ICT-related patents are referring to clinical medicine

(20%), chemistry (15%), and biology and biochemistry (14%). This reflects the cross-fertilisation of scientific fields and ICTs and the enabling nature of ICTs (OECD, 2015c).

52 While data or infrastructure components that enable cloud computing (e.g. virtual machines) can currently be ported from selected providers to other providers, the process requires an interim step of manually moving the data, software and components to a non-cloud platform and/or conversion from one proprietary format to another.

53 Some customers have therefore raised the concern that it will be difficult to extract data from particular cloud services that prevent some companies or government agencies from moving to the cloud.

54 Netflix, for example, uses Amazon's Web Services (AWS) for computing and storage (over 1 petabyte). Almost all of Netflix's information technology services run on AWS. Additionally, Netflix uses the services from Aspera to manage its data in Amazon's cloud. Netflix relies heavily on Amazon's infrastructure and, in the process, is one of Amazon's biggest customers. Simultaneously, Amazon is also a competitor in the on-demand video market with its Amazon Prime services, and Netflix is supporting the development of "an ecosystem that could lead to more competition for Amazon in the long term." Coincidentally, the adoption of these technologies by other cloud infrastructure providers would make it easier for Netflix to migrate to a provider other than Amazon (see King, 2013).

55 As an example, the Swedish standardisation committee "DIPAT" – SIS/TK 542, run by the Swedish Standards Institute (SIS), launched an initiative to work on national and European-level standardisation issues, linking and aligning the initiative with global efforts run by Subcommittee 38 of the Joint Technical Committee 1 of the International Organization for Standardization and the International Electrotechnical Commission (ISO/IEC JTC 1/SC 38). The goal is to assist in the development of harmonised, sustainable and well-designed standards.

56 This role is called for by the Individual Participation Principle of the OECD (2013c) *Recommendation of the Council concerning Guidelines Governing the Protection of Privacy and Transborder Flows of Personal Data* (OECD Privacy Guidelines) (see OECD, 2015b; Chapter 5).

57 The question is, should the data controller who will have to implement the mechanism pay, or the customers who request data portability, or the government that promotes the free flow of data across organisations and individuals?

58 See http://mashable.com/2010/09/17/google-voice-app-store-return/.

59 See: http://fing.org/?-MesInfos-les-donnees-personnelles-&lang=fr.

60 See: http://cyber.law.harvard.edu/projectvrm/Main_Page.

61 A data breach is "a loss, unauthorised access to or disclosure of personal data as a result of a failure of the organisation to effectively safeguard the data" (OECD, 2012). Where the security breach of intellectual property does not involve personal data, the term "unauthorised access" will be used instead.

62 Duhigg (2012) describes the analysis process as follow: "[…] Lots of people buy lotion, but one of Pole's colleagues noticed that women on the baby registry were buying larger quantities of unscented lotion around the beginning of their second trimester. Another analyst noted that sometime in the first 20 weeks, pregnant women loaded up on supplements like calcium, magnesium and zinc. Many shoppers purchase soap and cotton balls, but when someone suddenly starts buying lots of scent-free soap and extra-big bags of cotton balls, in addition to hand sanitisers and washcloths, it signals they could be getting close to their delivery date". As data analytics is not perfect, false positives are to be accounted for (see Harford, 2014). Target therefore mixes up its offers with coupons that are not specific to pregnancy (Piatetsky, 2014).

63 Adopted from OECD (2015d)

64 Note that non-exclusive frameworks like open source and public domain are also important for creativity and innovation because they provide a common ground on which creativity and innovation – using private or exclusive rights – can flourish. For example, the publication policies of firms like IBM show how publication to prevent patenting can be used successfully to establish technology standards which customers and others can use. Research commissioned by the UK's Intellectual Property Office (www.create.ac.uk/blog/2014/12/10/create-event-reflects-on-value-of-the-public-domain/) shows how the use of public domain creative material raises the commercial attractiveness of investment in new creative work. Non-exclusive frameworks complement, rather than compete with, IP rights.

65 The outcomes of the first phase of the OECD horizontal project on *New Sources of Growth: Knowledge-Based Capital* (KBC1, see OECD, 2013a) were discussed at the conference on "Growth, Innovation and Competitiveness: Maximising The Benefits Of Knowledge-Based Capital" on 13-14 February 2013, and the final conclusions were presented to ministers at the 2013 OECD Ministerial Council Meeting (MCM) (see http://oe.cd/kbcconference).

66 The potentials for productivity boost are huge. This is in particular true in services sectors where the productivity gap between global frontier firms and the rest is more pronounced (Figure 1), and where digitalisation can help overcome the local limitations that constraint the availability of traditional human-delivered services.

67 As Mayer-Schönberger and Cukier (2013) explain: "To datafy a phenomenon is to put it in a quantified format so it can be tabulated and analyzed".

68 For example to analyse and predict potentially vulnerable components; the resulting analysis is further used to optimise product design and production control.

69 It is interesting to note that according to Kushida and Zysma, the biggest opportunities will occur in sectors "where human delivery is combined with automation", subject to the work forces' skills to use ICTs to augment their existing capabilities. As highlighted in OECD (2015b), "The question however remains whether the effects on employment will lead to the replacement of jobs by machines, and/or to their "augmentation" or enhancement as better tools become available to the workforce (Davenport, 2014)." This relates to questions on the impact of advanced ICTs on skills and jobs discussed in OECD (2016d; 2016e).

70 Often this is due to the fact that "managers who are skilled at executing clearly defined strategies are ill equipped for out-of-the-box thinking" and "when good ideas do emerge, they're often doomed because the company is organized to support one way of doing business and doesn't have the processes or metrics to support a new one" (Parma et al., 2014).

71 Estimates are based on the voluntary, ad hoc module in the EU Community Innovation Survey 2010 on the skills available in enterprises and on methods to stimulate new ideas and creativity. The indicator corresponds to the percentage of firms in the relevant innovation category responding affirmatively to the question: "During the three years 2008 to 2010, did your enterprise employ individuals in-house with the following skills, or obtain these skills from external sources?" Innovative enterprises had innovation activities during 2008-10, relating to the introduction of new products, processes, and organisational or marketing methods. This includes enterprises with ongoing and abandoned activities for product and process innovation. The question on innovation-relevant skills also applies to non-innovative enterprises. Estimates are based on firms with "core" NACE Rev. 2 economic activities (B, C, D, E, G46, H, J58, J61, J62, J63, K and M71).

72 This section heavily builds on work by Andrews and Criscuolo (2013) on "Knowledge-Based Capital, Innovation and Resource Allocation", but with an emphasis on additional studies focusing on ICT adoption

and digital innovation. This OECD study is highly relevant for the discussion on the adoption of ICTs for digital innovation for many good reasons. First, the work is one of the most comprehensive studies that focusses on the effects of framework conditions on innovation, and thus very nicely summarises the role of institutional factors for explaining cross-country differences in capitalising on the digital revolution. Other studies such as Bartelsman and Hinloopen (2005), Conway et al. (2006), Aghion et al. (2008) and Bartelsman et al. (2010) have rather focussed on a single aspect of the framework conditions. Second, the work focusses on the framework conditions for successfully channelling resources to the most productive firms to invest more in KBC, the very complementary assets needed to successfully leverage ICT investments. And last, but not least, the reallocation of scarce resources is a major issues for digital innovation, when it comes for instance to resources such as ICT-related skills.

73 While affecting firm entry and exit and the growth of young firms, framework conditions are important determinants for entrepreneurship (OECD, 2015e). New and young firms are often the vehicles through which innovation enter the market. As shown by Criscuolo et al. (2012), this is because start-up companies can leverage the advantage of starting without the legacy of an existing business and customer base to experiment and thus can create a rich variety of presumably new business models. Evidence shows that most first patenting happens between the birth of a firm and its tenth year of existence (Squicciarini and Dernis, 2013), and that young firms tend to have a stock of patents that reflect more radical inventions (Andrews et al., 2014). The analysis of micro-aggregated data collected by the OECD from 18 countries suggests, however, that the share of start-ups has steadily decreased over the past decades (OECD, 2015e). In the case of the United States in particular, evidence suggests that this trend has been in place for two decades or more (see Andrews et al., 2014).

74 The degree of innovation is measured in terms of the firms' patent stock, and not in terms of the firms' ICT adoption and use. However, the policy message is still pertinent for the discussion on digital innovation. That said, that the work mainly focusses on KBCs for innovation makes it even more pertinent given the importance of complementary investments in KBCs for enabling digital innovation discussed above.

75 When comparing the United States and Japan, the authors find that ICT adoption rates remained lower in ICT intensive sectors such as finance, retail, and healthcare in Japan (compared to the United States), despite a higher penetration rate of high-speed broadband in Japan.

76 Over several years social networking and gaming applications have dominated the top ranks of application downloads in the main app stores. More recently, travel, mobility and retail apps have appeared among the most downloaded apps (TechCrunch, 2014). This indicates an increasing impact of digital technologies in these sectors.

77 This is exacerbated by the property of only partial excludability of KBC, which prevents firms from reducing information asymmetries via full disclosure due to risks that imitators will appropriate any rents arising from their KBC (see Andrews and Criscuolo, 2013).

78 Andrews and Criscuolo (2013) also note that "while internally-generated intangibles are expensed, otherwise indistinguishable intangibles that are acquired externally (as a complete set) through the market are treated as assets since they are separable and have a verifiable cost".

79 Adopted from OECD (2015a)

80 These include: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Turkey, the United Kingdom, the United States (OECD countries), and Egypt, Latvia, Lithuania and Russian Federation (non-OECD countries).

81 These include: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, Norway, Poland,

Portugal, Slovak Republic, Spain, Turkey and the United Kingdom (OECD countries), and Egypt, Latvia and Lithuania (non-OECD countries).

82 See www.digitale-agenda.de/DA/Navigation/DE/Home/home.html.

83 See www.agid.gov.it/sites/default/files/documenti_indirizzo/strategia_italiana_agenda_digitale_0.pdf.

84 See http://embamex.sre.gob.mx/italia/images/pdf/national%20digital%20strategy.pdf.

85 See http://apo.org.au/research/advancing-australia-digital-economy-update-national-digital-economy-strategy.

86 See www.france-universite-numerique.fr/IMG/pdf/feuille_de_route_du_gouvernement_sur_le_numerique.pdf.

87 See http://japan.kantei.go.jp/policy/it/index_e.html.

88 See www.gov.uk/government/publications/information-economy-strategy.

89 In 2012, the Digital Agenda for Europe underwent a review that identified areas where more focused action is needed to create growth and jobs in Europe. As a result of the review it added 31 actions.

90 See www.bmg.gv.at/home/Schwerpunkte/E_Health_Elga/E_Health_in_Oesterreich/.

91 See www.efit21.at/en/about-efit21.

92 See www.sozialministerium.at/cms/site/attachments/7/7/8/CH2477/CMS1332494355998/nap_behinderung-web_2013-01-30_eng.pdf.

93 See www.regeringen.se/sb/d/108/a/181801.

94 See www.government.se/sb/d/574/a/134980.

95 See www.regeringen.se/sb/d/15700/a/206004.

96 See www.government.se/sb/d/574/a/152926.

97 See www.government.se/download/70f489cb.pdf?major=1&minor=181914&cn=attachmentPublDuplicator_0_attachment.

98 See www.regeringen.se/sb/d/2498.

99 See www.government.se/sb/d/2025/a/202558.

100 See www.mizs.gov.si/si/medijsko_sredisce/novica/article//8881/a6a53e02d821d14c3dbcc42bea5b9b35.

101 www.dcenr.gov.ie/NR/rdonlyres/54AF1E6E-1A0D-413F-8CEB-2442C03E09BD/0/NationalDigitalStrategyforIreland.pdf.

102 See www.agendadigital.gob.es/Paginas/Index.aspx.

103 The definition of Telework in this Goal includes Telework of a formal, scheduled, contracted nature.

104 See http://e-estonia.com/nordicday/digitalagendas/.

105 Based on OECD (2014d)

106 National STI strategies serve several functions in government policy making. First, they articulate the government's vision regarding the contribution of STI to their country's social and economic development. Second, they set priorities for public investment in STI and identify the focus of government reforms (e.g. funding of university research, evaluation systems). They also mobilise STI actors around specific goals, such as energy, environmental issues or health – and in the case of digital innovation also actors in the ICT sector – and may help steer investments of private actors and increasingly autonomous universities and public research institutes towards priority areas or technologies including ICTs. Third, the elaboration of these strategies can engage stakeholders (the research community, funding agencies, business, civil society, regional and local governments) in broad consultations that will help building a common vision of the future and facilitate co-ordination within the innovation system.

107 But innovation encompasses a broader array of activities than R&D and patents as innovative firms aim to improve their competitiveness by also enhancing existing products and creating new ones, as well as by marketing and selling products more effectively. ICT firms are also among the most innovative when looking at overall innovation performance. On average, 74% of firms in ICT manufacturing introduced innovations, against an average of 51% for total manufacturing according to the results of the 2012 Community Innovation Survey. ICT services also account for a larger share of innovative firms than innovation core services (63% against 47%).

108 These sectors include aerospace, agricultural technologies, automotive, construction, information economy, international education, life sciences, nuclear, offshore wind, oil and gas, and professional and business services. Significant industry-government funded initiatives include the Aerospace Technology Institute (USD 2.9 billion, GBP 2 billion), the Automotive Advanced Propulsion Centre (USD 1.5 billion, GBP 1 billion), and the Centres for Agricultural Innovation and an Agri-Tech Catalyst (USD 232 million, GBP 160 million).

109 The other six technologies include *(i)* space, *(ii)* synthetic biology, *(iii)* regenerative medicine, *(iv)* agri-science, *(v)* advanced materials, and *(vi)* energy.

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ANNEX: COUNTRY SPECIFIC CASE STUDIES

Canada – Business development bank of Canada – Smart Tech

Overall policy objective for growth: Economic and productivity growth

Main policy levers: SMEs and Entrepreneurship

Key points

- Canadian firms have typically underinvested in ICTs, in particular Canadian SMEs. As productivity gains are increasingly attributed to ICT investment and adoption, this initiative aims to increase digital adoption by Canadian SMEs to fuel economic and productivity growth and ensure that Canadian firms can engage in the global digital economy.
- Reversing Canada's productivity gap can be achieved through efforts to increase business innovation; business practices rooted in applications of digital technologies help foster innovation; and while Canadian SMEs are applying digital technologies in the workplace today, opportunities abound to do more.
- Canadian firms, and in particular SMEs, adopt digital innovations at a lower rate than most OECD countries. Approximately 12% of Canadian SMEs sell online, and less than half of Canadian firms have an established presence.
- 87% of all companies in Canada have fewer than 20 employees; the majority do not have internal IT departments or in-house capacity.

Programme design

Objectives

The Business Development Bank of Canada (BDC), a Crown Corporation of the Government of Canada, is the only bank in Canada exclusively dedicated to entrepreneurs. It has a legislative mandate under the *Business Development Bank of Canada Act* to provide financial and consulting services that complement those services available from commercial financial institutions, with a particular focus on the needs of SMEs.

Smart Tech provides firms with the tools to increase their productivity and competitiveness through ICT adoption by building awareness, fostering consideration of ICTs and enabling ICT adoption.

Barriers to be addressed

Although Canadian consumers are strong ICT adopters, Canadian firms – especially smaller firms – are not. Only 46% of Canadian firms have an established online presence. Fewer than 18% of SMEs sell online, even though more than half of Canadians shop online. Furthermore, there is a widening ICT investment gap between Canada and the U.S., and international competitors. Canada ranks 18th out of 26 OECD countries in ICT investment as a share of overall capital investment: 9.4% compared to OECD average of 12.1% in 2012. Canada also ranks 15th in ICT investment as a percentage of GDP: 2.27% compared to the OECD average of 2.4%.

Policy levers/instruments

BDC re-aligned its existing support to SMEs in 2011 to focus on digital technology adoption designed around three stages:

1. ***Awareness*** – BDC offers free advice on its Smart Tech website:
   - eBooks on how to select and implement the right technology, and establish a social media presence (step by step guides)
   - Ask a PRO (how-to articles and Q&As)
   - Success stories/testimonials
   - Website Assessment (free personalized report scoring their website on features such as accessibility, user experience, popularity, design and build),
   - ICT Assessment (free personalized reports describing a company's technology situation, positioning it in relation to other Canadian SMEs, and recommending best practices for the areas where it would benefit by using ICT more)
2. ***Consideration and engagement*** – Paid for consulting services to help SMEs tailor ICT solutions to their business:
   - ICT Essentials (development and coaching group programme);
   - Website Diagnostic (more in-depth than the assessment)
   - ICT Diagnostic (more in-depth than the assessment)
3. ***Adopt*** – With financing and consulting, BDC helps SMEs invest in ICT:
   - CAD 200M in loans to purchase hardware, software and consulting services
   - Internet solutions to boost online sales such as Internet Strategy (how to increase revenues and ultimately productivity)

BDC uses a variety of ways to help entrepreneurs identify their needs and determine how to help them, beginning with awareness. Through its Smart Tech platform, firms can download free resources on technology and competitiveness, and the use of social media. Smart Tech also offers information on technology financing and a free website assessment tool, so entrepreneurs can start improving their website immediately.

Through its consulting practice, BDC can arrange for an Internet specialist to ensure that a firm's website is performing the way it should or for a consultant to develop an Internet strategy customized to a company's unique needs, in addition to financing, with flexible and easy-to-access loans for investments in hardware, software, and business methods such as social media and Internet marketing.

Implementation

Smart Tech was launched in October 2011, through the BDC, and is a key element of the "Economic Opportunities" pillar of Canada's digital economy strategy, *Digital Canada 150*.

Institutions

The BDC is a federally mandated and legislated Crown Corporation, reporting to Parliament via the Minister of Industry. The Government of Canada is the sole Shareholder.

National/subnational/supranational/regional policy coordination

In 1995, Parliament passed the *Business Development Bank of Canada Act*, leading to a new name and mission for the bank. The Act mandates BDC to promote entrepreneurship, with a special focus on the needs of small and medium-sized enterprises (SMEs) and to fill the market gaps and maximize financing alternatives for businesses by offering services that were complementary to those available from other financial institutions.

Results / impact assessment

Results to date: Interest in and use of these offerings have been stronger than expected. In the first 18 months of the initiative's existence from October 2011 to May 2013, the BDC SmartTech website had almost 220 000 visitors; the two e-books were downloaded over 10 000 times; and BDC undertook over 35 000 online web assessments, around 900 ICT assessments, and over 300 consulting mandates. In terms of lending mandates, BDC averaged 130 ICT loans per month, and provided nearly 1 800 loans.

For the period of April 1, 2013 - March 31, 2014, the BDC SmartTech website had over 307 000 visitors to the SmartTech website, undertook over 33,000 web assessments; 407 ICT assessments; and authorized an average of 120 loans per month to help SMEs adopt ICTs. Clients invest primarily in hardware, software, and IT Services such as cloud or software as a service.

Lessons learned

Appetite exists: To date, SmartTech has demonstrated the degree to which there is an appetite for solutions to support ICT adoption by Canadian SMEs. However, the BDC only serves a small and specific segment of the SME market in Canada, and there are many firms not captured by these offerings who would benefit from increased adoption.

Awareness is key: BDC is creating awareness and generating interest in SMEs that might not have otherwise considered investing in digital adoption.

Adoption is not a "high tech" issue: The top three sectors of the economy making use of the SmartTech programme are business services, retail, and manufacturing.

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China – Digital innovation for rural China

- China's fast urbanisation has lifted many people out of poverty over the last decade, but also left rural residents behind.
- In 2014, 45.2% of China's population (619 million) still lived in rural areas, distributed in 550 000 administrative villages (National Bureau of Statistics, 2015).
- Most rural residents work in agriculture, have low incomes and education levels, and often do not even have basic literacy and numeracy skills.
- In 2014, average annual incomes in rural areas reached around USD 1 708 versus USD 4 695 in urban areas (National Bureau of Statistics, 2015).
- Less than a third of rural residents have access to the Internet: in 2014, 30% of rural residents were connected to the Internet versus 64.2% that were connected in cities (China Internet Network Information Centre).

Programme design

Objectives

Reducing the digital divide is considered to be an important element for reducing the overall divide between rural and urban China. Over recent years, the Chinese government, including Prime Minister Li, has increased activities to address this divide, in part together with private companies. The main barriers to leveraging digital innovation for rural China are: *i)* poor broadband infrastructure, *ii)* low purchasing power, and *iii)* a lack of skills and capacity for using the Internet and digital technologies. Consequently, the focus of the government and private companies in rural areas currently lies on enhancing access to the Internet and smartphones, on improving skills and capacity, including through e-government services, and on developing e-commerce, including through easier access to credit online.

Policy levers/instruments

Access to the Internet and smartphones

In 2013, China launched its national *Broadband China Strategy* which aims to connect 98% of Chinese villages to fixed broadband with the speed reaching or exceeding 2 Mbps by 2020, up from 93.5% in 2015. Most villages have one central Internet point, but many households are still not connected. Three state-owned companies, China Telecom, China Mobile and China Unicom, are under the instruction of the government to achieve this goal. This includes the roll-out of optical fibre in some areas, such as in Jiangsu Province, which aims for complete optical fibre coverage to the home by the end of 2015. The government also promotes the application of wi-fi in rural areas by subsidizing project construction and operation. In addition, China's telecom operators are being instructed by the government to continuously reduce communication charges mainly on data traffic in the whole country. Internet uptake in rural areas can be stimulated accordingly.

Even if rural residents have Internet access, they often cannot afford the technology needed for actually using it. The price of an iPhone 6s, for example, is equivalent to over half of the average annual income in rural areas. In 2014, less than 30% of China’s rural residents owned a smartphone, compared to 60% of China's urban population (China Internet Network Information Centre, 2015). At the same time,

mobile technology seems crucial for Chinese rural residents to make online transactions: In 2015, 64.2% of online orders from rural residents were done via a mobile phone (Tencent, 2015).

To increase smartphone diffusion in rural areas, Chinese smartphone manufacturers try to develop cheap devices that are easy to use. In April 2015, Alibaba Group and China Telecom launched a joint venture to promote low-priced smartphones in rural areas. Alibaba Group presents data traffic and offers cheaper goods for the buyers. Since then, several smartphone manufacturers, including Coolpad, Hisense, TCL, Uniscope, Ctyon, Kingsun, have joined the programme. The cheapest smartphone in China is currently available at USD 48 (TechCrunch China, 2015).

Skills and capacity

Education in rural China tends to be of poor quality and fails to provide sufficient knowledge in agricultural science and technologies. One way in which the Chinese government addresses the resulting skills and knowledge gaps is by providing online education and resources. For example, the Chinese Institute of Agricultural Sciences under the guidance of the Ministry of Agriculture (MOA) has established the website www.farmers.org.cn, which provides information on national agricultural policy documents, domestic and foreign cultivation methods and experiences, as well as tailored training in the field of fishery technology and planting technology and so on, and an online Q&A forum. The MOA also provides training to big breeders, peasant brokers, village cadres and technician, to improve their computer skills and knowledge in agricultural science and technology.

Box A1. Introduction of a new potato variety in Wuyuan County

Wuyuan County, a traditional potato planting region in Inner Mongolia, experienced difficulties for a long time to become more productive and promote traditionally cultivated potatoes beyond the region. In 2010, locals discovered potato varieties on www.farmers.org.cn that are suitable for local climatic conditions. They learned the cultivation methods online, started cultivating the new varieties and were able to increase their output by two to three times.

E-government services

The Chinese government increasingly makes use of the Internet to communicate information to rural residents. Until recently, it was a common method for rural administrations in China to diffuse information to villagers via loudspeakers. This method is particularly ineffective in areas with low population density, for example in mountainous regions. Mobile Internet increasingly allows village administrations to communicate information directly to residents via mobile phones. Beyond providing information, village administrations are also building e-government services, including for online communication, voting for village affairs, and having meetings (Box 2).

Box A2. Public information system for Chinese peasants

Jiyuan, a rural area in Henan Province, is running a rural information system for peasants, which draws on a wide ranging database on agricultural science and technology, information from agricultural experts and relevant policies and regulations. The system connects cities, towns, villages, and enterprises, involved in large breeding and is also used as an interactive platform among rural residents. This system is focusing on social affairs.

Rural e-commerce

The Internet and digital technologies have started to transform life and economic activities in rural China, notably with the introduction of e-commerce to rural residents. Online sales in rural areas reached USD 28 billion in 2014. Meanwhile, more and more self-employed rural residents run online shops on e-commerce platforms, often selling local products. Many of the sales are consumer to consumer (C2C) and are carried out over e-commerce platforms like Taobao, the most popular C2C market place in China, operated by Alibaba. E-commerce has become an important driver of economic activity in numerous Chinese villages (Box 1). According to Alibaba, 50 % of shopkeepers on Taobao are rural residents.

Box A3. E-commerce in Chinese villages

E-commerce has emerged as a transformative force in rural China. Qingyanliu village in Yiwu city, Zhejiang province, for example, counts around 8000 people that are running over 1000 online shops, mostly on the e-commerce platform Taobao, with an annual turnover of about USD 313 million in 2014. Qingyanliu village is among the largest of such "Taobao villages", but no exception. According to Alibaba, the number of villages with an annual turnover of more than USD 16 billion from e-commerce has increased from 20 in 2013 to 211 in 2014 (Wang, 2014).

Online credit

Chinese rural residents that aim to start a business often have difficulties in accessing bank loans, given their lack of collateral and credit records. This situation is changing through online credits (petty loans) provided by e-commerce platforms to individuals and small businesses that aim to sell on their platform. Background checks are done by analysing online transaction data and in some cases, are complemented through face-to-face investigations in village-level service stations. For example, up until June of 2014, the Alibaba branch Ali Small Loans provided USD 31 billion in loans to 800 000 SMEs with less than 100 employees for an interest rate below 1%, which is lower than commercial bank rates. Jingdong, another e-commerce platform, offers users loans up to USD 2 350, which are interest free for 30 days, and thereafter charged at a rate of 0.5% over 2 years. Such loans serve rural residents to buy agricultural machinery or chemical fertilisers on the Jingdong platform.

Implementation

Both the Chinese government and the private sector are supporting rural e-commerce in China. The Ministries of Agriculture, Commerce, and Transport are respectively implementing policies to improve Internet access and logistics in rural areas. The government is furthermore planning to set up 200 comprehensive demonstration counties on e-commerce in rural areas, supporting each of them with USD 3 million.

The private sector, notably China's biggest e-commerce platform Alibaba, is playing a key role in rural e-commerce development. In 2014, Alibaba published its rural e-commerce strategy, in which the company plans to invest USD 1.6 billion over the next three to five years in order to build 1000 e-commerce operating centres in counties to supply services such as storage and logistic, and 100 000 service stations in villages. Village-level service stations serve as agents for online sales of agricultural products and provide training to the shopkeepers.

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Colombia – Plan Vive Digital

Since 2010, Colombia has been implementing the Plan Vive Digital. In 2015, Minister David Luna took charge of the office and has also acknowledged the importance of digital innovation. Colombia's initiative in the area of the digital economy is expected to promote significantly increase Internet adoption to reduce poverty, create jobs as well as increase competitiveness and productivity in the country. The direction for developing Colombia's digital economy is given by the identification of ICTs as a key enabler for innovation, competitiveness, economic and inclusive growth and to integrate Colombia in global value chains, knowledge and innovation networks.

The main objective is to make Colombia a regional leader in the digital economy, changing its productive base to make it less dependent on commodities and raw materials, such as mining and energy, to become an economy focused on digital creations. We consider ICT industry can have a key role in aiming a structural change of the Colombian economy in all productive sectors.

Good ICT infrastructure and services are a prerequisite to foster ICT use. Colombia has understood that having the backbone infrastructure deployed is not enough. Reaching the final user, especially user at the bottom of the income pyramid and in the rural areas of Colombia, is a key component for further development and it is one of the biggest challenges the country has.

In addition, in order to foster a local innovation ecosystem, talent is necessary. While in China the annual growth rate for system engineering graduates is 26%, and in Brazil it is 10%, Colombia faces a negative growth rate of -5% . Another goal of the plan over the next four years is to increase the number of the IT-related workforce. In order to tackle this issue, the ICT Ministry has a comprehensive digital Talent strategy.

Programme design

During 2010-2015, Colombia has adopted a holistic approach to foster the entire digital ecosystem by working simultaneously in four areas: infrastructure, services (supply), applications and users (demand).

The plan Vive Digital 2015-2018 is developing initiatives to foster the digital economy such as the Digital Talent initiative, Apps.co for digital entrepreneurship and the Digital Content initiative. It furthermore promotes entrepreneurship and investment in the IT industry, aiming to enhance exports in this area, and promotes access to (government) data to foster application development for new businesses and ICT based services.

In addition, the ICT Ministry has an e-government strategy to promote an open, more efficient, more transparent and more participative state that delivers the best possible services to citizens, by the strategic use of ICTs. The budget for implementing the e-government strategy over the next five years (2014-18), in addition to the budgets of each entity implementing the e-government strategy, is close to USD 250 million per year.

Objectives

Following is a selection of the most important goals.

More ICT Industry and innovative enterprises

FITI is a Colombian strategic initiative to foster the IT industry, with a focus on human capital. The four main dimensions of FITI are:

1. ***Education***: over the next four years, MINTIC is supporting the formation of over 59 000 new IT professionals in Colombia at the level of higher education through forgivable government loans and the promotion of scholarships awarded by higher education institutions and private enterprises;

2. ***Recognition of foreign education***: MINTIC works with higher education institutions and the private sector to promote the adoption of international standards and to achieve international accreditation of academic programmes in information technology;

3. ***New training and certification***: MINTIC works on the design of new training programmes and certification for ICT professionals in Colombia that meet international standards and are aligned with the latest trends in ICTs. For this aim, MINTIC engages both national universities and internationally-leading ICT companies. In addition, FITI aims to partner with the industry for specific skills training and to connect IT professionals with employers, head-hunters and academy; and

4. ***Internationalization***: to consolidate the local IT industry in international markets, for which there are several strategies such as having an Colombian IT trademark

The main goals related to the ICT industry are (i) to create, by 2018, 255 000 new direct and indirect employments related to ICT (ii) to have a 17 billion pesos ICT industry by 2018 (from 5.9 billion in 2014). Colombia is developing a number of initiatives that foster innovation in the digital economy.

International positioning of the Country IT Brand; foster exports of Colombian apps and digital contents through the participation in business roundtables and specialized events; achieve USD 30 000 million in 2018 in non-mining energy exports; internationalise services; good and effective use of the Free Trade Agreements (FTA); and foster electronic commerce and telecommunications.

Another goal is to increase the share of innovative enterprises from today's 21.7% to 30% in 2018 by implementing a technology hub as a regional reference.

We have 294 beneficiaries of the "Digital Talent" fund through which the Ministry granted forgivable loans to study in careers related to information technology at technical and professional levels. The number of beneficiaries in the department represents an investment of more than USD 2 billion.

More digital SMEs

MiPyme Vive Digital: a strategy to connect small and medium enterprises (SMEs) to the Internet, with the objective in 2010 to connect at least 50% of Colombian SMEs by 2014, up from 7% in 2010. As of August 2015, 74% of SMEs were connected to the Internet. Several initiatives contributed to reaching the goal, including training, marketing campaigns, events that match SMEs with the ICT industry, as well as tailor made apps for SMEs to facilitate supply chain interactions. The new objectives for 2018 are to have 50% of SME's with online presence and 50% of them making transactions online.

In addition, these programmes include Internet training courses, trade shows for SMEs and the IT industry as well as the promotion of e-commerce. Some of these programmes targeted on SMEs are run by large enterprises and co-financed by the government. Their aim is to provide SMEs that are sellers or buyers of large firms with training and incentives to use ICTs to improve the efficiency of the whole value chain. For instance, Cemex, one of the world largest cement companies, used to provide a 10% discount to SMEs ordering online and provided trainings on the use of the related ICT systems and programmes while the national government co-financed the cost of this initiative.

More development of the national market of apps and digital contents

Vivelab (digital content centres) seeks to provide a platform for digital entrepreneurship and specialised training to foster the development and production of digital content and applications. MINTIC has invested USD 11 million in the creation of Vivelab. This includes 17 training centres across Colombia, which are available for digital content developers to provide specialised training for 3D animation, 2D,

video games, business models and entrepreneurship, web development, digital publishing, and special effects and digital advertising. Vivelab centres are located in Manizales, Pereira, Armenia, Cali, Popayán, Bogotá, Bucaramanga, Medellín, Barranquilla, Cartagena, Montería, Sincelejo, Boyacá, Pasto, Pitalito Villavicencio and Yopal. Since 2012, our advice and counselling programmes have contributed to the creation and consolidation of more than 1 080 enterprises across the country.

Apps.co is the digital entrepreneurship programme that promotes the creation of new ICT businesses, focusing on mobile and web applications, software and digital content. The main objective of the initiative is to transform entrepreneurs and ideas sustainable and profitable businesses. Various apps have been developed for a variety of sectors including for agriculture, education, justice, health, social services, as well as apps that support the fight against poverty and that help people with disabilities. Apps.co has assembled the largest entrepreneurship community in the region with over 90 000 members in issues such as developing business models, managing start-ups and acquiring the right ICT skills. A planned next step to leverage the potential of Apps.co is to identify gaps and opportunities to strengthen Colombia's digital innovation ecosystem, to solve the needs of the productive sectors in the country as well as to provide seed capital to help scale up successful applications on Apps.co. This is planned to be done through public-private partnerships, using matching grant schemes jointly with private venture capital funds in different regions in Colombia.

Within Apps.co, **Bootcamps** have been established to strengthen Colombia's entrepreneurship network and to offer expanded and diversified courses on entrepreneurship, business, design, digital marketing, programming, legal issues, finance and social networks. Such Bootcamps would complement another programme currently run by Innpulsa, which aims to strengthen entrepreneurial culture in different regions of Colombia through events in which entrepreneurs, developers and digital market experts, share their experiences related to both failure and success.

The development of mobile applications (apps) has been an important element in implementing PSI policy over the past years. In particular, through the programme ¡Vive Gobierno Móvl!, in 2013-14, almost ten co-creation marathons (hackathons) were organised. So far, over 400 developers have participated in these events and have developed 59 apps for diverse purposes, ranging from human rights or post-conflict management, to education or environmental care, using open data submitted by 37 public institutions. The apps developed within this initiative are available in the government applications store.

Each hackathon event has a specific theme. For example, Agroton focused on challenges for Colombian peasants. Before the meeting, representatives from the Colombian agricultural sector were invited to define main challenges to be tackled. At the meeting, 150 software developers, 20 young agricultural leaders, over 20 representatives from the agricultural sector, and almost 20 public agencies worked together to find solutions for challenges. These included asymmetric information between producers and intermediaries, developing better sales channels, the fight against plagues and other harvest damages, and financing. Another example is a hackathon that focused on protecting victims of internal conflicts and violence (www.unidadvictimas.gov.co).

Other examples of apps include *Tu Bogotá*, which provides citizen information on where to buy property in Bogotá; *I Like Acacias*, which provides travel information for Colombian municipalities; and Employment in your pocket, which shows employment opportunities in the public sector.

More social inclusion: ICT's for everyone

Inclusiveness is key for Colombia. In order to address the digital divide, the ICT Ministry developed initiatives such as the "ICTs and Disability" which integrates three main projects to promote social, cultural and economic inclusion, as well as the inclusive education of people with sensory disabilities (Visual and

Hearing Impairment). The objective of this project, called CONVERTIC (Law 1618 of 2013), is to promote the access, use and adoption of ICT by people with visual impairment, through the free acquisition, installation, technical support and distribution of a licensed screen reader and a magnification software until 31 December 2017.

- The massive adoption of this tool benefits more than 1.2 million visually impaired people living in Colombia.

- Currently, more than 149 000 licenses of the Screen reading Software and the magnification software have been downloaded – Colombia being the first country in the world to provide this service for free.

Goals 2015:

- 70 000 software Licenses provided under the Convertic project. Train more than 3 200 people on the use of computers and smartphones through screen reading and magnification software

Another project of the ICT Ministry that contributes to the reduction of the digital divide is the Relay Center, which offers four different services aiming to provide a communications solution for the hearing impaired population. Up to August 2015, more than 220 000 calls have been relayed.

Movies for All is another project that contributes to reduce the digital divide in Colombia. It aims to provide free entertainment for people with visual or hearing impairments through subtitling and audio description technology in 10 cities of Colombia. Up to 2015, it has benefited more than 26 000 persons and 126 screenings have been carried out.

All these initiatives show that Colombia has taken important steps to reduce the digital divide, and that ICT policy is especially designed for the reduction of poverty and the generation of inclusion opportunities for those with disabilities.

A state more efficient and transparent with the use of ICT's

The e-government strategy includes activities to promote open access and re-use of PSI, such as:

- training and support strategies for staff and public entities to promote open access and use of public sector information;

- e-government innovation processes and exercises to enhance re-use of PSI;

- incentives and new business models, developed in collaboration with the IT industry, to further implement the e-government strategy, including its PSI component;

- tools and solutions that facilitate citizen participation, including the maintenance and operation of the national Open Data Portal.

Barriers to be addressed

The main barriers identified by the Colombian government to be addressed in order to improve the digital economy and foster innovation in the country are:

- Colombia's innovation system is still small, and lacks a strong business core. R&D expenditure is only 0.2% of GDP, compared to 1.2% in Brazil and 2.4% in the OECD area. Other measures of

innovation such as patent registrations and scientific publications per capita place Colombia below neighbours such as Argentina, Brazil, and Chile. Much can be learned from other emerging economies that are important actors in global innovation.

- The lack of skills and awareness and a slow scale-up is the most important barrier. In Colombia, there are not enough degrees related to technology and students do not find these studies attractive. The ICT Ministry is implementing a strategy of scholarships to encourage the study of technical and professional careers in ICT-related areas. The Colombian Ministry of ICT (MINTIC) is working on a talent roadmap that promotes an increase in the number of students in IT careers and will implement substantial improvements in the quality of education.

In Colombia, there is a lack of awareness of public servants in issues related to digital economy. The ICT Ministry is working on training programmes for public servants, but it is still a barrier.

The novelty of the current regulatory framework. Many changes have occurred in the last three to four years and may require more time to deliver optimal results.

In addition, there is a lack of regulation in digital entrepreneurships, in new business models, such as crowdfunding and there are big barriers for entrepreneurs to "legalize" the implementation of its incentives. These barriers are being analysed in a working group with other public entities (Minhacienda y Superfinanciera).

There is little innovation of regulation facing new business models, such as uber, drones, etc. Additionally, there is an unequal treatment for electronic commerce over traditional commerce in regulatory matters and public policy. There is a need to analyse tax incentives (for example, tax breaks or subsidies to encourage e-commerce, VAT exemption for online purchases, on smartphones, tax benefits for micropayments, etc).

Colombia also have a new Conpes to give tax benefits for companies that invest on Science, Technology and Innovation. The government is also working on the regulation of a public policy that enables the use of services for private and public entities in a cloud, such as medical, security and personal services.

The new system for distributing royalties allocates 10% of non-renewable resource revenues to an STI fund. This implies a significant increase in the resources available for STI. If well managed, this can significantly strengthen the innovation system and address imbalances between public and private innovation and between the regions.

Policy levers/instruments

As mentioned above, the Vive Digital Plan of the Colombian ICT ministry has been key for the development of the digital economy in Colombia.

In addition, a new Science, Technology and Innovation Policy and a Productive Development policy are being implemented in order to promote innovation, a priority for the Colombian government, having the goal of being one of the 3 most innovative countries in Latam by 2025.

Furthermore, CONPES document 3582, the National Policy for Science, Technology, and Innovation, promotes a knowledge-based economy and society and stipulates provisions for the funding and implementation of STI activities by various the stakeholders of the National System of Science, Technology and Innovation (SNCTeI).

The goals and objectives listed above cannot be accomplished without an efficient, open, transparent and more participative state that delivers the best possible services to citizens, by the strategic use of ICTs. To this end, Colombia's government developed an e-government strategy that states the following four

lines of action: 1) the use of ICTs for better public service delivery, including online interactions between citizen and public entities, with high quality standards and attending the real needs of users; 2) the use of ICTs for an open government, aiming to build a more transparent, participative and collaborative state, where citizens actively participate in decision-making through electronic channels; 3) the use of ICTs for public management, aiming to enhance the efficiency of internal procedures in public entities and to define guidelines for integrated ICT management in the public sector; and 4) the implementation of security and privacy policies for the use of ICT and information management.

Implementation

The promotion and development of Digital Talent will be the key to achieve the main goals and to successfully consolidate the ICT industry in Colombia. The implementation of the initiatives regarding digital economy and innovation are based on national policy co-ordination and on fostering public private partnerships.

Institutions

Several public entities provide leadership in fostering innovation in the digital economy, in particular MINTIC, the National Planning Department (NPD) and the agencies Innpulsa, SENA and Colciencias.

The National Planning Department monitors progress and accomplishments of goals defined in the National Development Plan 2014-2018. Each ministry is responsible for monitoring in its own area, and in cases of overlapping responsibilities, might work together with other ministries to assess progress towards joint objectives. Furthermore, the Colombian government has asked the World Bank to measure the effectiveness of its programmes in the area of STI over the last five years. This evaluation will also assess some of the initiatives mentioned above like Apps.co, Mipyme Vive Digital and other instruments developed by Innpulsa and Colciencias.

- The NPD is responsible for overall co-ordination of public policy for economic and social development, as defined in the National Development Plan 2014-2018.

- MINTIC leads policy development for the digital economy and supports the design of science, technology and innovation (STI) policy. In the latter area, MINTIC works together with Colciencias, which leads STI policy development, as well as with the Ministry of Trade, Industry and Tourism. In some programmes, such as Mipyme Digital, MINTIC also works together with chambers of commerce and businesses associations.

- Colciencias is the Department of STI, situated in the National Planning Department. Among its main activities are the promotion of policies that foster knowledge production, STI capacity, and more efficient use of knowledge and capacity for overall development in Colombia.

- Innpulsa is a government agency that supports and promotes high-growth economic activities, in particular through supporting innovation and high-impact entrepreneurship.

- SENA is the National Service of Learning, which operates 116 training centres and a network of 16 “techno parks” that focus on technological development and business innovation.

Non-governmental stakeholders, including businesses and civil society, play an important role in fostering an innovative digital economy in Colombia. The Colombian Chamber of Electronic Commerce, several IT Clusters, developer associations such as Bogotev, IGDA and Bogotech, local chambers of

commerce, accelerators (Social Atom, hubBOG, RUTA N), and investment funds – altogether constitute an increasingly flourishing ecosystem for digital innovation in Colombia.

Apps.co has a specific monitoring mechanism to evaluate its activities. This includes internal monitoring of the accomplishments of entrepreneurial teams in terms of reaching their business goals; as well as external monitoring, which consists of weekly reports to the ASPA platform, as well as of reports to the National Planning Department every trimester.

Lessons learned

1. Stimulating the digital economy and digital innovation is not a pure ICT sectorial issue, since ICTs penetrate now almost any sector and transform economies into digital economies. This is why a whole-of-government approach is essential to grasp the benefits of ICTs. The Ministries of Defense, Justice, Education, Health and Trade, Industry, and Tourism have all been key allies to foster demand in each of these sectors.

2. Public-private partnerships are an important tool in order to foster innovation. The participation of the private sector is essential to foster investment in innovation, science and technology. Tackling the low levels of innovation in industry and services is the key task for STI policy, and can have large impacts on productivity. Policy has thus far emphasized support for science and research-driven enterprises and university industry linkages. This is important, but the potential for innovation is not limited to such firms.

3. A good coordination among the different authorities and a clear division of tasks is required.

4. Framework conditions for innovation have improved significantly, though there remains scope for improvement. This entails continuing the regulatory reform process, increasing public-sector efficiency, further stimulating competition, including in the telecommunications sector, and strengthening the intellectual property system's contribution to innovation. Stronger competition provides a powerful incentive for businesses to innovate; firms will need to strengthen their innovation capabilities to succeed in a more competitive environment.

5. Human resources is the key to innovation. The access to and quality of secondary level education are very important, such as a more expanded tertiary level education. Reducing inequalities in the access to education is essential in order to have a more innovative and competitive system.

6. SMEs are key partners to foster digital innovation.

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Germany – Initiative on Smart Networks

In the context of the German 'Digital Agenda', the Federal Ministry for Economic Affairs and Energy launched the 'Initiative on Smart Networks' in 2015 in order to make use of the tremendous economic and social benefits resulting from the digital transformation in the key infrastructure sectors health care, energy, mobility, education and public administration.

Introduction

The world is becoming increasingly digital and interconnected. The changes resulting from digitization have a crucial impact on the German economy and on the daily lives of all its citizens. Digitization gives Germany the opportunity to sustainably increase its social welfare, stimulate growth, improve efficiency, and build a digital vision for the country. Therefore, the German Federal Ministry for Economic Affairs and Energy actively promotes and shapes the transition into a new digital era. Fostering the exchange of smart networks within and across the five infrastructure sectors health care, energy, mobility, education and public administration is crucial in order to ensure the success of a digital transformation. In this vein, smart networks place an opportunity for technological advancements and innovative use of information and communication technology (ICT) in the target sectors. A systematic interconnectedness of existing digital infrastructures between the sectors, together with the use of innovative ICT and digital applications within the sectors may enable a major economic growth stimulus (55.7 billion euros p.a. from 2022 onwards)[110] in Germany. This is why the German government has – as part of the Digital Agenda – established a national strategy on smart networks in Germany. In this context, the Germany Federal Ministry for Economic Affairs and Energy launched the 'Initiative on Smart Networks' in 2015, which focuses on supporting the implementation of the national strategy on smart networks and aims at giving the application and integration of smart networks a leap forward.

Programme design

In order to benefit from the major opportunities of smart networks, the initiative “Smart Networks” enables and fosters communication and exchange of knowledge between the main stakeholders in Germany, i.e. companies, associations, academic and non-profit institutions. The partners within the initiative's network are in turn representatives both from the ICT-sector and from the five sectors, and co-operate actively with the initiative in the form of joint events (e.g. a roadshow), workshops and experience exchange, where ideas and best-practices are exchanged. Hence, the initiative makes a valuable contribution to the cross-sectoral interconnectedness of the main stakeholders. Moreover, the initiative is informing the partners on a monthly basis about ongoing political, social and economic developments within the field of smart networks. The interaction between the stakeholders is facilitated through an “Open Innovation Platform” where ideas and best practices can be shared, discussed and evaluated.

Objectives

The 'Initiative on Smart Networks' is based on the German national Strategy on Smart Networks. The goals of the strategy are:

1. **Strengthening of basic infrastructures** (health care, energy, transportation, education and public administration): support of smart network initiatives within the respective sector by both (i) enhancing drivers, e.g. connecting sectors and partners, exchanging knowledge, and digitizing information, and (ii) reducing obstacles, e.g. user acceptance rate, and recognition of personal benefits.

2. **Developing cooperation across infrastructure sectors**: use of cross-sectoral synergies and experiences through mutually beneficial co-operation.

3. **Improving the framework conditions:** fostering innovation as well as eliminating obstacles to improve framework conditions and to develop a cross-sectoral approach – in particular in the field of data protection, user authentication, data platform architectures, and standardization.

4. **Increasing participation: increasing participation of stakeholders at an early stage to enhance** acceptance among professional and end users – therefore, advantages and disadvantages, opportunities and risks, costs and benefits shall be evaluated in a discourse with all stakeholders.

Barriers to be addressed

One major barrier for smart networks in Germany is the fact that the development of ICT in the sectors health care, energy, transportation, education and public administration is mainly promoted in an isolated manner for each sector. Hence, there are several different initiatives and strategies that foster the use of ICT in the respective sectors. By consolidating and enhancing the various strategies into a more cross-functional strategy, smart networks have the potential for sustainable growth and efficiency gains.

Another barrier is the difficulty regarding the acceptance of digital applications among professional and end-users. These barriers put the enormous potential benefits of smart networks at risk: research shows that the overall benefit of smart networks within the basic infrastructures in Germany from 2020 onwards is EUR 55.7 billion (~2% of GDP).

Policy levers/instruments

In order to achieve its stated goals, the initiative uses different coordination mechanisms and instruments. One of the main pillars for the connection of the stakeholders is the Open Innovation Platform, which is an interactive online communication platform fostering the exchange of ideas, proposals, advice, and best-practice examples in the field of innovative smart networks in Germany. This creates a broad, action-oriented dialogue with currently approximately 700 experts from different infrastructure sectors, who are exchanging experiences and communicating with each other every day through a single platform. Even international industry experts engage and share their 'lessons learned' in other countries with the community on the platform. Simultaneously, the initiative is preparing a roadshow through Germany in 2015/2016, which will help introduce the smart networks locally and supports the interconnectedness with and among the stakeholders on a regional level. Furthermore, the initiative is strengthening the technical knowledge and experience on the topic of smart networks by publishing studies, surveys and guidelines for both government officials, and project leaders. Through all of these efforts, the initiative has managed to build a strong and interdisciplinary partner network. These network partners enrich the initiative with knowledge and expertise of smart networks in different industries and engage actively in the initiative's actions. Hence, the initiative increases the overall understanding and acceptance of digitization in Germany, and is able to provide explicit recommendations for the German government as well as explicit guidelines for German project leaders.

Implementation

The “Initiative on Smart Networks” was founded within the framework of the 'Digital Agenda' in Germany and in the context of the national 'Strategy of Smart Networks'. The Federal German Ministry for Economic Affairs and Energy is primarily responsible for the “Strategy of Smart Networks” within the German Federal Government and closely collaborates with a private consulting company to implement and run the “Initiative on Smart Networks” form March 2015 onward.

Institutions

The German Federal Ministry for Economic Affairs and Energy cooperates with other German Federal ministries[111] and coordinates its actions accordingly with them.

National/subnational/supranational/regional policy coordination

The "Initiative on Smart Networks" is co-operating with and reporting to the German Federal Ministry for Economic Affairs and Energy. It is also liasing with the German national IT summit, especially with the focus group smart networks. The Initiative is also in thorough communication with regional, communal and municipal associations aiming to reconcile and foster the implementation of ideas as well as promote the distribution of Smart Network solutions nationwide, as well as in exchange with the European Commission.

Results / impact assessment

The initiative reports in regular and defined intervals to the German Federal Ministry for Economic Affairs and Energy about the current project status and key developments. The main tools for impact assessment are interim reports and regular coordination sessions with the German Federal Ministry for Economic Affairs and Energy.

Since the launch of the "Initiative on Smart Networks" in March 2015, it successfully hosted its own kick-off event in June 2015. Through this, and further events the Initiative participated in, it could increase its level of recognition and win several important partners. An important first achievement of the initiative was a representative survey and study on the acceptance of digital applications among end users in Germany. The findings were used to derive recommendations for the German Federal Ministry for Economic Affairs and Energy. The recommendations of the study include:

- Demonstrating Smart Networks applications vividly to the public by implementing pilot projects or regions in selected areas
- Convincing professional end users of the benefits of Smart Networks in order to increase the overall acceptance rate of the German population
- Managing data protection and security transparently
- Communicating benefits clearly and easily understandable

A study about the public funding opportunities, on the other hand, helped increase transparency and provided a national overview over current public funding activities and opportunities. These findings helped to identify obstacles – tremendous regional differences in support programmes, unequal distribution of support in the areas of innovation, foundation, and scaling[112] as well as among the sectors,[113] and to derive recommendations for government in order to foster the comprehensive implementation of Smart Networks in Germany. The suggested recommendations of the public funding study include:

- Public support programmes should be implemented for each sector in order to specifically foster the development and initiation of Smart Network solutions
- More support programmes for scaling and replicating successful Smart Network projects
- Assimilation of the supply of regional support programmes throughout Germany

- Completion of the funding navigation data base by including European Union support programmes and deleting expired programmes from the website

So far, the most crucial success of the initiative is the Open Innovation Platform, which acts as the central and interactive communication platform for experts from different key infrastructures. Meanwhile, almost 700 experts are exchanging their ideas and knowledge on the platform. The first campaign on the platform ended recently and dealt with the acceptance of innovative digital applications among professional and end users. Numerous contributions from different stakeholders on the topic resulted in a guideline for project leaders and the Federal Government, which actively addresses recommendations and obstacles for the success of the digitization in Germany. Currently, the Open Innovation Platform hosts a campaign aimed at collecting best practice examples for projects implementing smart networks in Germany.

Lessons learned

Since its launch, the 'Initiative Smart Network' has successfully carried out various actions in order to reach the stated goals of strengthening the infrastructure, developing cross-sectoral cooperation, enhancing framework conditions, and improving user participation. Along the successful road, the Ministry of Economic Affairs and Energy has experienced some 'lessons learned', which were crucial for the effective implementation of these actions:

- The success of Smart Networks and their applications depend on their overall public acceptance. Thus, policy measures should be taken in order to foster the public acceptance rate. Those measures have to be carefully and thoroughly communicated to the public in order to be effective. Currently, measures which target a better public acceptance, are often not well communicated towards the public.

- The political entities must foster the distribution of Smart Network solutions in collaboration with strong partners from the industry, science, and municipalities. Still, such a network by itself has no positive effects; rather it has to be coordinated in a way that it has the desired impact – e.g. increased participation rate, enhanced support of projects, and better understanding of the benefits of Smart Networks.

- This co-ordination should not solely be done by the ministry itself; instead, it makes sense to establish a separate and dedicated entity in order to better satisfy the needs of the different stakeholders and act as an independent as well as flexible partner of the ministry.

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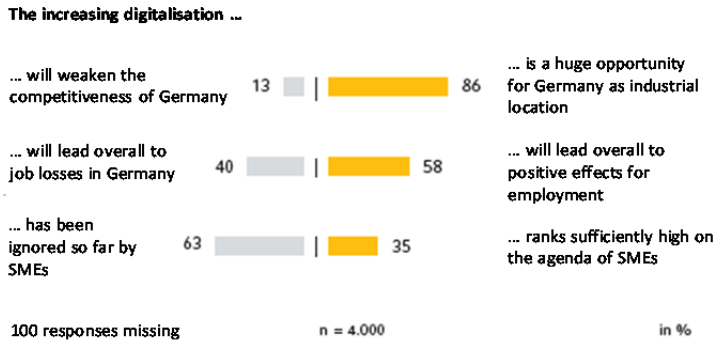
Germany – "Mittelstand-Digital"

Introduction

The initiative "Mittelstand-Digital" (EN „SMEs digital") of the German Federal Ministry of Economic Affairs and Energy (Bundesministerium für Wirtschaft und Energie, BMWi) aims at showing small and medium-sized enterprises (SMEs) and skilled crafts, the importance of using software for business processes and the importance of supporting these enterprises in digitising their business processes. For the year 2016, it has an overall annual budget of approx. EUR 29 million.

This initiative was created against the background that digitalisation of the economy is particularly challenging for the 3.6m SMEs in Germany (of which approx. one third are skilled craft workshops; hereinafter, the term SMEs shall include skilled craft workshops, unless otherwise stated) (Figure A1).[114]

Figure A1. The role of digital transformation for Germany's economy



Source: Commerzbank (2015), "Company.News - Zeitung der Mittelstandsbank", www.firmenkunden.commerzbank.de/portal/media/corporatebanking/hauptportal/archiv/company-news/2015_03_company_news.pdf

These enterprises and workshops typically do not have a dedicated IT department, and in many cases their financial resources do not allow for engaging external IT support companies. However, new software solutions, internet applications and standardised e-business processes could be of particular benefit for SMEs, offering enormous potential for enhanced efficiency and a wide variety of new fields of business.

Programme design

The funding priority is currently based on three "pillars":

- The new initiative "**German Mittelstand 4.0 – Digital Production and Work Processes**", supporting SMEs and skilled crafts with successfully using digitalisation, connectivity and Industrie 4.0 applications.

- The initiative "**Simply intuitive – Usability for SMEs**", which aims at developing and testing support mechanisms for SMEs to increase quality and usability of business and production software used in SMEs.

- The initiative "**eStandards – Standardising Business Processes, Securing Success**", which aims at developing a "common language" for SMEs and skilled crafts of different fields of business to enable efficient data exchange.

"German Mittelstand 4.0" replaces the initiative "**eCompetence Network for Enterprises**", which was very successfully concluded in September 2015, offering a number of regional points of contact on a nationwide basis to provide neutral and practical information on e-business solutions to SMEs.

Each of these initiatives strives to tackle some of the particular challenges of the digital revolution which SMEs are facing today. In more detail:

German Mittelstand 4.0 – Digital production and work processes

Objectives: This initiative aims at supporting SMEs and skilled crafts with successfully using digitalisation, connectivity and Industrie 4.0 applications.[115] The objectives (as laid down in the official public tender specifications) are as follows:

- Raising awareness of SMEs, and supporting SMEs, with a view to the technological and economical opportunities and challenges of digitalisation, including Industrie 4.0;
- Strengthening competitiveness and opening up new fields of business for SMEs;
- Enhancing technological and organisational competences as well as competences for work structuring;
- Strengthening the potential for networking through security and trust (provider/user relation);
- Supporting the development of needs-oriented, safe, and market-ready solutions for SMEs through providing opportunities for demonstrations and testing.

Barriers: Various studies show that many SMEs have a deficit of knowledge/awareness of the chances and new business opportunities offered by digitized business and work.[116] At the same time, the available information mostly does not take into account the specific needs of SMEs. A study funded by the German Federal Ministry of Economic Affairs and Energy titled "Erschließen der Potenziale von Industrie 4.0 im Mittelstand" (EN "Tapping the potentials of Industrie 4.0 for the German Mittelstand") confirmed that current research and projects on digitalisation of the economy and on Industrie 4.0 focus too strongly on the development of specific technologies, while lack a collation and presentation of the results in a format and language that is appropriate for reaching SMEs and skilled crafts.

Concluding the above, the main barriers can be summarised as lack of awareness, knowledge and competence.

Instruments: The project will comprise ten "Mittelstand 4.0 Competence Centres", four "Mittelstand 4.0 Agencies" and one "Centre for Digital Skilled Crafts".

- The first six Competence Centres have already started their work at the end of 2015/early 2016; the other Competence Centres shall be established in the course of 2016. The task of the Competence Centres will be to collect and collate up-to-date, practical knowledge on digitalisation, Industrie 4.0 applications and connectivity of business processes, to further develop this knowledge and to "translate it into the language of SMEs". The Competence Centres will introduce this knowledge into SMEs and skilled crafts and will competently inform, qualify and raise awareness of the opportunities and challenges provided by digitalisation. They will also collect information on easily reproducible solutions which are "fit for SMEs" in order to show SMEs what is feasible and to motivate them to start the process of digitalisation and networking within their companies. In the Competence Centres, SMEs will be able to test their own technical

developments or client interfaces/product interfaces, receiving professional support in the process. The Competence Centres will therefore be equipped with the appropriate infrastructure, e.g. rooms, demonstration facilities, testbeds etc. The 2016 annual budget for the Competence Centres is approx. EUR 20 million.

- Additionally, the Centre for Digital Skilled Crafts will specialise in transferring knowledge on digitalisation into skilled crafts workshops.

- The four Mittelstand 4.0 Agencies will each have a specific thematic focus, with one agency on cloud computing technologies, one on digital process and resources management, one on digital communication, knowledge management, e-learning and innovation management, and one on digital commerce (e.g. e-invoice). These agencies will be working on a nation-wide basis and will prepare up-to-date information and translate them into the "language of SMEs". This information will be brought directly to SMEs and skilled crafts workshops, and also to multipliers such as associations or trade and craft chambers. The budget for the Mittelstand 4.0 Agencies is up to EUR 7.5m (total) in the next three years. The Mittelstand 4.0 Agencies and the Competence Centres will work in close cooperation.

Simply intuitive – Usability for SMEs

Objectives: The initiative "Simply intuitive – Usability for SMEs" aims at helping SMEs apply usability criteria during the development and transfer of usability-methods, criteria, best-practice-examples and demonstration projects which support SMEs in the entire business software development and procurement process. The main goal is to help SMEs in gaining expert knowledge geared to the target groups methods and criteria and gain practical experience together with specialists. The transfer of this knowledge, methods and best-practices is impelled by over a dozen competence centres. The goal is to help SMEs generate expert knowledge on usability criteria despite small budgets. The initiative is directed towards two groups of addressees: On the one hand SMEs as software users, which can tap their full potential by implementing software with a high usability and thus work more efficiently. On the other hand, the initiative also aims at supporting SMEs in the software business to better integrate aspects of usability into their software (and the software development process) and thus create more competitive and more successful products.

Barriers: While in recent years usability has been an increasingly important aspect for end-user software, particularly for mobile apps on smartphones and tablets, software products for SMEs have mostly concentrated on aspects of technical functionality. With software products becoming more and more flexible and thus substitutable with regard to their technical functionality, usability becomes an important competitive factor. However, especially SMEs currently do not put much emphasis on product usability; there is a lack of awareness of this topic and of its economic importance,[117] and at the same time, existing usability methods and criteria are not targeted against SMEs and are too much research driven. A study commissioned by the Federal Ministry for Economic Affairs and Energy shows that factoring in aspects of usability indeed has a positive effect on the success of a company. Software producing SMEs run the risk of falling behind in competition with bigger software producers if they neglect usability aspects; in their capacity as software users, SMEs might forfeit efficiency advantages.

Instruments: The initiative "Simply intuitive – Usability for SMEs" supports more than a dozen projects which develop and test support solutions for SMEs which improve the quality and usability of the software products in use and thus increase the competitiveness of both software producers and software users. Each project acts as a competence centre which offers information and support to SMEs. At the same time, each of the projects has a different thematic focus, concentrating on the specific usability needs for a certain kind of software (e.g. enterprise resource planning (ERP), customer-relationship management

(CRM), or document management software (DMS)). Basically, the main emphasis is laid on development of specific "light weight" usability methods which are suitable to small software developers. These methods are evaluated with use cases in different sectors and domains. The budget for this initiative is EUR 16 million.

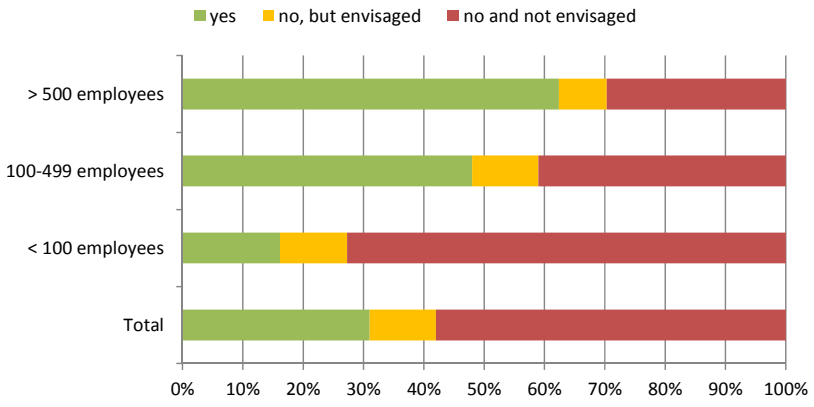
> ***Practical example:*** In the context of one of the projects of this initiative, "KompUEterchen4KMU", a software company developed a resource planning tool for a medium-sized construction company. Like in many traditional smaller construction firms in Germany, resource planning in this company was still mostly done by the use of a magnetic chart indicating the current use of all construction sites, machines and employees. Such a chart has the disadvantage of being only locally available, and it can be easily brought into disarray by either an inadvertent stroke with an elbow or even a gust of wind. The software company and the client, therefore, developed a software for mobile devices embodying all the functionalities of the magnetic chart. The main usability aspect was that the software, in order to ensure acceptance by the users, kept as close to its analogue predecessor, the magnetic chart, as possible.

eStandards – Standardising Business Processes, Securing Success

Objectives: Digital standards are the "lingua franca" in e-business; they are the basis for efficient interconnection and automated exchange of data within as well as between companies or with public administration bodies. However, in a first step, the use of standards leads to high financial and administrative costs. In the medium and long-run, standards can considerably increase the speed of business processes and lower costs. The initiative "eStandards – Standardising Business Processes, Securing Success" aims at helping SMEs to increase their efficiency and lower their costs through the use of e-standards, thus giving them a competitive advantage both on the national level and on the international level.

Barriers: SMEs face considerable initial costs if they want to use and implement e-standards. In addition, many SMEs and crafts workshops are not yet aware of the opportunities offered by the use of e-standards. For example, a study by Berlecon Research came to the conclusion that only one third of all companies were using e-standards, and only 16 % of small companies with less than 100 employees were using e-standards (Figure A2).

Figure A2. The use of e-business standards in businesses



Identifiable barriers for implementation of e-business standards were, in particular, high initial costs for revision of master data and the unclear (from an ex-ante point of view) cost-benefit ratio for the enterprises. See Berlecon Research, 2010: E-Business-Standards in Deutschland: Bestandsaufnahme, Probleme, Perspektiven:

Instruments: The initiative "eStandards – Standardising Business Processes, Securing Success" has supported and still supports a large number of projects which both develop software tools and implement model projects. The budget for this initiative is EUR 20 million.

Practical examples: One of the projects of this initiative, "MAC4U", developed a demonstrator which allows the end customer to design personalized accessories to mass products and have them printed by a 3D printer. The idea is that this system could be installed in a retail store. When the customer buys a mass product, he can use the system in the store to create personalized additions that in turn personalize the formerly impersonal mass product. The system exchanges the necessary parameters with the manufacturer of the mass product to ensure that the accessory fits. For example, the project demonstrator was able to print personalized gear knobs for a series vehicle. In a first attempt to implement the principle in real life, the Aachen based optician „Heiliger" is evaluating the service to implement them in its stores to personalize temple sterns for glasses. Here, a demonstrator can already be visited at different trade fairs and in the 3D-Lab at Aachen University of Applied Sciences. This example demonstrates how the system could help SMEs to provide value adding services, differentiating the local retailer from, for example, online shops.

Many small and medium automotive suppliers still handle their document exchange, e.g. invoicing, via telefax, mail or e-mail. This can be made more efficient by using the EU e-business standard "auto-gration".The now concluded project "Car4KMU" aimed at providing a scientifically and practically proven national introduction and implementation strategy for the "autogration" standard. Using autogration would enable SMESMEs in the automobile industry to streamline their exchange of business documents with the car producers (OEMs). The project helped SMEs to identify potential areas of application of the auto-gration standard to make them more attractive as a business partner for an OEM. After the conclusion of the project (31 July 2015), the consortium is in dialogue with the German association of the Automotive Industry (VDA) to promote the national introduction strategy. Also, associated partners such as Knorr-Bremse connected a multitude of SME suppliers with their sourcing and invoicing systems using the introduction strategy formulated within the project. The introduction strategy has therefore already proven its value. The tools provided for multipliers such as chambers of commerce, innovation networks etc. by the project facilitate further dissemination and inclusion of SME into the automotive value chain. As such, the project will have intermediate and long-term results, which cannot be forecast here.

eCompetence Network for Enterprises (former initiative, now concluded)

Objectives: The funding initiative "eCompetence Network for Enterprises", which was concluded on 30 September 2015, aimed at supporting SMEs and skilled crafts workshops nationwide through 38 "e-Business Pilots". The e-Business Pilots give support to interested SMEs by offering provider-neutral and practical information. They offer skilled assistance for choosing and using efficient, user-friendly and affordable IT tools and solutions, in particular in areas of knowledge management, e-commerce and m-commerce, IT security, ERP, process management, online marketing, social media and m-business.

Barriers: Implementation of electronic business processes is a big challenge for many companies. This is particularly true for SMEs, which often struggle to set up and maintain adequate ICT competences and infrastructures. SMEs and skilled crafts workshops often do not have a dedicated IT department, nor do they have the necessary financial resources or workforce. At the same time, a growing diversity of products and decreasing market transparency add to the challenges: hardware, software, IT tools and e-business solutions are often very complex and have a multitude of functionalities which are hard to comprehend. Finding the right ICT solutions and customizing them to the company's needs is therefore time-consuming and binds a lot of manpower.

Instruments: The 38 e-Business Pilots offered free-of-charge informational presentations and one-on-one meetings, workshops and showrooms, but also provided media such as leaflets, guidelines, practical examples and interactive checklists. For example, an SME could use interactive online questionnaires to find out its specific needs with regard to e-mail management, newsletter organisation, IT security etc.[118] Even after the official conclusion of the project, these tools will continue to be available for another two years.

Implementation

Institutions

The funding priority is coordinated by the German Federal Ministry for Economic Affairs and Energy (BMWi). For each of the funding initiatives described above, the BMWi is co-operating with a project management team and a consultancy firm for additional research. Other institutions involved were the German Chambers of Commerce and Crafts, as well as various universities.

National/subnational/supranational/regional policy coordination

Please see the structures described above for the initiatives.

Results / impact assessment

To illustrate the results and impact of the initiatives, we would like to provide figures on the eCompetence network:

Within the eCompetence Network for Enterprises, around 3 500 events on ICT solution topics (e.g. workshops, regular entrepreneurs meetings, entrepreneurs breakfasts, etc.) in support of SME were organized, 10 000 individual briefings were conducted, and the total number of contacts with local companies is estimated as more than 60 000. On top, there were around 3m online contacts each year and more than half a million downloads of information booklets, IT-guides and check-lists. Statistically, each of the 3.6 million small and medium sized enterprises in Germany participated in the information offers of the eCompetence Network, off- and online. Based on a survey conducted among the e-Business Pilots, around 90% of SMEs who contacted the Pilots could be helped.

The concrete results of the initiative are hard to measure, since there are no regular surveys among SMEs for these topics. In addition to the primary effects for the designated target group, considerable, sustainable, secondary effects through other multiplicators should also be taken into account: methodical knowledge has been documented and published for knowledge transfer, the need for neutral information points has been emphasized vis-á-vis chambers, associations and educational facilities, the universities which were part of the project aim at continuing to make digitalisation of SMEs part of their curricula, and a part of the structures implemented through the project will continue to work (at least with a reduced range of offered services) under new project co-ordinators and financing.

Lessons learned

So far, the various initiatives have shown that the challenges brought about by digitization vary significantly between regions. For example, we have found that learning cultures are very different, depending on the region, which has to be taken into account with regard to the format of events as well as of publications. Addressing these different cultures and needs has proven very important for the success of the measures. In the initiative “eCompetence Network for Enterprises”, these regional differences could be successfully addressed by the local/regional “eBusiness Pilots”, which knew whether an entrepreneur’ breakfast, an e-business day during the weekend, webinars, leaflets or other measures would be best for the SMEs in their city/region or for their respective sector.

The initiative also shows that trust is a very important factor for SMEs. Unbiased, official information by the Federal Government has therefore found a lot of acceptance, while information provided by commercial IT consultants is view rather sceptically. So far, the initiative has proven helpful to support SMEs when choosing an appropriate IT consultant for their specific needs. Nonetheless, certain inhibitions of SMEs have to be overcome to prove that information which is provided free of charge is actually of

some value and helpful. There stills seems to be a certain mentality of "what costs nothing is worth nothing" among SMEs.

Finally, it has also proven very helpful to create networks between many different participants and stakeholders (funders, project managers, research institutions, chambers of commerce, industry associations, universities etc.). Furthermore, it has proven very important to create projects which offer opportunities where one entrepreneur can learn from another entrepreneur. To our experience, such measures on "eye level" get the most acceptance from SMEs.

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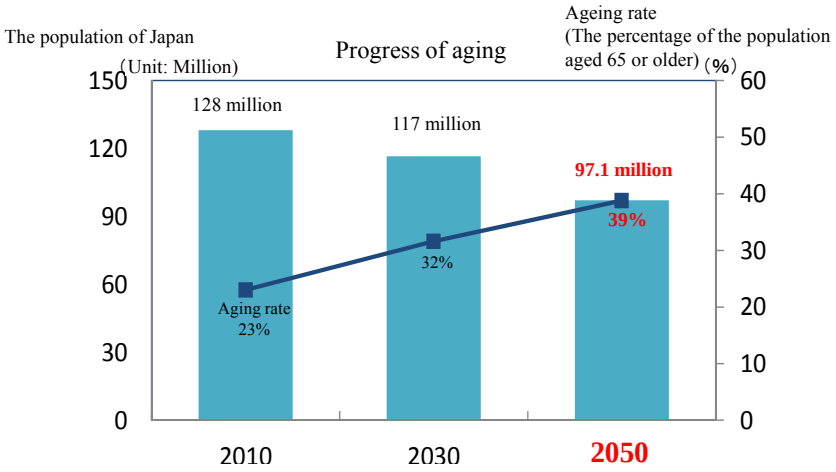
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Japan – Platinum Society

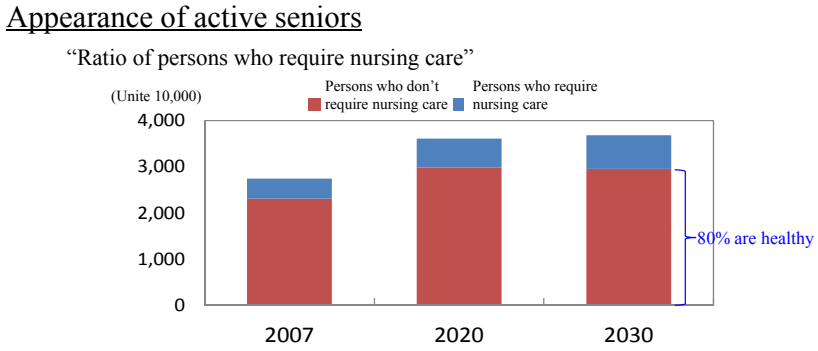
Japan is facing various policy challenges due to the emergence of a super-aged society in Japan. These challenges include:

- Increase in the rate of aging and rapid increase in the elderly in urban areas (see Figure A3);
- Increase in medical spending and decrease in workforce;
- A tenuous level of community consciousness.

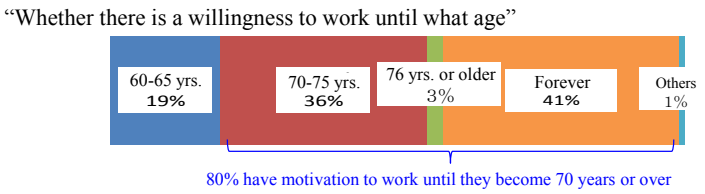
Figure A3 Trends in aging in the Japanese population



Source: FIJITSU Research Institute: Gerontology for Super-aged Society (February 2012).



Source: "Japan Industry Midterm Outlook" Industry Research Division, MIZUHO Corporate Bank, Ltd (May 2012).



Source: The Institute of Gerontology, the University of Tokyo (June 2011).

Programme design

Objectives

The initiative aims at promoting the realisation of a "Smart Platinum Society" where all generations of people can be active thanks to innovation (including ICT).[119] To realise a "Smart Platinum Society" the following points are envisioned:

1. Vision I: Live independently by maintaining health for a long time
2. Vision II: Work with motivation and participate in social activities
3. Vision III: Creation and global expansion of new industries in response to super-aged society

Barriers to be addressed

The following barriers will be addressed:

- A low public interest in health (disease prevention), thus requiring efforts toward elicitation.
- The potential of the elderly is not sufficiently exhibited in the super-aged society.
- Many areas hesitate to introduce a network (called Electrical Health Record) for medical information linkage or cannot maintain the network for a long time, because the network requires high introduction and operation costs.
- Social security costs (medical care and long-term care costs) need to be suppressed because they pressure the finances of the country.

Policy levers/instruments

The initiative was supported via a budget of EUR 11.8 million for financial year (FY) 2013 (supplementary budget) and EUR 1.3 million for FY 2014 (initial budget) for the implementation of the Smart Platinum Society. In addition, EUR 3.6 million (FY 2015) was provided for a project on next-generation medical and long-term care and advancement of health ICT infrastructure. Furthermore, EUR 1.1 million (FY 2015) was provided for supporting a new work style of ICT-related employees.

The initiative includes the following policy levers:

Vision I

- Establishment of ICT health models (for disease prevention): health promotion models based on the analysis of medical examinations and receipt data;
- Nationwide deployment of infrastructure of medical and nursing care information linkage: including (i) Electronic Health Record (EHR) minimum base models, and (ii) Promotion of home care and long-term nursing care information linkage;
- Creation of life support business via comprehensive data linkage models in related fields, including the health, medical, and nursing care fields;

Vision II

- Improvements in ICT literacy: including through workshops and by learning and teaching each other;
- Realisation of new work styles through flexible working models in response to the employment environment and lifestyle;
- Development and practical application of robots including social interaction of communications/network robots

Vision III

- Creation of the Smart Platinum Industry
- Global cooperation and international expansion including international cooperation with Europe, the United States, ASEAN, etc.

Implementation

Institutions

The following institutions are involved:

- The Ministry of Internal Affairs and Communications in cooperation with the Ministry of Health, Labour and Welfare promotes the project.
- The Health and Medical Strategy Office is the playmaker of the Cabinet for the health and medical fields.

Results / impact assessment

The following results could be achieved so far:

Vision I

- Establishment of ICT health models (for disease prevention). This includes the development and deployment of health-promotion models based on the analysis of medical examinations and receipt data. The health-promotion models have been verified by taking advantage of incentives, such as generic points (the number of monitoring people: 20 000). As a result, the interest of previously indifferent people could be raised and related activities promoted.
- Nationwide deployment of infrastructure of medical and nursing care information linkage. This includes the development and deployment of an Electronic Health Record (EHR) minimum base model. The infrastructure of inexpensive minimum medical information linkage of high quality where small and medium-sized clinics could participate has been verified (the number of participating institutions: 34; the number of verification monitoring people: 76). The cost was halved as a result of utilising ICTs, including cloud computing. Furthermore, the standardisation of information linkage in the home care and long-term nursing care fields was verified (the number of participating institutions: 50; the number of verification monitoring people: 130).

Organised items were shared in the standard specifications of the system and in the home care and long-term care fields, and published as documents.

- Creation of life support business. This includes comprehensive data linkage models in related fields (including the health, medical, and nursing care fields), established effective models of a comprehensive community care system utilising ICT, and supported local governments addressing the solution of challenges in the super-aged society (currently ongoing).

Vision II

- Improvements in ICT literacy through lectures. ICT-related lectures were held in local public facilities such as community centres. Literacy improvements were noted, including elderly people that could pleasantly utilise ICT as a convenient tool in their daily lives.

- Realisation of new work styles. This includes the promotion of flexible working models in response to the employment environment and lifestyle. Telework models targeting organisations, such as small and medium-sized companies were verified, challenges based on the industry and company size, and established telework models identified.

Vision III

- Global Cooperation and International Expansion. This includes international co-operation with Europe, the United States, ASEAN, etc, the introduction and verification of a health management system for patients with chronic disease in Singapore and the remote diagnosis system in Thailand toward an overseas expansion of ICT system services in the medical field. Furthermore, the joint research and development of communications robots with EU (currently making an appeal for plans) is being planned.

Lessons learned

The main lesson learned include: the importance of incorporating the vision of a "Smart Platinum Society" into Japan's ICT policies.

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Korea – Creative Economy & innovation centre

A **creative economy & innovation centre** is an integrated facility located nationwide specialising in the regional specialty to enhance the creative economy initiated by President Park Geun-hye by:

- supporting start-ups and SMEs in each specialty area,
- organising the partnership or ecological relations between the relevant big corporation and regional enterprises,
- arranging funds for them to overcome financial difficulties,
- encouraging managerial and technological innovation and advisory services (called mentoring),
- promoting communications and cooperative works among participants, and
- exploring new markets at home and overseas in a concerted manner.

Since Daegu Center opened in September 2014, a total of 17 centres started operations nationwide taking advantage of their specialty in the region.[120]

Programme Design

Objectives

The creative economy & innovation centre has the following four objectives:

1. **Supporting any individual or entity with creative ideas for commercialisation**: providing one stop service to commercialise business ideas and establish a hub of regional entrepreneurial activities.

2. **Playing a leading role in facilitating innovation in various regional entities and nurturing specialised regional businesses**: collaborating with the "Techno Park," research institutes and universities in each region to select strategic business areas that are closely related to the region's specialties and to the major business of the key hosting corporation in each regional centre, and developing the selected businesses into a new frontier for future growth.

3. **Providing a business platform for the innovation and growth of start-ups and SMEs in collaboration with large corporations**: nurturing start-ups and SMEs as a business partner of incumbent corporations for cooperation and co-prosperity by providing necessary assistance in production development, market entry and overseas business expansion based on the know-how and network of the partner corporation.

4. **Creating or matching more jobs for young people using the network of each innovation centre**: identifying the employment demand and supply in each region and generating more jobs for young people in co-operation with industries, universities and job centere in the region.

Policy levers/instruments

In order to achieve the abovementioned goals, the creative economy & innovation centre project launched several coordination bodies and carried out regulatory reforms.

- The Operation Committee for Creative Economy and Innovation Centers, which consists of officials from the Ministry of Science, ICT and Future Planning, Ministry of Trade, Industry and Energy, representatives from partner corporations, and the head of related local municipalities, was launched.

- A Regional Creative Economy Council for each creative economy & innovation centre was established to identify and pursue projects for the development of the creative economy in the region and public-private collaboration.

- The National Council of Creative Economy & Innovation Centers was launched to enhance cooperation and information sharing among creative economy & innovation centres across the country.

- Regulatory reforms to lay the legal basis for the centres were carried out, including the revision of the Regulation of the Establishment and Operation of the Public-Private Joint Committee for Creative Economy, etc. and the revision of the Framework Act on Science and Technology.

Implementation

The launch of creative economy & innovation centres in 17 large cities across the country was announced in January 2014 as part of Korea's initiative to establish the offline platforms of the creative economy, and an investigation and analysis of innovative infrastructure in each region was carried out in the same month to prepare for the establishment of creative economy & innovation centres. In March 2014, the 'Plan for the Establishment and Operation of Creative Economy and Innovation Centers' was developed to provide a more detailed plan for the installation of 17 Creative Economy & Innovation Centres. Furthermore, Creative Economy Councils were created with the aim of boosting the regional economy by supporting the commercialisation of creative ideas and the growth of start-ups, SMEs and other regional enterprises. To encourage the participation of large conglomerates in the country's creative economy initiative and create a win-win relationship between start-ups and SMEs and conglomerates, a strategy for building a partnership between a regional creative economy & innovation centre and a large corporation was devised in September 2014.

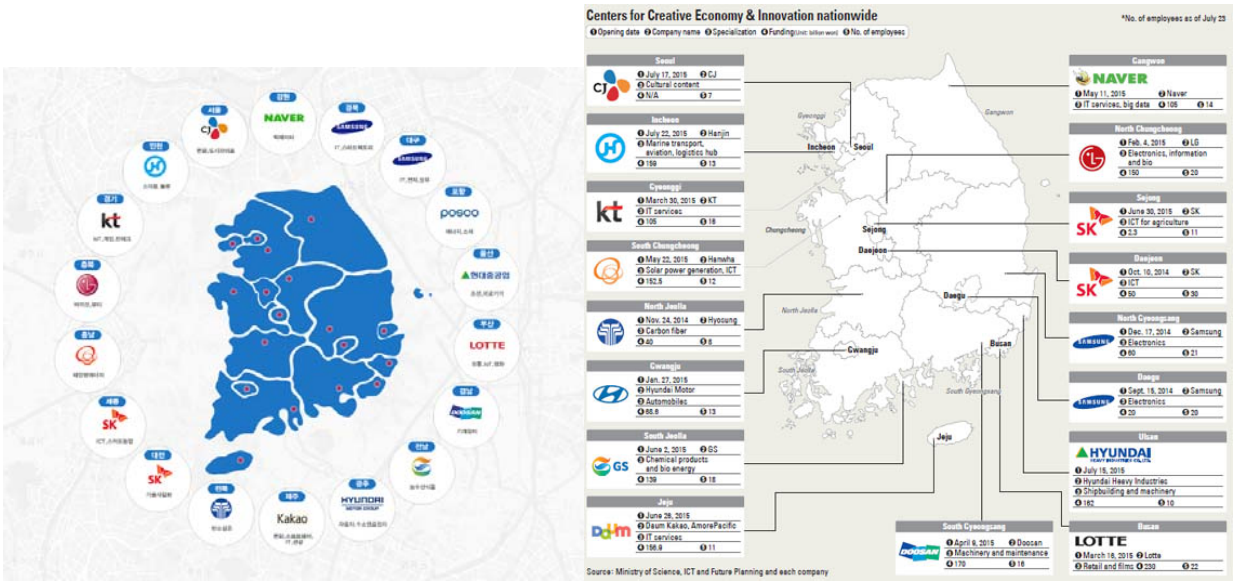
In October 2014, the 'Creative Economy & Innovation Center Operation Plan', which includes a new vision and operating model for the centres, was announced with the objective of creating a sustainable system for the centres by strengthening co-operation with regional organisations and incentivising large corporations to participate. In July 2015, when the establishment of Creative Economy & Innovation Centres had nearly completed, the 'Plan for Expanding the Functions and Activities of Creative Economy and Innovation Centers' was announced to monitor and evaluate the current status of 14 centres and shed new light on the role of the centres in creating a sustainable regional innovation ecosystem. To generate more jobs for young people in local communities, a plan to expand job opportunities for young people using Employment Zone at Creative Economy & Innovation Centres by providing job training, internship programmes and job placement services was prepared in August 2015. In December 2015, strategic business areas for each regional centre were selected and announced after considering each region's specialties, major industries, and potential for further development and integration with related industries.

Table 1. Location and theme

Region	Theme & specialty	Corporation in charge
Seoul	Culture & lifestyle	CJ
Incheon	Logistics industries, aviation	Hanjin
Gyeonggi	IT-based convergence industries	KT
Chungnam	Clean energy, agriculture as the 5th industry	Hanhwa
Daejeon	Global venture business	SK Telecomm
Sejong[1]	ICT-based agriculture	SK Telecomm
Chungbuk	Bio & beauty, environment-friendly energy industry	LG
Jeonbuk	Carbon-related industries, traditional culture	Hyosung
Jeonnam	Bio-chemical, new materials and convergence-oriented agro-fishery	GS
Gwangju	Mortor vehicle-related start-up and common people-oriented innovation platform	Hyundai Motors
Gyeongbuk	Smart factory innovation, convergence type culture and agriculture	Samsung
Daegu	Fashion, machinery and automobile parts, traditional industries	Samsung
Ulsan	Ship-building & marine plant, medical automation industry	Hyundai Heavy Industries
Gyeongnam	Machinery manufacturing innovation	Doosan
Busan	Global distribution, Film and video-oriented ecology, IoT-based smart city	Lotte
Gangwon	Big data, crowd sourcing tourism, health care and smart farm	Naver
Jeju	Smart tourism platform, electric car and renewable energy	Daum-Kakao

Source: http://koreanlii.kr/w/index.php/Creative_economy_%26_innovation_center

Figure A4. Regional clusters for promoting digital innovation in Korea



Source: http://2.bp.blogspot.com/-ikUC_ZsKGFw/VbjFRgo3ttI/AAAAAAAAFnw/3JBaseEQplY/s1600/centers-for-creative-econ.jpg

Institutions

Several public and private entities participate and support the creative economy & innovation centre project, including the Ministry of Science, ICT and Future Planning, local governments, key hosting corporations, and Creative Economy & Innovation Centres.

- The Ministry of Science, ICT and Future Planning is responsible for overall development and coordination of policy for Creative Economy & Innovation Centres, inter-ministerial cooperation, regulatory reforms and progress monitoring.

- Local governments provide financial and personnel support for Creative Economy & Innovation Centres, and coordinate partnership and cooperation between the centres and regional entities.

- A key hosting corporation paired with each regional creative economy & innovation centre provides support for start-ups and SMEs in product development, market entry and overseas business expansion based on its know-how and network.

  – Creative economy & innovation centres serve as an open innovation channel for these large-sized companies in exploring new business ideas as they have opportunities to work with small but creative start-ups and SMEs discovered by the centres.

  – This is a win-win business model where participating conglomerates, start-ups and SMEs collaborate in R&D, product development and marketing, and share profits.

- Creative economy & innovation centres serve as a regional hub of the creative economy initiative and facilitate exchanges and collaboration among participating entities.

Results/impact assessment

There are three important achievements of Creative Economy & Innovation Centres as of the end of 2015.

- **Support for start-ups, SMEs and regional strategic businesses:** as the centres currently serve as business incubators for 578 start-ups, their combined revenues have increased by approximately KRW 33.7 billion with 283 jobs newly created. With regard to support for SMEs, the centres have been providing financial and sales support for the development of viable business models and new products, for the introduction of smart factories as well as for patent application. In terms of fostering regional strategic businesses, the solar business hub (Chungnam), carbon business incubator centre (Jeonbuk), IoT-based smart city (Busan) and smart farms (Sejong) are in progress.

- **Expansion of the roles and activities of the centres:** The centres have expanded their roles and activities by establishing links between their programmes and government initiatives, as well as by strengthening collaboration with local governments, regional industries, universities and research institutes.

Globally recognised achievements

(TEGway) The wearable thermoelectric generator developed by Korean start-up TEGway, which has been supported by Daejeon Creative Economy & Innovation Center, received the grand prix award for top 10 emerging technologies that would change the world selected by UNESCO.

(IRIENCE) The ITU Telecom World 2015 selected IRIENCE, a Korean start-up, as one of the three recipients of the Entrepreneurship Award for the company's iris recognition device.

(DOT) Another start-up, DOT Incorporation, was also hailed as the Winner of the ITU Telecom World Entrepreneurship Award in 2015 for its braille smartwatch and this world's first braille smartwatch was introduced in Times magazine in August 2015.

Lessons learned

- For the country's creative economy initiative to produce tangible results, a variety of support programmes that boost entrepreneurship and innovation, and that provide support for younger people in local communities to turn their creative ideas into new businesses should be continuously developed and implemented.

- The most unique aspect of Korea's Creative Economy & Innovation Centres is the pairing of a large conglomerate and a centre. To ensure sustainability in this Korean model for creative economy and innovation, a collaborative ecosystem in which large corporations, start-ups and SMEs can work together to create and share profits, and co-prosper should be established.

Mexico – Creative Digital City

Creative Digital City (CCD) is the restoration of an urban environment to consolidate an ideal space for people, a modern and interconnected stage where talent and creativity breed knowledge, boost the use of new technology, and improve the quality of life in the Guadalajara Metropolitan Area.

Located in the heart of Jalisco's capital, CCD concentrates creative industries such as studios involved in the production of film, television, videogames, CGI, interactive media and mobile apps, among many others, thus positioning the state as a productive centre that is relevant to a sector that constitutes the vanguard of global economy today.

Introduction

Since its inception, CCD was designed as an ecosystem, a place that favours creating and sharing knowledge and development opportunities with a high impact on productive, social and cultural matters.

That is why it is located in downtown Guadalajara's heart, one of the most beautiful and emblematic cities in Mexico, surrounded by the traditional Morelos Park, with the conviction of creating new opportunities and recovering the quality of the neighbourhood in this area that is so important for the community of Guadalajara.

- To strengthen Mexico's position within the creative economy through the creation of more and better jobs, competitive advantages for the industry and new spaces that foster talent, innovation and productivity.
- To identify and maximise the creativity, the talent, the courage and the determination that characterises people from Mexico and Guadalajara through a space where using technology and boosting innovation offer economic, transportation, environmental and social benefits.

Therefore, CCD is positioned as a global node of audio visual, digital and interactive production for the world and Hispanic markets, which guarantees the materialisation of a world-class sustainable, productive and innovating integrating model.

Jalisco's geographical location and the moment that currently identifies it as an information technology producer constitute the ideal context to internationally showcase the talent and potential that Mexico has in terms of content creation.

Furthermore, the state's closeness to the United States of America and South America, as well as its contiguity to the Pacific and Atlantic Oceans, makes it an interconnected geographical point that offers competitive and strategic advantages for an efficient mobilisation of products and services with added value.

Programme design

The brain of the Smart City

The Data Centre is the core of the Creative Digital City's (CCD, by its initials in Spanish) technological infrastructure. It gathers the telecommunication and digital processing resources that will contribute to develop creative industries, innovation and entrepreneurship.

It is the control panel of the Smart City's Urban Operating System (UOS) and it analyses data collected from sensors and devices installed on water, power and transport infrastructure, as well as on maintenance services and telecommunications, in order to optimise and predict actions depending on the circumstances of the moment.

Its **design** is flexible and scalable in accordance with the growth and demand of the activities taking place in CCD. It will be a support node for creative and technological industries and entrepreneurs.

Objectives

Creative Digital City's (CCD) development plan is designed to work as a catalyst for innovative ideas in one of the sectors with the most productive and economic growth worldwide: the creative industry.

The plan is aimed at two great strategic lines. The first one consists of strengthening the creative digital industry, capable of generating intellectual property expressions linked to technological innovation; the second one, in establishing a competitive and entrepreneurial framework.

The digital hub is a concrete action that serves this purpose through an urban and connectivity infrastructure that allows to secure business networks and strong profitable collaboration links in all the creative ecosystem's value chains.

Within this entrepreneurship framework, CCD has the following initiatives:

- CCD VENTURES: it´s a venture capital fund, which will be distributed between April and May 2015 to the most outstanding projects from a list of 300 registered participants.

- CCD Incubator: still in the process of development, this instrument will lead, with an entrepreneurial approach, the formation of creative digital projects, many of which will launch from those registered to CCD Ventures.

Barriers to be addressed

Having in mind the size and magnitude of the areas that this initiative encompasses, it's not difficult to foresee the challenges that results from positioning the identity of Guadalajara and Mexico within the growing industry of media, such as: internet, cine, digital games and mobile applications.

Therefore, and in response to the challenges that this digital revolution imposes, the Master Plan of CCD combines the physical design with the master digital planning. This is based on the acknowledgment that that, for the urban environment of tomorrow, a bit will be as vital as an atom and the silicon as construction material will have the same relevance as the concrete. This plan of digital nature includes a number of ways in which the digital sector will make from CCD a unique place to live and work.

At this moment, the telecommunications infrastructure in the downtown of Guadalajara offers a good base to access a high-speed internet and wireless network. However, because of the nature of the project of CCD and the industrial sector that would be located here, there is a need to review the key aspects of the existent infrastructure, the capacity to grow and the property of the network to ensure that a good telecommunications platform and infrastructure exists. Such aspects are:

- **The actual juridical framework of telecommunications in Mexico.** The regulatory framework of telecommunications in Mexico could restring the development of a telecommunications network. The licencing requirements should be carefully analysed for a better comprehension of the opportunities. It will require detailed conversations with the regulatory entity and the enterprises of telecommunications for a deeper understanding of the possibilities.

- **Duct Network and the actual physic fibre.** Any duct network and fibre proposed should be integrated in the infrastructure of the duct and in the existing fibre of telecommunications. The

physic capacity of the existing network ducts is unknown at the moment and it could prevent the addition of more fibre to extend the network of CCD.

- **Centrals capacity for international connectivity.** The kind of industry that is expected to be attracted by CCD will require international connectivity with a high broadband. The capacity of the existent international central could be a restriction to provide the levels of connectivity required.

- **The capacity of the backbone network in the level of the city.** It is possible that the capacity of the backbone network fibre of the city will not be big enough to manage the requirements of the additional broadband implied in the connection of the CCD polygon.

Implementation

Authority of Digital Governance

The digital governance include: people skills, leadership, organisation, process, policies and necessary measures to successful administer, and manage the integration of the digital services (hardware and software) through CCD.

The key functions include but are not limited to:

- Provides orientation to ensure that data are precise, coherent, complete, available, safe and that integration of different systems follows the orientations, policies and established rules.

- Provision of data security measures including regulation and control of sensitive or confidential personal data.

- **It is not an IT function** - should be property of CCD and it must be implemented across the company.

- It **is a long-term initiative** that should be planned and sponsored in the highest level of the company.

- It is established across the company and it cannot be seen as optional.

- The Governance initiatives of digital data services must be legitimated by:

  – Communicate a convenient vision,

  – Establish achievable performance goals, and

  – Allocation of the company resources.

A successful data governance begins with the organisations, roles and right responsibilities. All models should include, as minimum, the following functions:

- **Executive Sponsor**: Tend to be legally responsible for the quality and precision of the data, and they should trust the internal controls to administrate the access, use and quality of data

- **Management Committee**: as a direction committee, must have real authority, including the capacity to solve business problems, approval projects, and dispute resolutions. The committee shall be directed by a leader of data governance.

- **The data owners or business administrators** are responsible for data creation and implementation of business rules of the company, including the data and norm policies

- The data administrators are the data caretakers and are responsible for the management of the data assets. They have some clear responsibilities that include:

  – Ensure the efficient use, share and understanding of data and that complies with the quality and integrity standards.

  – Help to enforce the normalisation and adhesion of regulations and policies

  – Facilitate the participation of supportive organisations (for example: internal legal auditory) to guarantee that data are complete in its content and that it complies with all the business requirements.

Valuation of High Level Technology

Three potential partners of technology provide the infrastructure for cities to facilitate the integration at large scale of systems across the municipal services:

- **Accenture**: is an independent provider of hardware and a partner of software, with experience in multiple products. They have demonstrated experience in integral solutions for which the solution of the urban operative system will collaborate with the cities to create unified architecture for the delivery services and the function of an information services market

- **IBM**: offers a wide range of products and services, including network solutions, public services operations, assets management and cybersecurity. IBM accounts with well-developed channels, extensive resources and a great environment of system integrators and third parties providers to support its multiple offers for the city

- **CISCO:** include products and services through smart networks, videoconferences, dynamic management of transport, automation solutions, an urban operative platform, and smart communities.

The smart communities assist in transforming physical communities to connected communities to help:

- perform a sustainable economic growth

- enable the environmental sustainability through resource management and operational efficiency

- improve life quality of the citizens from the communities.

Taxonomy of public and private associations (PPP)

These services have been identified as services based on concessions, for the reason that CCD could easily create agreements at service levels with third parties.

- **Public Digital Screens**: As part of the sustainable vision that CCD offers its residents and projecting to the world, the display of the use of renewable energy showcase an important technology. More information could be displayed including the air and water quality and the green options of transport. The smart parking meters could encourage behavioural changes in individuals and they could serve as visual representations of the sustainable activities of the enterprises, encouraging more awareness and investments in renewable and sustainable energy.

- **Creative Software based on the Cloud for users registered teachers:** it will allow the registered users to use the software at any place where they get access to the cloud. This will increase the overall quality of content and creative digital projects from the CCD, since users have access to the latest version of software through any location. Revenue could be generated from subscription payments in advertising income. Therefore, it is expected that there will be a strong interest from the private market in this project. This could allow the provision of the monopoly of this service within the area of the CCD, which would encourage the provision of this service to allow the provider invest in the infrastructure in a low-risk environment. In addition, this would generate income for CCD

- **Smart Public Lighting**: The public lighting is a key public service provided by the public authorities to local and municipal levels. Good lighting is essential for the roads and security staff. Public lighting ensures the visibility in the dark for drivers, cyclists and pedestrians, thus reducing traffic accidents. Indirectly, public lighting also facilitates crime prevention through the increase in the sense of security and personal protection of the public and private properties adjacent. Due to its public good nature (non-exclusive and non-rivalrous use), this service would not be supplied by the private market without public incentives. Therefore, our main recommendation is a concession around a structure of building, managing, and transfer that will be put out to tender for potential suppliers who wish to compete for the contract of the public authority.

- **Park Smart**: Parking is expensive and limited in almost all major cities in the world. Innovative systems are needed to park to satisfy in the short-term the parking demand, to increase the efficiency of the time and the emissions of the conductors. Due to the high demand of time and services of fuel saving, this could be a profitable company and therefore, our recommendation is that the concession is granted through a competitive bidding process and run in an operation of construction-property-management and transfer. The auction creates income for CCD, allows that "experience" of the private sector run the operation and in the same way, allows the control of the public lands, as the roads.

- **Platform for Distance Education**: The increasing accessibility to services for distance education to local residents through the physical infrastructure is a public service that will handle low levels of operators' revenues through advertising, instead of costs of use. Therefore, our main recommendation is that this is served by a concession with license under a structure of building, managing, and transferring. Allowing the contractor to cover its original infrastructure investment cost and agreeing on profit margins, may help overcome the lack of incentives due to the public nature of this service.

- **Live labour Marketplace**: a digital centre as the CCD attracts residents with a highly-skilled labour force. This opens opportunities for digital television. The companies make use of the specific role of advertising as well as the workers unemployed since their skills tend to be suitable for your needs. This could be expanded from announcements of specialised labour, to be an active market where the demand is quickly satisfied by skilled labour, which minimises the costs of delays and offers support when needed.

Our main recommendation to encourage the creation of a labour market of public access is to allow market forces to shape the project, animated by a highly regulated market where the license to run the application will be concessioned to a certain number of participants or to a single participant.

Institutions

The Master Plan of CCD emerges from an unprecedented collaboration of private industry, all levels of government and international experts, along with the citizens and institutions of Guadalajara. Together they have define a model of an advanced city that waves together the existent urban fabric with the new digital enterprises, production, education in new skills and places to live, shop, eat and play, all centred in *Parque Morelos* in the historic hear of the city.

This plan lays out a practical roadmap to achieve these objectives based on an integral strategy of phase development:

- *Phase 1*: the process begins with a series of catalyst projects to establish the physical infrastructure and the institutional framework of CCD. The catalysers include: the restoration of *Parque Morelos* as the central piece and front door of the project, the creation of the "Ingenium" – a campus devoted to training for work in digital media industries; and a New Mexico Media Museum of media and marketing centre. Facilities are planned to accelerate the growth of local start-ups, as well as to attract a flagship global company to anchor the district.

- *Phase 2*: it will focus on the attraction of critical mass of production and media companies, services on CCD trust-owned sites surrounding *Parque Morelos*, and launching a host of digital services to support the companies, workers and residents.

- *Phase 3*: the next 10-12 years will see maturation of CCD with retail, restaurants, entertainment and housing along active urban streets enabling a high quality of life

In many ways, CCD is already underway. It was launched with the establishment of the Guadalajara CCD Association Civil (A.C.), a partnership of public and private entities which manage the process and push forward on the implementations of catalyst projects. After extensive analysis, CCD has received DUIS certification, from the federal government, as a sustainable and feasible project eligible for federal assistance.

National/subnational/supranational/regional policy coordination

The proposed territory for Digital Creative City in Guadalajara shows a complex composition of actors and interests, which suggests a high-conflict possibility, but at the same time represents a great opportunity to create new ways of relation and management.

Speaking of urban transformations as it is sought in CCD Guadalajara, a key element should be inclusion. Inclusion does not mean that that everybody forms part of everything, all the time. Rather it assumes a characteristic of the project from its conception to the operations phase: an urban design whose borders look up to what is left out of the polygon performance, allowing the entry and continuity of the dynamics of change; it is about designing an open system, contrary to what is usually thought in the logic of enclaves, where the borders are barriers that intend to keep at bay, the urban elements from the context where they are being inserted.

Inclusion also refers to the planning and managing processes regarding its capacity to attract and permit the attendance of the actors that show an honest interest in the development of the zone of action. This presumes recognition on the potential contribution of each one of the actors when they enter this multilateral exchange dynamic that seeks opportunities and solutions. The local actors have a high creative potential that should be included in the equation of the city model that recovers its cultural, intellectual, economic and identity resources to consider a new direction. This is seen as a differentiation factor.

The land-use planning is related to a wide range of local, regional, national, and community policies and especially among them, those of regional development, urbanism, housing and infrastructure. However, there are still predominating the approaches, interests and sectorial competencies over the horizontal/territorial. Given that the space, land or territory, is a limited asset and it's planning and use conditions the possibilities of the future development, care should be taken on the coherency of the group of actions to develop upon it.

The concept of territorial governance proposes to understand planning as a practice or process of organisation of the multiples relations that characterised the interactions among actors and diverse interests on the territory. The outcome of this organisation is the development of a shared territorial vision, sustained in the identification and valorisation of territorial capital, needed to achieve the sustainable territorial cohesion at all different levels, from the local to the supranational.

Results / impact assessment

There are 6 strategic axes of CCD that seek an interconnected, sustainable and flexible environment in the city:

- **Component**: Its goal is to be an economic attraction centre and a reference for a smart urban model that provides a high quality of life with great respect for the history in which it is embedded. It is an adaptable project to rescue both open and closed spaces in Downtown Guadalajara to create a new sensory experience with the proper selection of housing, productive, commercial, entertainment and educational areas.

- **Transport**: A safe, accessible, efficient environment promotes pedestrian traffic and aids to discourage the use of cars as the main mean of transportation. CCD's transportation strategy is set at a large scale together with optimisation transport policies in metropolitan areas. The light rail, BRT and a public transportation route re-engineering, as well as a network of park-and-ride car parks, are fundamental part of the strategy. They are completed by public bike and shared taxi services in Downtown Guadalajara, plus the consolidation of an agile airport transfer.

- **Infrastructure**: The implementation of advanced infrastructure international norms will improve CCD users' quality of life and will contribute to their sustainable vision. The area will have accurate solutions to prevent natural resource waste and exploitation through a smart operating system and a waste re-use strategy. A data center will be installed to channel the information produced by the use of space and natural resources and telecommunications. CCD will have rainwater and wastewater harvesting and treatment systems, and it will benefit from renewable energy and recycling, and waste management plans.

- **Sustainability**: The design of buildings, distribution of courtyards, and organisation of interior spaces and optimisation of public services, follow CCD's sustainable approach aimed at being a development with zero carbon footprint. The whole complex will be put through the Leadership in Energy and Environmental Design (LEED) certification, which sets actions to reduce carbon dioxide (CO2) emissions and urban heat islands, run an efficient water an energy management, increase thermal mass, improve waste collection, and use low polluting materials.

- **Smart City**: The city as an entity that adapts immediately to its surroundings and that responds to the community's needs, the activities performed and the environmental conditions in real-time thanks to a series of sensors and devices linked to the Data Center that positively impact economy, productivity and sustainability. The CCD will have sensors to measure and control the status of the green spaces, street lights, security and water supply, among other services. There

will be a series of interactive kiosks with relevant and updated information for users and it will have free Wi-Fi access for them.

- **Urban Design**: Urban intervention in CCD is aimed at establishing a mixed use model, with an adapting future scheme that fuses creative industry spaces with educational, housing and commercial spaces, with multiple open areas for human interaction within a pedestrian enjoyment range. Split into four sectors — with Morelos Park as the fundamental piece, — CCD's buildings will be an example of rescue and rehabilitation of patrimonial estate, their integration with new infrastructure and their close relationship with multiple story courtyards, distinctive of traditional Guadalajara.

From the overall Master plan it is expected the following results and benefits:

- three urban renewal typologies have been identified, exemplifying rehabilitation and integration of historic and contemporary architecture.

The potential benefits from CCD include:

- 33 000 new jobs, and
- 550 businesses by 2023.

Approximately:

- 70 representative digital services have been identified; this is not a comprehensive list, but represents the fact that the digital shall be at the core of CCD's development and supportive of its growth.
- 70% energy demand onsite reduction and;
- 40 000 tons per year less of carbon emissions from CCD.
- 83 technical specifications DUIS submitted: the DUIS strategy is an align effort of federal government to promote a more orderly and sustainable urban development of Mexican cities.
- More than 100 institutions and individuals are involved on the development of CCD – with a digital approach of citizen empowerment, the CCD can be the ideal way for enhancing interactive use of new technologies and digital inclusion within the community.
- The first 100 years of capital is at the centre of the design for the governance and operating models. They have been designed to be representative, robust and detached from the impact of political circles.
- CCD will create the first green infrastructure in Guadalajara at Parque Morelos a 0.25 ha, water retention pond system for all storm water from buildings.
- A 45% reduction of the overall number of parking spaces required by standard code, thanks to the sustainable multimodal transit approach and an increase in parking efficiency also related to the digital management.

Norway – Telecare: streamlining the Norwegian health and care service

Overall policy objective: Improving patient life quality and achieving significant service time savings by incorporating telehealth and telecare in health and care services

Challenges to be addressed

There is an increasing need to significantly reduce the costs of health and care services while continuing to improve patient life quality. Telehealth and telecare have the potential to significantly reduce operation costs in health and care services.

Estimates show that an average municipality will be able to reduce the operating costs of around NOK 25 million annually in 2030 and NOK 55 annually in 2040 with the use of telecare (moderate impact). Nationally, this means – based on a calculation performed by Ny Analyse in 2015 – annual savings of NOK 23 billion in 2040, and that 19 000 more people can stay at home longer.

Programme design and implementation

In the Oslo Municipality, the Health Care Services are organised at the level of city districts, each district being responsible for providing Health Care Services to their citizens. Four of these districts (Gamle Oslo, Grünerløkka, Sagene and St. Hanshaugen) take part in the Norwegian National Programme for Personal Connected Health & Care, piloting telehealth and telecare technologies as part of their services. Following a shift in strategy of health care and rehabilitation activities, the districts have changed the way they deliver health and care services to citizens living at home. As part of this strategy, they offer assistive technologies to the elderly and remote care to citizens with chronic diseases (including a questionnaire and medical measurements such as blood pressure, weight, blood sugar levels etc.).

Impact assessment

Recent figures show a significant reduction in the need for health care services to citizens shifting from traditional care to technology-assisted care. The average care time at home for this group has been reduced by 59 %, and the number of visits from home care services has been reduced by 34 %. At the same time, the citizens report increased confidence in managing their own health and everyday life, and the majority are satisfied with receiving less visits from careers.

This contentment is reflected in a stark reduction of hospital admissions and outpatient consultations, although there is no evidence of improved medical condition – on average chronic ill patients tend to get worse over time. Nevertheless, after 6 months, the observation group has reduced their number of hospital admissions by 32 %, the length of each admission by 25 % and the number of nights in hospital in total by 39 %. At the same time, the number of outpatient consultations was reduced by 42 %.

Lessons learned

- **Successful implementation** of assistive technologies and remote care largely depends on the involvement of the end users at an early stage, and careful consideration of the end user's capability of – and interest in – benefitting from the technology.

- **Close co-operation between the health care services and the technology providers** is essential to optimise the functionality of devices and services to meet the needs of both care personnel and end users.

- **Benefits of care technology roll-out will materialise over time.** However, the introduction of new technology requires implementation of change management in the public sector. By proper organisation, customisation of services, and supervision of end users, the effects of the technology will materialise gradually.

- **National co-ordinated approaches are needed** to scale the use of care technologies to the whole of the public sector and create conditions for a thriving care technology market.

Sweden – Smart Grids, Gotland

The Smart Grid Gotland project aims to ensure that a large proportion of wind power is integrated into the electricity grid while retaining or improving the power supply quality and allowing consumers to participate more actively in the energy market. Two major activities will therefore be carried out on Gotland in order to achieve these aims:

1. The existing electricity supply network between the Källunge and Bäcks substations will be upgraded to create a smart grid.

2. The project will carry out a market test across the whole of Gotland

There are several reasons for developing the smart grid right on the island. There is a lot of wind on the island, the geographical area is large enough to carry out full-scale projects and the island already has a modern conventional distribution system. Gotland is in a limited area so it is easier to examine how a large proportion of irregular wind power can be handled in the network, without the stability of the transfer being affected.

Project facts

Name: Smart Grid Gotland
Contributing partners: Vattenfall, ABB, Gotlands Energi AB, Svenska Kraftnät, Schneider Electric and KTH. All partners finance the project together with Energimyndigheten (The Swedish Energy Agency).
Duration: 2012 to 2016



Introduction

In the future, electricity will be an environmental and economic energy carrier and will most likely have a more prominent position in the energy system. But if more and more functions in the society will be dependent on electricity then electricity needs to be more reliable and available.

More and more electricity customers want the opportunity to choose energy sources themselves, want the possibility to control their consumption and to have the possibility to affect the cost.

Sweden's target for the share of renewable energy in the year 2020 is 49 % according to the 20-20-20 targets. To achieve this target it is expected that the production of renewable energy needs to be increased.

A large amount of this renewable production will be wind power which is often produced far out in the distribution grid. A large amount of electricity production in the distribution grid brings new challenges when it comes to power quality and surveillance and control of the grid. Wind power and other renewable energy sources such as solar energy also vary over time which puts new demands on the grid. The distribution grid of today was built in the 20th century and a modernisation of the grid necessary.

So what actually is a smart grid? Smart grid is a term that is used increasingly often in today's society in order to describe a complex concept that is not always easy to define in exact detail.

The Swedish Energy Agency's website summarises the term as follows: the term "Smart Grid" is often used to refer to an electricity-based energy system that allows for the following aspects in a cost-efficient manner:

- Connection to large-scale and small-scale sources of renewable energy.
- More efficient control and regulation of components and systems for power generation and electricity grids.
- Adaptation of the electricity grid in order to integrate energy storage solutions and electric vehicles.
- Integration of technology for adjusting consumption based on the availability of electricity. For example, systems that can automatically regulate the usage of energy based on current prices and that provide information allowing active energy usage choices to be made by consumers.

The Swedish Energy Markets Inspectorate (EI) describes the term as follows: "Intelligent networks, or smart electricity grids, refer to the combination of new technology, functionality and regulatory frameworks for the electricity market etc., which facilitate in a cost-effective manner the introduction and use of renewable sources of energy, lead to lower energy consumption, and contribute to reducing power loads at times of peak energy use, as well as creating opportunities for electricity consumers to take a more active role regarding energy consumption." (Smart Grid Gotland website)

Programme design

Objectives

The project Smart Grid Gotland has three overall objectives:

1. Cost-efficiently increase the hosting capacity for wind power in an existing distribution system
2. Show that novel technology can improve the power quality in a rural grid with large quantities of installed wind power.
3. Create possibilities for demand side participation in the electricity market, in order to shift load from peak load hours to peak production hours.

The three objectives have been translated to five measurable objectives:

1. Increase the hosting capacity of wind power from 195 MW with 5 MW by use of load shift.
2. 20% reduction of SAIDI (System Average Interruption Duration Index) in the grid between substations in Källunge and Bäcks.
3. Active participation of 30 industrial companies.

4. Attract 2000 households to participate in a market test under market driven conditions.

5. Active customer will contribute to a load shift of +/- 10%.

Barriers to be addressed

- Ways to increase the awareness of how the adoption and use of ICTs can enable digital innovation, efficient production and productivity growth. Need to show how active participation on the electricity market through the use of ICTs makes it possible for customers to lower their electricity costs and thereby lower the system costs.

- Show how the use of ICT can increase the awareness of how customers can make use of price signals where the price is based on current wind power production on Gotland and announced to the customer by use of price signals communicated digitally. The customers will get an indication whether the price is high or low via a smart energy box and hence be able to affect the electricity cost.

- To stimulate the ICT adoption in SMEs, where adoption seem slower, it is important to also involve some industrial companies. Through smart control system, it will be possible to prioritise processes with low energy consumption when the energy price is high and to run energy demanding processes when the price is low.

- Wind Power Integration: The objective for sub project wind power integration is to optimise the hosting capacity for wind power in an existing distribution grid and to do so in a cost-efficiently way.

- Power quality and distributed generation: The objective of the sub-project power quality is to show that new technology can improve the electricity quality in a rural grid with large quantities of distributed power production to a low socio-economically cost.

- Market test: The objective for sub project market test is by active participation on the electricity market make it possible for customers to lower their electricity costs and thereby lower the system costs.

Implementation

Wind Power Integration

The objective for sub project wind power integration is to optimise the hosting capacity for wind power in an existing distribution grid and to do so in a cost-efficiently way.

The sub project can be divided in four different areas. The sub project will develop and test different technical solutions regarding energy storage, show and demonstrate how feasible wind power generation is to provide services for network support, develop improved processes for information exchange between different system (voltage) levels and develop new SCADA-functionalities to support the smart grid concept.

Power quality and distributed generation

The objective of the sub project power quality is to show that new technology can improve the electricity quality in a rural grid with large quantities of distributed power production to a low socio-economically cost.

The sub project will be conducted in a number of different activities intended to develop and test different technical solutions. The sub project will, for example, show that there are commercially feasible technical solutions such as zone concept and automatic restore of the grid which contributes to decrease the outage time and hence improve the power quality. The sub project will also carry out pilot test that intends to solve problems connected to privately owned photo voltaic systems on the low voltage grid such as over-production.

Market test

The objective for sub project market test is by active participation on the electricity market make it possible for customers to lower their electricity costs and thereby lower system costs.

The sub project will carry out a market test where the price is based on current wind power production on Gotland and announced to the customer by use of price signals. The customers will get an indication whether the price is high or low via a smart energy box and hence be able to affect the electricity cost.

The market test will also involve industrial companies. Through smart control system, it will be possible to prioritise processes with low-energy consumption when the energy price is high and to run energy demanding processes when the price is low.

The market test is planned to start autumn 2013. The market test is open for all electricity customers in Gotland and hopefully approximate 2 000 households and 20 to 30 companies will sign up for the market test, and actively participate on the electricity market under market driven conditions.

Research platform

Smart Grids research platform is the comprising name for the technical installations. The following installations are included in the platform:

- Smart meters: The smart meters will measure energy consumption and also send back information about power quality and outage back to the grid owner. This means that there will be real-time surveillance of the low voltage grid. The smart meters will be installed in approximate 3000 households in the test area between the substations in Källunge and Bäcks.

- Smart substations and rural grid: This sub project includes development and specification of cost-efficient and functional solutions for two substations and for rural grid (e.g. self-healing network and islanding). Besides a photo voltaic test, only technical specifications for the sub project will be developed in part 1 of the project. The physical installations will be realised in part 2.

- Information and communication technology: Every single installation that is a part of the project will be interconnected by use of a very extensive information and communication network. The sub project starts with a specification phase where an IT-security architecture is constructed and where bottlenecks and weak spots are identified. After the installation phase begin, which then follows by the verification phase in order to assure the fiction regarding, for example surveillance, access protection and maintenance of security systems to mention a few of the areas that are verified.

- Smart Grid Control Center: The project will use a new more advanced SCADA system for operation and monitoring of the grid between the substations in Källunge and Bäcks. The smart SCADA differs from a conventional SCADA both concerning scope, the low voltage network is normally not included, and concerning functionality, systems for demand response that are normally left out. In addition to the operative SCADA, there will be a non-operative copy which will be used for research purposes and safe introduction of new grid applications.

- Market installations: The sub project is responsible for procurement, implementation and installation of the technical installations needed to perform a market test with 2000 households and 20 - 30 industrial companies under market driven conditions. The necessary installations, i.e. systems for visualisation of the price signals and systems to make appliances (heaters etc.) react on price signals, will appear different for different customers.

Institutions

Participating organisations: Swedish Energy Agency, Vinnova, Gotlands Vindel Producenter, Swedish Civil Contingencies Agency, SEK (Svensk Elstandard), Power Circle, Region Gotland, Entrepreneurs of Gotland, Svensk Energi, Svensk Vindenergi, LRF, Nationellt Samordningsråd för Smarta Elnät, Swedish Energy Market Inspectorate and Villaägarföreningen.

National/subnational/supranational/regional policy co-ordination

A reference group has been put together for the Smart Grid Gotland project; the reference group consists of representatives from a number of governmental agencies and interest groups (see below). The idea with the reference group is twofold: it ensures that the business community and society in general is kept informed about project activities, and it also acts in an advisory role so that the project can benefit from the reference group's knowledge and experience.

The reference group's meetings have been designed in such a way that details of specific questions and issues are sent to the participants prior to each meeting so that these can be discussed at the meeting. At the first meeting, which was held on 30 November 2012, there was a particular focus on presenting the project and highlighting the expectations of the members of the reference group. At the second meeting, which was held on 11 March 2013, the focus was on the quality of power supplies.

The Swedish government is initiating a new national forum for smart grids. The forum shall support and enable the development of new technology, use and business models in the field of smart electricity grids.

The secretariat of the forum is placed at the Swedish Energy Agency. Members of the steering committee will be appointed in the beginning of 2016.

Lessons learned

- **Importance of awareness:** Results indicate interested and motivated participants becoming aware of possibilities from ICT and investments in ICT infrastructure.

- **Support important to bridges technical barriers:** Challenges regarding communication and connectivity between the installed components for measurement and steering, identified in some cases.

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Sweden – Connected vehicles at Scania

The present Scania case illustrates the process through which investments in ICT investments are complemented with investments in KBC to enable digital innovation, which in turn enhances business performance and ultimately leads to higher aggregate productivity (see figure 2 in the main report). Scania is a large firm which has received innovation support, but this case complements the previous country cases as it aims to highlight the results of the data-driven innovation activities and not the innovation support itself. The results show that improvements are needed to make surface transportation smarter and greener. Connectivity is transforming the transportation system and connected vehicles are at the heart of this transformation. The technical solutions for fully automated vehicles are already here but implementation is hampered as the regulatory framework needs to be updated to become more digitally friendly. The present policy options need to be updated to enable successful connected vehicle implementation.

Introduction

Connected vehicles and new data-driven sources of growth are urgently needed to help the world move to a more sustainable growth path following the financial crisis. Data-driven innovation which involves the creation and diffusion of new products, processes and methods, can be a critical part of the solution. While not a goal in itself, data-driven innovation, as exemplified in the Scania case, can provide a foundation for new businesses, new jobs and productivity growth.

This present case supports the view that governments play a key role in fostering a sound environment for data-driven innovation. The case underlines the importance of state aid for investments in enabling ICT infrastructure, but it also underlines the importance of support instruments with the power to embed data-driven innovation across the economy. It could be both direct and indirect support instruments such as programmes which target data-driven innovation but also more general programmes that can embed data-driven innovation in the design.

It is evident that fully reaping the benefits of digital innovation pose tremendous challenges for policy makers and entrepreneurs alike. Firms now invest as much in intangibles such as software, databases, research and development, skills and organisational capital, as they do in physical capital, such as machinery. Such technological changes are an important driver of growth. Data-driven innovation underpins the growth and dynamism of economies. In addition, productivity is the ultimate engine of growth in the global economy. Raising productivity is therefore a fundamental challenge for countries going forward.

In January 2015, the Swedish Agency for Growth Policy Analysis delivered a report, commissioned by the Swedish Ministry of Enterprise and Innovation, on how the digital economy contributes to economic growth and how it influences the business conditions that spur data-driven innovation and entrepreneurship. Quantitative evidence on how ICT contributes to productivity was triangulated with qualitative case studies on the manner in which data-driven innovation creates value in firms and economic growth of nations. The Scania case[121] is especially highlighted in this case study as it exemplifies how innovative activities contributes to business performance and increased productivity at Scania and to economic growth for Sweden.

Objectives

The Scania case presents evidence on the process through which investments in ICT enable digital innovation, which in turn enhances business performance and ultimately leads to higher productivity. In accordance with the OECD innovation strategy from 2015, in an evidence-based policy process, it may prove essential to highlight evidence on the link between innovation and economic growth.

Policy implications

The present case supports the view that governments play a key role in fostering a sound environment for data-driven innovation. The case underlines the importance of state aid for investments in enabling ICT infrastructure, but it also underlines the importance of state support to development projects directed at data-driven innovation across the economy.

Countries need to seize this opportunity to harness digital innovation to boost economic growth and spur job creation. ICTs have triggered deep changes in economies and have underpinned the forces driving productivity gains. ICTs have enabled the emergence of micro-multinationals (small firms with a global reach), as even tiny firms now have the ability to tap a global market via e-commerce and other ICT tools enabled by broadband. In addition, as this case shows, leveraging the transformative power of digitalisation in traditional sectors such as the transport sector is also essential.

The Scania case shows that improvements are needed to make surface transportation smarter and greener. Connectivity is transforming the transportation system and connected vehicles are at the heart of this transformation. The technical solutions for self-driving trucks are already available, but implementation is hampered as the regulatory framework needs to be updated to be digitally friendly.

In the case study, the informant at Scania explains: "Besides the purely technical challenges of this, there are also issues of liability tied to traffic safety that are difficult to investigate legally and must be sorted out."

The present policy options need to be updated to enable successful connected vehicle implementation.

In addition, the case also shows that Scania is increasingly using the so-called "communicator" to collect data to monitor and analyse the efficiency of the vehicles, thus taking advantage of the IoT. Connected vehicles, generate data, which drives the transformation process, at both Scania and its customers. Still, as business becomes more data-intensive, i.e. fleet management services, the use of data raises the issue of who owns that data, as well as the question of establishing if there is a need to reform the current data protection legislation, in order to further stimulate innovation through more efficient use of data.

Implementation and results

The automotive industry has long constituted a cornerstone of Sweden's exports and employment. Sweden has prominent companies in manufacturing both on the car side and in heavy vehicles. In 2013, means of transport accounted for SEK 125 billion in exports, which corresponded to 11 % of Swedish exports, equal to forest products. According to the Swedish trade association BIL Sweden, the automotive industry currently employs 120,000 people including subcontractors. Like many export-intensive industries, the international and Swedish automotive industry was struck hard by the latest financial crisis. Between 2006 and 2010, the number of those employed in the Swedish automotive industry dropped by 21%. However, both sales figures and employment have recovered since the crisis.

Today's modern cars and heavy vehicles contain a large number of processors and other advanced electronics. High environmental requirements on exhaust emissions, including the Euro 6 standard, are a central driving factor for development towards increasingly advanced technology.

The possibility of utilising new digital information and communication technologies (ICT) constitutes another important driving force. The concept of connected vehicles covers both technologies for optimising vehicle performance, such as in the areas of the environment and safety, and factors for greater comfort for drivers and passengers. The area encompasses many different kinds of uses. Communication often takes place between different units. A connection between several vehicles can, for example, be used to automate the function of maintaining distance between the vehicles. A connection between the vehicle and its surroundings (in the form of the manufacturer, the repair shop or the transport company) can be

useful to optimise fuel consumption or remotely update the vehicle's software. With a digital connection between the vehicle and the driver, possibilities can be created for better traffic safety through analyses of and feedback on the driver's driving patterns and behaviour.

By extension, the development in connected vehicles is leading to driverless cars, a concept that has already come far and has been tested by Google in car traffic in the United States Autopilot functions for automatic parallel parking, automatic braking or active lane control, for example, can be seen as steps on the road to the driverless vehicle and already exist as standards or options in some vehicle models.

Digital development in the automotive industry has been under way for a long time. An important difference today is that the development towards advanced wireless communication technologies and greater computational capacity, creates a need for access to new cutting-edge expertise. This means that the vehicle-makers need to enter new kinds of partnerships with companies in the IT sector. The development also opens up for competition from other kinds of companies that see that their technical knowledge provides opportunities to take over parts of the value chain, in e.g. the transport industry. For automotive industry stakeholders, a highly current and central issue is where the major value will be generated in the value chain in the future and how today's technical development affects this. Stakeholders like insurance companies or suppliers of some large components in the vehicle also believe that their business would benefit from having access to more data from, e.g. the vehicle's sensors. Consequently, these stakeholders also want to be a part of the development in connected vehicles.

Scania has existed for more than a century and is one of the world's largest manufacturers of trucks and buses with operations in a hundred countries in every populated continent. Of the company's total of around 41 000 employees, just over one fourth work in Sweden. Manufacturing is spread over six countries in Europe and in South America.

In 2013, the net sales for the service area accounted for 19 %, which makes it the second largest product area after trucks (64 %). The buses area corresponded to 7 % of net sales and used vehicles to 5 %. Scania has the goal of increasing service sales so that it corresponds to 25-30 % of total sales by 2020. Services in this sense have traditionally comprised technical service or financing of purchases, but are now increasingly shifting towards also covering various connected services. The company counts on connected services accounting for around one sixth of sales in the service product area by 2020. Connected services will also indirectly be a decisive enabler for other parts of the product area to be able to increase their sales.

There are several reasons that Scania has chosen a strategy for greater service content. Since service sales are not affected by economic fluctuations in the same way as sales of newly produced vehicles, the company thereby has an ambition to create a better balance in the company's sales seen over a business cycle. Scania also sees conversion to services as a way of increasing sales by creating new services that meet the changing customer demands in the transport sector. The combination of services and vehicles also makes it possible for Scania to more clearly create its own niche on the market for heavy vehicles. In this area, Scania wants to strive for their connected vehicles to work smoothly in transport companies with vehicles from several different makers in their fleets.

In Scania's judgement, the trend is moving towards transport companies increasingly specialising in their logistics and purchasing repairs and other services externally instead of doing it themselves. The relationship between Scania and their customers is also shifting to being more of a partnership where the companies jointly work to develop and optimise the profitability of the transports. The overall objective of Scania's strategy is to work to improve its customers' profitability. To do this, it is important for the product development towards more sustainable, safe and efficient transports to take place in co-operation with the customers.

The market's development also makes it more difficult for Scania to take payment for certain services that were previously a part of the product portfolio. One such example is support for the management of a

transport company's vehicle fleet, so-called fleet management services. Over time, this service has been standardised. Today, there are third-party suppliers of such systems, putting pressure on prices. This part of the value chain therefore lies partially outside Scania's business today. By developing new services and customer values around this area, based in part on the possibilities of connected vehicles, Scania is building a new position that makes it possible for this market to be taken back in part or in whole.

The basis of Scania's solutions concerning connected vehicles is the communicator, or as they themselves call it: "the black box". The technology for the connection to the network is currently based on mobile communication in the GSM network. This is both for cost reasons and because of the GSM network's large coverage rate. The next generation of black boxes will also have built-in technology to use 3G and 4G in the markets where this is possible.

In order for the system to work and data to be continuously transferred, it is important that the mobile network infrastructure works well and is geographically comprehensive. Without mobile coverage, data cannot be transferred, which also means that there are no connected vehicles. However, Scania has no networks of its own for this, but instead joins partnerships on roaming with large global telecommunication operators to guarantee that this will work.

As a part of Scania's business strategy, the strategic decision was made a few years ago to deliver a communicator in all of its vehicles. This applies regardless of whether the customer's order at the time means that a communicator needs to be installed or not. Despite the additional cost that this entails, Scania considers that the possibilities it provides over time are greater than the costs it entails. A critical mass of connected vehicles is needed to generate large enough data volumes so that the system and services can continue to be developed with high quality. In October 2014, Scania reported in a press release that the company will surpass 100 000 connected vehicles in the rolling vehicle stock at year-end. The company also reported that service sales had good growth. The number of connected vehicles makes Scania one of the largest players in the world in this area as well.

The development of the service portfolio constitutes an important part of ensuring its customers' profitability. Using various (digital) services, Scania aims to influence both the customers' costs and revenues. On the cost side, this may involve more efficient fuel consumption or needs-based service programmes. On the revenue side, the primary profitability factor is the actual time available for transport work for the vehicle, so-called *uptime*.

In manufacturing, Scania works based on a module-based product range where the customers can choose modules for the various vehicle models based on needs. The company has chosen the same starting point for its service portfolio. In the scope of what Scania calls *ecolution*, there are a number of different services, for instance, for reduced fuel consumption and more environmentally friendly driving with the aim of optimising the earnings capacity for the respective vehicles at the transport company by reducing costs. Scania estimates that the users of these services have, on average, reduced their fuel consumption by 10 %. To really get at what affects consumption most in the driver's way of driving, Scania has created a service in this package involving coaching of the drivers based on driving data collected via the data connection. The key here is in creating the right conditions for behavioural changes and pedagogically conveying these grounds so as to generate a difference for the respective driver. The coaching service supplements the possibilities of direct feedback in driving that drivers receive from the vehicle's various built-in warning and support systems.

Another digital service that Scania has launched is *remote diagnostics*. The vehicle's connection provides opportunities for a repair shop or mobile on-call mechanic to read the vehicle's status (error codes and data from other sensors) as early as when the fault is reported. Today, this is instead usually first done when the mechanic is physically in the same place as the vehicle. Remote diagnostics provide the possibility to make the right diagnosis earlier and efficiently remove multiple on-call visits to the vehicle, where it instead is better to order towing from the beginning or where special parts and/or tools need to be brought with to the visit. By being able to study sensor data from the vehicle, it becomes possible to make the right decision about repairs

and more efficiently plan services. There is huge potential in this area. Today, Scania is only at the beginning of this development where just a small share of existing work orders is handled via remote diagnostics.

Through continuous reading of the vehicles' status within a number of parameters, there are also possibilities for transport companies to get daily reports on the status of their vehicle fleet. Based on this data, individual and needs-based service programmes can be developed for the respective vehicle, which would add value for both Scania and its customers. Based on sensor readings and historical data, it is possible to calculate the probability that a certain critical part is at risk of breaking at a certain time. These parts can then instead be replaced before they have time to break. This would in turn lead to fewer unplanned breakdowns of the vehicles and thereby more time for transport work.

From a future perspective of 5 to 25 years, it is predicted that all or part of the driver's tasks will be able to be performed by automatic digital systems. Besides the purely technical challenges of this, there are also issues of liability tied to traffic safety that are difficult to investigate legally and must be sorted out. In the short term, such a development means that part of the driver's time in the cab will be freed up and can be used for other tasks. Based on today's operations, this could, for instance, be the statutory period of rest or administrative duties in the company. It could also have consequences for what skills are needed in a driver. In the long term, this development may mean that the driver is not needed for more routine transport assignments.

With today's existing technology, there is a large supply of various data about the vehicle. Considering the direction of the trend, the supply of data will grow strongly in coming years. For Scania and other companies to be able to utilise this new data volume, new competencies are needed linked to analysing and interpreting data. With large amounts of available data, it is now a matter of sifting through, analysing and presenting the right data at the right time.

Successfully using these new possibilities is in part a matter of new competencies and functions in the company in terms of analysis and calculations. It also means that these competencies must be combined with an understanding of the technology in the vehicles and the specific conditions that exist with regard to communicating with e.g. service technicians the world over.

Being able to concretely demonstrate the benefits of the new digital technology internally at Scania is and will in this context become important, especially so that important functions like service technicians and development staff will want to change their way of working and see the possibilities of the new digital technology. There are so many and so great possibilities that they are difficult to survey, even for those who work with this daily. Scania is just at the beginning of this development. The major business benefit in digital services based on connected vehicles is to be realised in the coming years.

Lessons learned

- **Importance of awareness:** Results indicate interested and motivated participants becoming aware of possibilities from ICT and investments in ICT infrastructure.

- **Support important to bridges technical barriers:** Challenges regarding communication and connectivity between the installed components for measurement and steering, identified in some cases.

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Sweden – Smart and Sustainable City Development

"A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects" (ITU-T, 2014).

Smart City Pilot Projects in Stockholm

There are two leading pilot programmes spearheading the Smart City initiatives of Stockholm, and each is described below.

Stockholm Royal Seaport

As part of the Stockholm Royal Seaport (SRS) urban development project, plans are underway to build about 12 000 new homes and 35 000 new office spaces. The development will largely take place in areas previously used for port operations and other industries. Stockholm Royal Seaport is part of the City's vision of a world-class Stockholm by 2030 and has been selected as one of 18 urban development projects that form part of the Clinton Climate Initiative's global Climate Positive Development Programme.

The SRS project started in late 2012 and is expected to be fully completed by 2030. This pilot programme is founded around seven innovation areas financed by the City and private partners:

- C/O City is a programme to promote "ecosystem services", i.e. to support the increased presence of natural ecosystems within the city. Targeted at the real-estate sector, the programme aims at measuring and promoting the level of "greenness" of a given city district.

- Urban Smart Grid is a programme aimed at renovating the Royal Seaport district with smart grid objectives in mind. In particular, it is expressed via the Active House pilot in which dwellings have been designed and built to take advantage of smart grid energy systems and efficient energy usage.

- The Smart Waste Collection Project aims to develop existing vacuum waste collection technology with world-class solutions for usability, function and sustainability. It offers features such as individual waste tagging (for feedback and information purposes), food waste recycling into biogas energy, waste heat to energy conversion, etc.

- Smart ICT aims at building or re-using a single infrastructure for all of the City's ICT needs in Royal Seaport (transport, logistics, healthcare and media). The goals here are to reduce the environmental cost of infrastructure duplication, enable new business opportunities targeted at residents and empower citizens.

- Smart Communications is a programme aiming at delivering economic prosperity, environmental performance and social equity through a better and more comprehensive use of communications.

- SpaceTime is a smart travel programme designed to help people living and working in the area to travel more efficiently and with as minimal an environmental impact as possible. It works through extensive data collection and sharing to recommend routes, facilitate shared rides and other common transportation opportunities.

- Smart City SRS will integrate and analyse data from the various city sectors, including energy, water, waste and transportation, to provide real-time feedback to city planners, industries, organisations, and citizens. It will bridge the gap between data collection and insight by developing an open data integration platform coupled with real-time analytics and feedback processes.

Årstafältet

Årstafältet is a second, European Union funded, urban renewal project on an area of grassland in the south of Stockholm. Its goals are more focused (if possible) on sustainability than those of the Royal Seaport. It takes place within the overarching ambition for the whole city of Stockholm to become completely fossil-fuel free by 2040, with the immediate objective of reducing carbon dioxide emissions to the equivalent of three tonnes per person by the end of 2015. One of three so-called "Lighthouse City" locations in the "GrowSmarter" project under the European Union Horizon 2020 programme, the Årstafältet project has been formulated around 12 "smart solutions" for sustainable growth:

1. Efficient and smart building shell refurbishment to minimise heat loss and energy consumption.

2. Eco-conscious building logistics in the build phase through efficient transport and a dedicated logistics platform.

3. Smart energy-saving tenants, i.e. tenants who have the tools to use as little energy as possible in their daily lives.

4. Smart local electricity management with a "virtual power plant" concept for small distributed electricity generation.

5. Smart street lighting to reduce energy use, with lamp posts as sites for sensors, Wi-Fi and mobile network equipment.

6. Waste heat recovery to re-use the byproduct of heat-generating systems, such as data centres, for heating.

7. Smart waste collection, with optical sorting of waste, automatic collection, and waste statistics for residents.

8. Big data management feeding all relevant district data into an open data platform.

9. Sustainable delivery to manage up-front the delivery and distribution of goods in the district.

10. Smart traffic management to anticipate travel demand, manage traffic and prioritise certain traffic types.

11. Alternative fuel driven vehicles, integrating charging capability, refuelling facilities for heavy duty vehicles and smart guiding to recharging stations.

12. Smart mobility solutions to implement smart parking and car-pooling as well as bicycle use.

Other pilots

There are many other smaller scale pilot projects that relate to Smart City initiatives in Stockholm. Two of them deserve a quick mention since they are promising approaches:

- The Kista Science City has launched a project called Urban ICT Arena to test the potential of Internet of Things connectivity in an urban environment. This was announced in June 2015 so is very fresh, but Stokab is actively involved in providing fibre to the street furniture that will be used to host devices and sensors for this initiative.

- The Elderly Care Administration of the City of Stockholm is running a small scale pilot in the fall of 2015 to test elderly home care services to 20 fibered homes in the city. The goal is to fine tune the service proposition to be able to offer similar care services to the whole city.

The Smart City Vision

Put together, these pilot projects will explore a lot of the services and applications that are considered the most interesting to deliver the potential of the Smart City. Most of these, however, have not been field tested, certainly not at scale, and that is what makes these pilot projects so valuable. The question remains how they fit into a broader vision.

In 2010, the City of Stockholm published a document entitled Stockholm, The Walkable City. It's a long-term planning document that integrates a lot of the thinking around the city's sustainability objectives. However, it was 2010, and many of the applications that are now being envisaged in Stockholm and elsewhere had not yet been imagined. In 2012, it was only the very beginning of Smart City thinking and, while the e-service programme that the city had put in place was impressive, it was still "only" an e-service programme.

Smart city project in Mamö

In the city of Malmö, Sweden, a new urban district, Hyllie, will be constructed where smart energy solutions including smart homes and smart grids will be key to deliver ambitious sustainability goals for 2020. The project started in 2011 and is financed by the Swedish Energy Agency, Eon, VASyd and the City of Malmö. This is an example of a policy where national funding is targeted towards the demonstration of innovative solutions and emerging technologies.

In Malmö, Sweden, the environment is a key issue and sustainable development is a driving force that unites many of the players that operate in the city. The City of Malmö has ambitious environmental goals: by 2020, the city's organisation is to be climate neutral, and by 2030, all of Malmö will be 100 % sustained by renewable energy.

Hyllie – Malmö's largest development area – will lead the way toward the most sustainable city. To shoulder this responsibility, in February of 2011, the City of Malmö, VA SYD and E.ON signed a climate contract for Hyllie. Under this contract, they jointly undertake to lay the foundation for Hyllie to become the Öresund region's most climate-smart city district and a global benchmark for sustainable urban development. When fully built, the area will comprise about 9,000 homes and an almost equal number of workplaces.

Hyllie's objectives will be reached if all of the players active in the development of the city district work together. In Malmö, there are many companies that want to focus on innovative technology and to contribute to new approaches to transportation, living and working. Hyllie holds the potential to become the example it aspires to be. The actors are working in unison to test and develop the concepts that will serve as a role model for Malmö's continued progress as a sustainable city.

Programme design

Objectives

By as early as 2020, Hyllie will be 100 % sustained by renewable or reused energy. The focus is on an energy supply model that is based on Hyllie's potential to create a resource-efficient ecocycle and energy-efficient solutions. The renewable energy is to derive from wind power, solar power and biofuels. A significant share of the energy production is to be locally produced in the form of such solutions as solar cells on the properties. New Hyllie-destined wind-power production is planned for the region and E.ON has commissioned the Flintrännan biofuel-based district-heating plant in Malmö.

The re-used energy comprises energy recycling from waste and wastewater in Hyllie, which generates district heating, electricity and biogas. The electricity and district-heating network will also be capable of using surplus solar energy produced in the properties or surplus from other processes that generate heat where it is needed.

A smarter and more sustainable energy system focuses on the properties and people. Energy consumption is reduced by using the right choice of materials and smart consumer-adapted solutions. In Hyllie, they strive to not only make new construction projects energy efficient, but also equipped for tomorrow's energy solutions. To optimally use the energy supplied to the network in the best way, the properties must communicate with the overall system – and in certain cases also with each apartment's control system. This function makes it possible to regulate the load in the system, to store and optimise energy, and to maximise the use of recycled or renewable energy. Hyllie's Climate contract also aims to ensure that a significant share of the properties in Hyllie installs some form of local energy production, such as solar and wind energy.

Barriers to be addressed

The rate of urbanisation is increasing globally and Malmö is growing as a city. This entails new challenges, but also new opportunities since urban areas hold the key to sustainable development. These are the areas where employment opportunities emerge and where there is strong potential to develop sustainable energy and transportation solutions.

Environmental matters impact everyone at all levels. What we eat, how we travel, work and live – at home and at the office – have an impact on the local and global environment. Living and working in the Öresund region's most climate-smart city district is meant to facilitate sustainable living. Hyllie will offer ample ability to live, travel and work in an energy and resource-efficient manner.

Historically, energy production has derived from a limited number of major, primary sources. Energy has gone in one direction, from the source and out to consumers, and production has been governed on the basis of estimates about future consumption. With a rising share of renewable energy in our society, access will vary since the production of wind power and solar energy, for example, are contingent on the weather. In addition, future energy systems must also be able to cope with major fluctuations in demand. With a significant number of electric cars in the vehicle fleet, there can be major fluctuations in electricity demand within the span of a few hours.

Smart grids intelligently integrate all sorts of energy sources, both large and small scale. They also enable property owners, households and businesses to become more active in the energy market through such measures as selling the surplus from their independent energy production. In other words, the energy flow goes in two directions. By using energy when the supply of renewable energy is high and the price is lower, the need for demand for reserve or balance energy is minimised.

One of our greatest challenges today is traffic, which causes problems with emissions, noise, poor air quality and urban congestion. The transportation sector accounts for one-fourth of Sweden's energy consumption and since most of today's vehicles are powered by fossil fuels, we can significantly reduce greenhouse-gas emissions if we switch to other fuels and to more climate-minded means of transportation.

Hyllie aims to make it easy to walk, bike or use public transportation instead of taking your car. The Malmö Central Station is a mere six minutes from Hyllie, and central Copenhagen is less than 30 minutes away. Malmö is already growing as a bicycle city, in which about 40% of all business travel is by bicycle. From Hyllie, the city and the sea are a 15-minute ride away on scenic bicycle paths. Buses in Malmö are currently powered by natural gas, biogas or a mixture of the two. However, by 2020 at the latest, all buses will be powered by fossil-free fuels, and biogas is one of the most important alternatives. It can be locally produced and is classified as the most climate-adapted vehicular fuel.

If you still need a car, there will be access to carpooling in Hyllie. It will also be easy to charge your electric car or fill up using biogas. You can already charge your electric car in Hyllie's commuter Park and Ride parking lot and in the Emporia shopping center, and more charging locations are being planned adjacent to the residential units in Hyllie.

Policy levers/instruments

On a national level, the Research, Innovation and Demonstration fund for energy amount to SEK 1 300 million. These funds are managed by the Swedish Energy Agency and focused on six priority areas from bioenergy and power distribution system to energy efficiency in industry and buildings as well as energy system studies. Smart grids are an important field and the Swedish Energy Agency funds several demonstration projects in this field, where Hyllie is one example. Other examples are the Royal Seaport in Stockholm and Smart Grid Gotland.

Implementation

Hyllie is at the forefront of the development of a sustainable energy system. The area will integrate electricity, heating and cooling, the smart grids and other intelligent energy solutions that will hallmark the future. Smart grids enable flexibility in the chain of consumption and can optimise the use of renewable energy sources through better control and monitoring. In Hyllie, people will actively be able to measure, monitor, control and influence their own energy consumption using smart energy solutions, and be able to independently produce energy. To enhance the efficiency of energy consumption, building contractors that are interested, can install flow meters for the individual metering of hot tap water and heating. When combined with Hyllie's energy efficient properties and the use of electric and biogas-fuelled vehicles, this will result in enhanced energy consumption efficiency and less of an impact on the climate.

By as early as 2020, smart solutions for the regulation of consumption and storage of energy in Hyllie will enable an improvement in the balance between production and consumption compared with current conventional energy systems.

Support for smart grids

The Smart grids for a sustainable energy system in Hyllie project highlights issues related to the role that consumers, properties and infrastructure will play in the future energy system. Hyllie's energy solutions do not focus exclusively on renewable energy, but also on enabling consumers to become actively involved in their energy consumption. A sustainable approach to transportation, waste management and recycling is another key cornerstone. Under the project, an integrated infrastructure system is being developed for electricity, gas, heating and cooling, which focuses on optimising the interaction between central and local production using smart grids. This includes enabling the buildings in

Hyllie to utilise the overall potential of the smart system, whereby locally produced renewable energy, including solar or wind energy, will account for a major share of energy demand.

E.ON's Smart grid platform - Customer Energy and System Optimisation platform

- Facilitates monitoring, measurement and optimisation of energy consumption
- Creates bridges between production/distribution and the customer's use of energy
- Optimisation of city district's energy flows by price and access to renewable production in almost real time.

The smart home

How much electricity and heating can be conserved by controlling consumption? The development of Hyllie includes a number of pilot projects that can be advanced on in Hyllie, such as the Hållbarheten apartment block in Västra Hamnen, which E.ON built to develop new energy solutions. The building has photovoltaic cells, solar panels and a small wind power generator on the roof; even the elevator in the building produces energy. The apartments are equipped with outlets for electric cars, electric bicycles, charging posts, intelligent home controls and detailed metering of energy and energy consumption. For example, home energy consumption can be controlled using an app and various programs can be preprogrammed so that the temperature decreases when leaving home and the washing machine starts when activity on the electricity network and the price are lower.

The measurement and regulation of energy

An energy monitoring system will be implemented in Hyllie. The system will contribute to balancing the consumption of and access to renewable energy production by monitoring, measuring and regulating power output, thus optimising the city district's energy flows in accordance with price and the share of available renewable production. By including forecasts of such factors as energy prices, energy production capacity and weather, the system can create scenarios based on which properties and consumers who are connected to the system can act.

Smart properties with new energy technology

Hyllie will enable property owners, those working in the area, and residents to become an active part of the energy system. The first pilot project in Hyllie is already in place. In the Smart grids for a sustainable energy system in Hyllie project, in partnership with E.ON, Roth Fastigheter has tested smart and cost-effective energy solutions with residents in focus. The apartment block has been fitted with solar thermal collectors and all apartments have been equipped with smart home systems that regulate and control power output and energy consumption. A screen in the hallway allows tenants to monitor their energy consumption in SEK. The property as a whole is also able to optimise its energy flows in relation to price and production. The pilot project will make it possible to measure thermal inertia in the property, to cap output peaks and to test new pricing models. Residents of the property will achieve a higher standard of living and the property owner will conserve energy and save money as the supply and demand of energy are optimised.

Use of surplus energy

Hyllie will be characterised by a mix of residential designs – ranging from housing, office buildings and hotels to larger public facilities, such as arenas, trade fairs, a swimming complex and a shopping

center. This results not only in complex energy usage but also in opportunities to leverage the synergism created between different property segments.

When one property generates an energy surplus, a deficit may arise in another property. Residual flows and energy surpluses in one business may be utilised by another. In terms of heating, waste heat or a surplus of locally produced heat can be used more efficiently in temperature-dynamic district heating. The distribution network and the properties' technical systems can manage temperatures in the district heating water ranging from 65 to 95 degrees Celsius, thus enabling a property to deliver low-temperature heating. This heat can then be used in another property. This is one way to create a smarter district heating network.

Storing energy in buildings

By constructing buildings that retain heat longer, energy consumption can be optimised and cost savings can be achieved. In 2012, the Hyllie Climate Contract was awarded the Concrete Prize from the construction trade press magazine Concrete, for its efforts to optimise energy consumption by maximising a building's ability to store heat. Hyllie will test how to regulate a property's energy consumption based on weather forecasts by, for example, proactively storing energy in a building prior to a cold front. In this work, the concrete's structural properties are being studied since they are integral to the ability to store thermal energy.

Smart charging of electric cars

One way to optimise the use of renewable energy while also reducing costs, is to decide how and when you want to charge you electric car. As a consumer, you will be informed of the supply of renewable energy in the system and how much electricity costs via a smart phone or tablet computer. If you want to charge your car in an eco-friendly manner while there is plenty of renewable energy, you can easily pre-programme this feature. This is currently being tested in E.ON's pilot Hållbarheten project in Malmö, and the results of the study will form the basis for the solutions in Hyllie.

Car batteries as a buffer

With smart electricity grids, cars can be charged when electricity is inexpensive and the surplus can be returned when it is more expensive. As a consumer, you can use the electricity yourself or sell it back to the network. In other words, the electric cars can store energy. The electricity grid can essentially be balanced to a certain degree by the electricity that is stored in the cars' batteries as described above being used as a buffer. E.ON is planning to study this in greater detail in the aim of developing a prototype.

Institutions

The Smart grids for a sustainable energy system in Hyllie has the support of the Swedish Energy Agency and is being implemented by the City of Malmö and E.ON in cooperation with building developers and other players. Parts of the project are included as the only Swedish demonstration project to participate in the EU Future Internet Smart Utility Services (FINESCE) project, which is developing smart energy applications.

Smart cities and networks

The issue of smart metering and smart homes has since the beginning been associated with the concept of Smart Grids with a dual concern of providing tools for a better management of electrical networks. They face many challenges (energy transition, decentralised production, controlling and

anticipating peak demand...) including the need to strengthen consumer information in order to improve consumer behaviour and better control consumption.

The intelligence in networks is not, however, limited to the issues of the energy sector. Indeed, these sensors, meters and communication devices are increasingly used in a variety of networks and services (telecoms, electricity, gas, water, heating and cooling, street lighting, mobility, security, etc.). The multiplication of 'smart devices' allows deeper changes in public services and contributes to modernising the management of cities, supporting the development of smart city initiatives, by allowing among others:

- An optimisation of networks and services planning (leak detection on the drinking water system, better information for the user and pricing for transport networks, etc.);
- New forms of participation for the citizens, who can be more easily involved in their city (production of information / data, co-construction of urban space, new communication channels with public entities, etc.);
- A better knowledge of the territory, which facilitates planning and allows supervision and anticipation of natural hazards.

The implementation of new communicating devices in utility networks and cities is an opportunity for both the operation of public services, and for innovation in services for the citizens. The number of connected devices exceeded, since 2008, the number of people connected worldwide, and is expected to continue its strong growth to reach over 50 billion by 2020. The overall volume of data generated will also be multiplied by 30 between 2010 and 2020.

For cities, utilities and operators of public services, several opportunities can be seized, such as the sharing of resources (sensors, IoT networks, storage and analytics...) to optimise costs and the interoperability between systems to allow the crossing of data from separate datasets. Among other benefits, impacts on the economic development of the territory are expected, with the development of innovative services based on collected data.

There are however risks that need to be anticipated by public authorities regarding these new technologies and initiatives. The new technologies of Smart Cities may trigger the fear of some citizens regarding a massive collection of data (Big Brother), and an increasing reliance on telecom networks may prove critical in case of a malfunction or a malicious attack. What's more, the unprecedented increase in the data collected by local authorities may be hard to exploit properly, by cloaking the data that are really relevant.

The development of intelligent public networks represents a strategic and technical challenge, and many questions are raised:

- Many actors are expected to be involved in Smart City initiatives, what are the new organisational schemes that will allow them to cooperate efficiently?
- How to integrate local specificities in these organisational schemes (local technical and human resources, governance and organisation in the territory, technical inventory, etc.)?
- Open Data, Big Data… Are there clear boundaries for the ownership and management of data useful for the management of the city?
- How to ensure the neutrality and interoperability of systems that will be implemented?

Local authorities should make a priority of identifying a horizontal approach for their territories, providing foundations for a long-term development of Smart City initiatives. It is essential to identify areas of synergies and interoperability between city services related to the collection and management of data. It is a matter of optimising public funds by avoiding the duplication of infrastructure, equipment or solutions, and ensuring that the systems implemented by the communities themselves or their service providers and delegates are interoperable.

As an example, it is technically feasible to have a single Internet of Things network for the collection of data required by various public services. It is even facilitated by the emergence of new technologies enabling Low Power Wide Area Networks (LPWAN) such as LoRa and Sigfox, particularly appropriate for the transmission of small chunks of data as explained in Diffraction Analysis' report '*Entering the IoT market as a broadband operator'*, published in May 2016. Such a network could be used to connect smart metering systems, sensors on parking spaces or trash cans, or to monitor assets of the city.

To allow synergies by the use of a single network, it is, however, necessary to anticipate some issues that may arise, such as the choice of common specifications for sensors, how to share the costs associated with the deployment and maintenance of the network, and if necessary, the use of different technologies to suit various needs (e.g. CCTVs and smart meters don't have the same bandwidth requirements). Establishing the right governance for Smart City initiatives is key, with enough centralisation to ensure optimal use of assets and priorisation of projects but enough freedom of initiative that public or private entities can come up with new applications to better serve the common needs.

Lessons learned

The development of smart cities needs a strong focus on environmental sustainability, together with social and economic aspects. Focus on overcoming the prevailing siloed paradigm through integration and connection of infrastructures and systems, participation and co-creation enabled by ICT.

Challenges are:

- Providing infrastructure and services to current and future urban populations, and meeting increasing expectations regarding city services
- Enabling smaller cities to remain attractive for residents
- Promoting social cohesion and limiting gentrification and segregation occurring in urban areas
- Tackling the problems of urban sprawl and informal settlements
- Creating attractive cities for citizens and businesses whilst staying within the Earth's system processes (planetary boundaries)
- Moving toward resilient cities that can continue to provide ecosystem services in urban areas
- De-coupling economic growth from environmental impact
- Climate change mitigation and adaptation
- Shifting from linear to circular flows of materials and nutrients, and energy cascades

- Fair forms of accounting for the environmental impacts of the production and consumption of goods and services
- The protection of trust, security and privacy; system vulnerability due to increased integration
- Interoperability of emerging ICT infrastructure; managing the complexity of urban systems
- Overcoming the digital divide; preventing social and economic inequality between users and non-users of ICT
- Adapting to changes in working life, employment and labour markets resulting from increasing automation
- Mitigating the environmental impact of ICT

To implement Smart City initiatives and solutions, engaged governance is essential as challenges are manifold. The projects often require diverse skills from a variety of actors, public or private, and the quality of the leader will play an important role in their success of. Identifying the leader may sometimes be difficult, depending on the geographic scope of the project: a building, a district, a city, an agglomeration or a region.

Having an acknowledged entity in charge of Smart City initiatives however brings benefits, as it allows for the mutualisation of resources between projects (human or technical), and facilitates the consultation of stakeholders. This entity should however enjoy a strong political backing to make it possible to transform local authority in a cross-disciplinary manner.

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ANNEX NOTES

110 Source: BITKOM/Fraunhofer ISI (2012): Gesamtwirtschaftliche Potenziale intelligenter Netze in Deutschland.

111 Federal Ministry of Family Affairs, Senior Citizens and Youth, Federal Ministry of the Interior, Federal Ministry of Health, Federal Ministry of Transport and Digital Infrastructure, Federal Ministry of Education and Research

112 Innovation: 89 programmes; Foundation: 34 programmes; Scaling / Replicating: 15 programmes

113 Energy: 21 programmes; Transportation: 15 programmes; Health: 11 programmes; Administration: 6 programmes; Education: 2 programmes

114 Cf. TNS Infratest Survey among 4,000 enterprises with more than 2.5m Euro revenue per year. Conducted between Nov 2014 and Jan 2015 for Commerzbank (Source: Commerzbank 15. Studie der UnternehmerPerspektiven 2015, page 33.):

115 Examples for industry 4.0 applications include: cyber physical systems, production within smart factory, big/smart data, additive manufacturing (3D printing), mobile processes

116 For example, a survey by GfK Enigma for DZ Bank among 1,000 SMEs revealed that for 70% of enterprises with an annual revenue below 500m EUR, digitization of processes was still without relevance in 2014 (source: GfK Enigma: Umfrage in mittelständischen Unternehmen zum Thema Digitalisierung – Bedeutung für den Mittelstand im Auftrag der DZ Bank, Juli/August 2014)

117 The study "Gebrauchstauglichkeit von Anwendungssoftware als Wettbewerbsfaktor für kleine und mittlere Unternehmen (KMU)" by University of Mannheim et. al., which laid the basis for the initiative in 2012, showed SME's lack of knowledge about usability methods: 38% of the 153 interviewed enterprises had no knowledge about design methods, 43% had no knowledge about analytical, and even 49% had no knowledge about evaluation methods.

118 Examples can be found here: http://mittelstand-digital.de/DE/Wissenspool/online-ratgeber.html

119 The term "platinum" indicates that this initiative is an improvement of the former "silver" economy initiative.

120 See http://koreanlii.kr/w/index.php/Creative_economy_%26_innovation_center

121 See GrowthAnalysis, 2014.