THE FUTURE OF PRODUCTIVITY

OECD
BETTER POLICIES FOR BETTER LIVES

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FOREWORD

Productivity is the ultimate engine of growth in the global economy. Raising productivity is therefore a fundamental challenge for countries going forward. This new OECD report on *The Future of Productivity* shows that we are not running out of ideas. In fact, the growth of the globally most productive firms has remained robust in the 21st century. However, the gap between those global leaders and the rest has increased over time, and especially so in the services sector. This implies that knowledge diffusion should not to be taken for granted. Future growth will largely depend on our ability to revive the diffusion machine, both within and across countries. At the same time, there is much scope to boost productivity and reduce inequality simply by more effectively allocating human talent to jobs.

Over the coming decades, there will be several challenges to global growth, in spite of the continued rise of emerging economies. Global growth will be affected by population ageing, and a levelling out in education attainments in OECD economies and in labour force participation. More than ever, productivity will be the main driver of future growth and prosperity. Higher productivity growth is also essential to accommodate the impact of demographic pressures on public budgets, to escape the middle income trap that afflicts many emerging economies and to foster a new era of efficiency that drastically shrinks our footprint on the environment. Reviving the diffusion machine will also promote inclusive growth. The rise in wage inequality largely reflects the increasing dispersion in average wages paid across firms. Raising the productivity of laggard firms, via better diffusion, could contain increases in wage inequality.

The list of structural obstacles to diffusion is long. However, this report shows that four factors are key to more effective diffusion. First, global connections need to be extended, via trade, FDI, participation in GVCs and the international mobility of skilled labour. Second, firms – especially new entrants – should be able to experiment with new technologies and business models. Third, economies need to make the most of scarce resources by enabling labour, capital and skills to flow to the most productive firms. Fourth, we need investment in innovation, including R&D, skills and organisational know-how to enable our economies to absorb, adapt and reap the full benefits of new technologies. Investment in education and skills is particularly important to ensure that workers have the capacity to learn new skills, to make the most of digitisation and to adapt to changing technologies and working conditions. Skills and productivity are the real sources of strong, inclusive and sustainable growth.

The OECD has been at the frontier of productivity research for many years. We have been the thought-leaders in advising governments on policies for advancing frontier innovation and promoting productivity diffusion to ensure inclusive growth. We have been at the forefront of productivity measurement. This report marks the start of a renewed and concerted effort across the OECD to put productivity at the heart of our work on strong, inclusive and sustainable growth.

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OECD Secretary General

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This book also draws on the recent research of other OECD colleagues, notably Peter Gal and Alessandro Saia, as well as Silvia Albrizio, Flavio Calvino, Carlo Menon and Mariagrazia Squicciarini. It also draws on the work of external experts, Eric Bartelsman and Stuart Graham.

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EXECUTIVE SUMMARY

Productivity growth slowed in many OECD countries even before the crisis, which amplified the phenomenon. The slowdown in knowledge-based capital accumulation and decline in business start-ups over this period also raises concerns of a structural slowing in productivity growth.

The economic forces shaping productivity developments can be better understood by focusing on three types of firms: the globally most productive (i.e. global frontier firms), the most advanced firms nationally and laggard firms.

- Productivity growth at the global frontier has remained relatively robust in the 21st century, despite the slowdown in average productivity growth. For example, labour productivity at the global frontier increased at an average annual rate of 3½ per cent in the manufacturing sector over the 2000s, compared to an average growth in labour productivity of just ½ per cent for non-frontier firms, and this gap is even more pronounced in the services sector. However, firms at the global frontier have become older, which may foreshadow a slowdown in the arrival of radical innovations and productivity growth.

- The rising gap in productivity growth between the global frontier and other firms raises questions about: *i*) the ability of the most advanced firms nationally to adopt new technologies and knowledge developed at the global frontier; *ii*) diffusion of existing technologies and knowledge from national frontier firms to laggards; and *iii*) the rise of tacit knowledge as a source of competitive advantage for global frontier firms.

The aggregate gains from the diffusion of global frontier technologies and knowledge will be magnified by policies that facilitate the reallocation of scarce resources to the most productive firms.

- The most advanced national firms in some economies have productivity levels close to the global frontier, but their impact on aggregate productivity is muted, to the extent that they are undersized.

- Relatively high rates of skill mismatch imply rigidities in labour market matching and constrains the growth of innovative firms and influences wage inequality. Tackling skill mismatch is particularly important in light of the projected slowdown in human capital accumulation and evidence that mismatch has increased over time (EC, 2013a). Moreover, addressing policies to reduce skill mismatch can help improve equality by incentivising firms to pay for better-matched skills.

- It is important that young firms either grow rapidly or exit but not linger and become small-old firms.

Three policy areas appear to be of key importance to sustain productivity growth: *i*) foster innovation at the global frontier and facilitate the diffusion of new technologies to firms at the national frontier; *ii*) create a market environment where the most productive firms are allowed to thrive, thereby facilitating the more widespread penetration of available technologies; and *iii*) reduce resource misallocation, particularly skill mismatches. Reviving diffusion and improving resource allocation has the potential to not only sustain and accelerate productivity growth but also to make this growth more inclusive, by allowing more firms and workers to reap the benefits of the knowledge economy.

Policies to sustain productivity growth include:

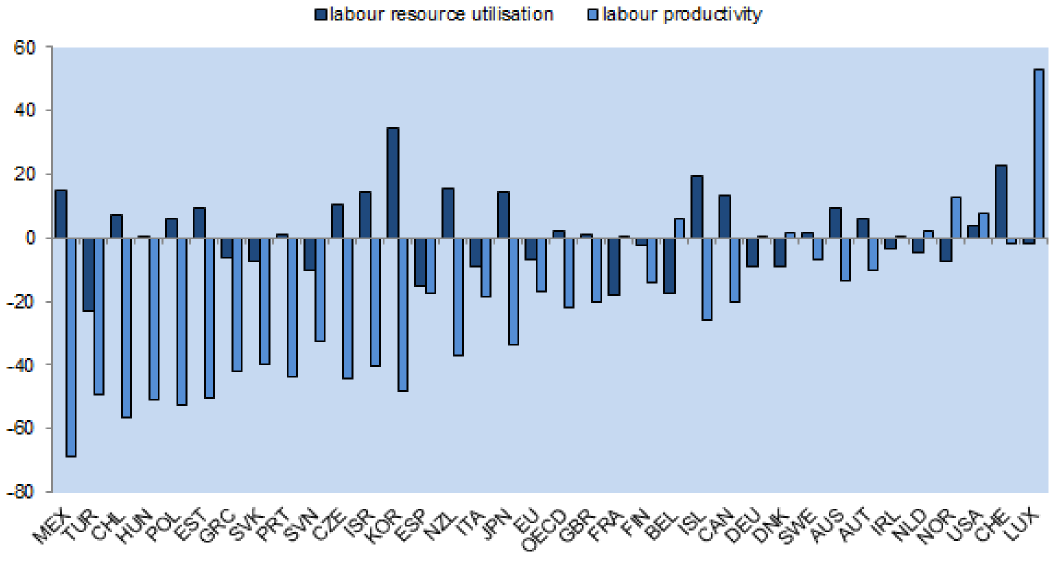
- Improvements in public funding and the organisation of basic research, which provide the right incentives for researchers, are crucial for pushing out the global frontier and to compensate for inherent underinvestment in basic research.
- Rising international connectedness and the key role of multi-national enterprises in driving frontier R&D imply a greater need for global mechanisms to co-ordinate investment in basic research and related policies, such as R&D tax incentives, corporate taxation and IPR regimes.
- Productivity growth via the diffusion of innovations at the global frontier to national frontier firms is facilitated by trade openness, participation in global value chains (GVCs) and the international mobility of skilled workers. Rising GVC participation magnifies the benefits from lifting barriers to international trade and from easing services regulation.
- Well-functioning product, labour and risk capital markets as well as policies that do not trap resources in inefficient firms – including efficient judicial systems and bankruptcy laws that do not excessively penalize failure – help firms at the national frontier to achieve a sufficient scale, enter global markets and benefit from innovations at the global frontier.
- A competitive and open business environment that favours the adoption of superior managerial practices and does not give incentives for maintaining inefficient business structures (e.g. via inheritance tax exemptions that may prolong the existence of poorly managed family-owned firms) facilitates within-firm productivity improvements. Stronger competition also enables the diffusion of existing technologies to laggards, which underpins their catch-up to the national frontier.
- Innovation policies, including R&D fiscal incentives, collaboration between firms and universities and IPR protection, should be designed to ensure that they do not excessively favour applied vs basic research and incumbents vs young firms.
- Framework policies that reduce barriers to firm entry and exit and improve the efficiency of matching in labour markets can improve productivity performance by reducing skill mismatch.
- Reforms to policies that restrict worker mobility and amplify skill mismatch – e.g. high transaction costs on buying property and stringent planning regulations – and funding for lifelong learning will become increasingly necessary, to combat slowing growth and rising inequality.

INTRODUCTION

Paul Krugman noted in 1994: "productivity isn't everything, but in the long run it is almost everything". Productivity is about "working smarter", rather than "working harder". It reflects our ability to produce more output by better combining inputs, owing to new ideas, technological innovations and business models. Innovations such as the steam engine, electrification and digitisation have led to radical changes in the production of goods and services, raising living standards and well-being. Indeed, the large differences in income per capita observed across countries mostly reflect differences in labour productivity (Figure 1). At the same time, productivity is expected to be the main driver of economic growth and well-being over the next 50 years, via investment in innovation and knowledge-based capital. Thus, it is of little surprise that the recent productivity slowdown has sparked widespread interest, with the debate centring on the extent to which the productivity slowdown is temporary, or a sign of more permanent things to come.

Figure 1. Large differences in income per capita mostly reflect labour productivity gaps, 2013

Percentage difference in labour resource utilisation and labour productivity compared with the upper half of OECD countries[1]



Notes: GDP per capita can be decomposed into the contributions of labour productivity (GDP per hour worked) and labour resource utilisation (total number of hours worked per capita). The sum of the percentage difference in labour resource utilisation and labour productivity do not add up exactly to the GDP per capita difference since the decomposition is multiplicative. Compared to the simple average of the 17 OECD countries with highest GDP per capita in 2013 based on 2013 purchasing power parities (PPPs).

Source: OECD, Going for Growth Database.

The sources of future productivity growth

Indeed, the future of productivity is highly uncertain and the debate has manifested itself in two polar views. There is a pessimistic view, reflected in some of the work of Robert Gordon, which holds that the recent slowdown is a permanent phenomenon and that the types of innovations that took place in the first half of the 20th century (e.g. electrification) are far more significant than anything that has taken place since then (e.g. Information and Communication Technologies, ICT), or indeed, likely to transpire in the future. Future economic growth will also slow further, owing to a number of headwinds related to demography, education, inequality, globalisation, environment and debt. By contrast, others, such as Brynjolfsson and McAfee, take a more optimistic view and argue that the underlying rate of technological progress has not slowed and that the IT revolution will continue to dramatically transform frontier economies.

Given this uncertainty, countries should look to tap sources of productivity growth where there is potentially large and sure scope for improvement over the short to medium term. *The Future of Productivity* illustrates that the main source of the productivity slowdown is not so much a slowing of innovation by the most globally advanced firms, but rather a slowing of the pace at which innovations spread throughout the economy: a breakdown of the diffusion machine. Indeed, a striking fact to emerge is that the productivity growth of the globally most productive firms remained robust in the 21st century but the gap between those high productivity firms and the rest has risen.

The strength of global frontier firms reflects their capacity to “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 ideas.

The rising gap between frontier firms and the rest raises questions about the obstacles that prevent all firms from adopting seemingly well-known innovations. It also suggests that future growth will largely depend on reviving the diffusion machine, which propelled productivity growth for much of the 20th century, most notably in manufacturing. Raising the productivity of laggard firms, via diffusion, could also reduce the rise in wage inequality, given that the observed rise in wage inequality appears to reflect the increasing dispersion in average wages paid across firms.

Productivity diffusion is especially challenging in the services sector, partly due to low competitive pressures which blunt the incentives to adopt best practices. This partly reflects policy weaknesses and productivity problems in the services sector will become increasingly costly for two reasons. First, the weight of services in our economies will continue to rise. Second, it may hinder the effective functioning of GVCs since logistics, finance and communication are the oil that greases the wheels of globalization.

Scope for diffusion depends on four key factors. First, global connections, via trade, FDI, participation in GVCs and the international mobility of skilled labour. Second, experimentation by firms – especially new entrants –with new ideas, technologies and business models. Third, the efficient reallocation of scarce resources to underpin the growth of innovative firms. Fourth, synergic investments in R&D, skills and organisational know-how – particularly managerial capital – that enable economies to absorb, adapt and reap the full benefits of new technologies. But OECD countries differ significantly in these four areas, implying that diffusion comes easier to firms in some economies rather than others.

Another crucial finding to emerge from our work is that the aggregate benefits of diffusion are magnified by a market environment that fosters the growth of the most productive firms. The larger are the more productive firms, the greater the extent to which their good performance gets reflected in overall economic growth. Unfortunately, in some economies, even though the most advanced firms can have productivity levels close to the global frontier, their aggregate impact is muted to the extent that they are under-sized. This suggests that there is much to be gained by reforms that make it easier for productive firms to attract the resources required to underpin their growth.

More specifically, *The Future of Productivity* demonstrates that there is much scope to boost productivity and reduce inequality simply by more effectively allocating human talent to jobs. Yet, the research in this book suggests that around one-quarter of workers report a mismatch between their skills and those required to do their job. A better use of talent could translate into significant labour productivity gains in many OECD economies.

In order to provide the evidence base needed for policy making in this area, the book adopts a holistic approach spanning traditional growth accounting and analysis of aggregate data to explore past growth performance (Chapter 1); long term economic projections to identify relevant issues for future productivity; and, especially, firm and industry level evidence on productivity growth and its determinants. Chapter 2 provides a framework for analysing the economic forces that shape productivity developments, while Chapter 3 identifies a set of structural themes relevant for future productivity. In this regard, future labour productivity growth will increasingly depend on a policy framework that: *i*) fosters innovation at the global frontier and reaps the benefits of globalisation by facilitating the diffusion of new technologies; *ii*) creates a market environment where the most productive firms are allowed to thrive, thus facilitating the more widespread penetration of available technologies; and *iii*) makes the most of human capital. In turn, Chapter 4 reviews evidence on how policies can boost productivity in these areas.

It is important to recognise that currently available firm-level data sources are not ideal, particularly for analysis of the productivity dynamics of laggard firms. In light of this, the book relies on a mix of critical review of existing evidence, descriptive analysis and when possible, firm level econometric analysis to try to provide insights, sometimes speculative, into some elements of the productivity puzzle (see Box 4 for an outline of the various empirical approaches). Nevertheless, it is reassuring that the results from policy analysis using incomplete firm level data are often confirmed by analysis using official industry level data. It is also possible to infer some aspects of the distribution of firm productivity within countries from recently collected OECD data on the distribution of firm size and age.

The final chapter offers some conclusions and identifies avenues for future research. Of course, there are a number of policy issues that while likely relevant for future productivity are not addressed for sake of brevity. These include the links between productivity and debt and inflation, infrastructure investment, including new forms of infrastructure, demographic change and immigration, corporate governance, and sectoral differences in the diffusion of technologies and innovation. These issues are beyond the scope of this book, but nonetheless represent potentially fruitful areas for future research.

A policy agenda to clear the path for higher productivity growth

So what can policy makers do to revive productivity growth? First, we need to keep pushing out the global innovation frontier. This requires significantly more public investment in basic research to support the continued emergence of breakthrough innovations – such as the Internet, aerospace and antibiotics – which had their origins in public research. The worrying trend across the OECD is that governments, universities and firms are all investing less in basic research. Given the tight fiscal climate, reversing this trend will be easier if countries share the costs and risks of such research through stronger global collaboration. Pushing the frontier also requires enabling experimentation with radical new technologies and business models. Since innovation is about trial and error, failure needs to be recognised as an opportunity to learn and rebound, rather than being seen as the end of the game. Thus, the policy environment should enable successful firms to grow, but also let weak firms exit the market, so that scarce resources can be released to underpin the growth of the successful ones.

Second, we need to revive the “diffusion machine”. This requires a policy framework that supports basic research and experimentation but also one that fosters the transmission of frontier knowledge to laggards and an efficient allocation of scarce resources. Pro-competition reforms to product markets, especially in services, are required to incentivise firms to adopt better technologies and business practices. This will also help reduce the costs and improve the quality of goods and services, which will boost the benefits of GVC participation. Closer collaboration between firms and universities is also needed to allow firms, especially smaller ones, to benefit from university connections with the global knowledge frontier and to provide them with access to research labs, knowledge and human talent. At the same time, a level playing field that does not favour incumbents over entrants is crucial, but this feature is often missing from many policies. For example, it is important that R&D tax incentives are designed so as to be equally accessible and beneficial to incumbent, young firms and start-ups. Finally, public investments in education and life-long learning are essential to ensure that workers have the capacity to learn new skills and adapt to changing technologies.

Third, policies that improve the allocation of scarce resources – labour, capital and skills – are crucial, to maximise knowledge diffusion and support productivity growth more generally. The primary reforms that promote firm growth are those that make product markets more competitive. Beyond that, reforms that reduce skill mismatch and the scarcity of risk capital are important to enable innovative firms to attract the skilled workers and capital they need to expand. For example, policies that lift impediments to labour mobility can help reduce skill bottlenecks. Bankruptcy laws that do not excessively penalize failure can also reduce skill and capital bottlenecks. High rates of skill mismatch often coincide with the presence of many small, old and unproductive firms that absorb valuable resources. However, it is crucial that young firms are able either to grow rapidly or exit. If they linger too long, resources are wasted. Finally, advanced early stage risk capital markets are key for the growth of young innovative firms, which would otherwise have difficulties securing finance, due to their lack of a track record.

The Future of Productivity reminds us that fostering innovation and promoting knowledge diffusion requires an environment where scarce resources, particularly human talent, flow to their best use. Reviving diffusion and improving resource allocation has the potential to not only sustain and accelerate productivity growth but also to make this growth more inclusive, by allowing more firms and workers to reap the benefits of the knowledge economy. To be sure, this reallocation process can also involve costs, but governments have the tools to minimise the disruption to workers, firms and society as a whole. They can do this via education and adult learning policies that make skills complementary to technical progress, while mechanisms to support displaced workers and insure workers against labour market risk more generally, such as well-designed social safety nets and portable health and pension benefits, are vital. Only when these measures are implemented might future innovations translate into both higher productivity growth and an inclusive and less unequal society.

The OECD has been at the frontier of productivity research for many years – in fact, one of the first acts of the OEEC, which administered the Marshall Plan, was to establish a Committee for Productivity and Applied Research. Accordingly, this book should not be viewed in isolation but instead as the latest offering in a rich and growing tradition of productivity research at the OECD.

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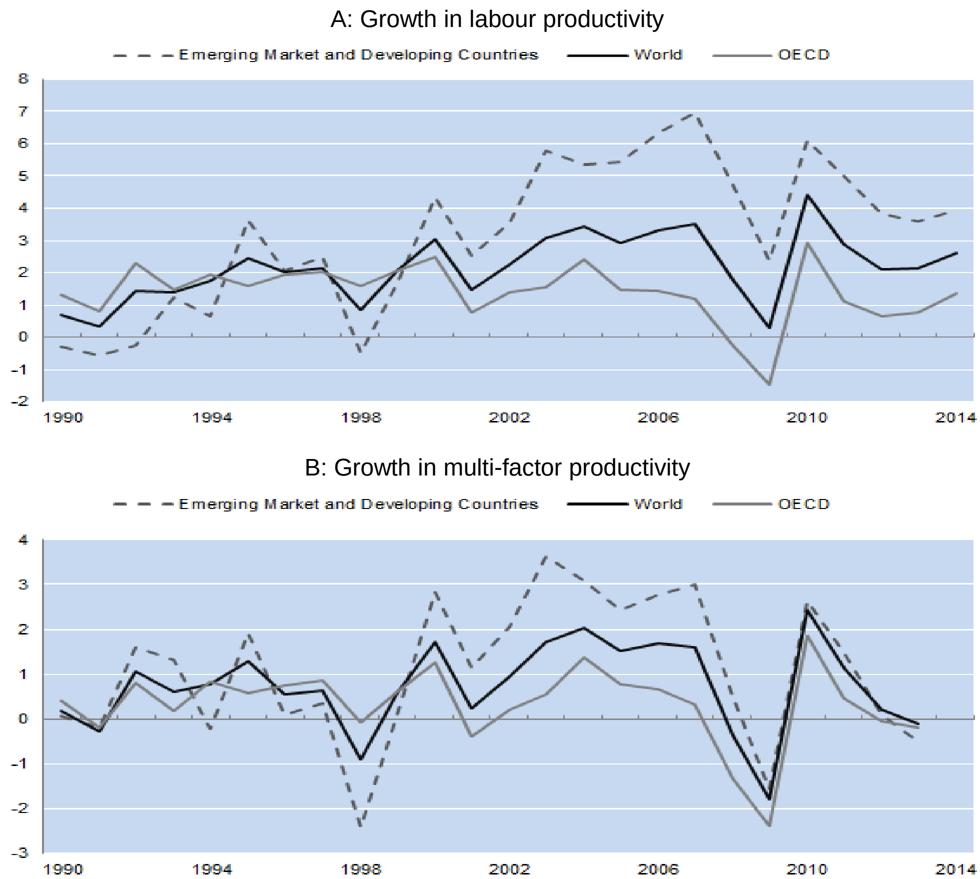
CHAPTER 1. THE PAST AND FUTURE OF PRODUCTIVITY

1.1 Global productivity has been solid, despite the slowdown in OECD countries

From a global perspective, the trajectory of labour productivity growth has accelerated from 1990 until the eve of the crisis (Figure 2), reflecting a pick-up in productivity growth in emerging market economies, which more than offsets the slowdown observed in the OECD area. However, in the post-crisis period, there was relatively weak growth in multi-factor productivity (MFP), which reflects the efficiency with which inputs are used – via improvements in the management of production processes, organisational change or R&D and innovation more generally (see Box 2 for a discussion). Thus, much of the growth in the labour productivity of emerging markets reflects increased capital deepening (see Figure A1 in Appendix 1).[1] This raises important questions about the capacity of both emerging and OECD economies to adopt new technologies and allocate resources efficiently – a key theme explored in this book.

Figure 2. Global labour productivity growth since 1990



Notes: Multi-factor productivity (MFP) growth measures the growth of GDP over the combined contributions of total hours, workforce skills, machinery and structures and ICT capital. Emerging market and developing countries include China, India, and other developing Asia economies, Latin America, Middle East, North Africa, Sub-Saharan Africa, Russia, Central Asia and Southeast Europe. World refers to the 122 countries included in the Database. Excluding China lowers the overall rates of world labour productivity and MFP growth, but the main trends remain the same. Results are available on request.

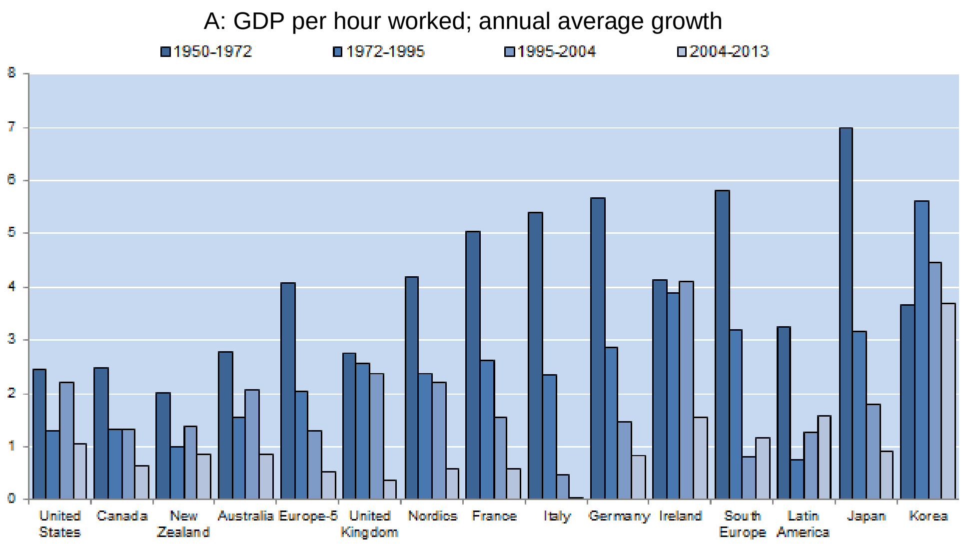
Source: OECD calculations based on the Conference Board Total Economy Database. See Appendix 1.

1 The subsequent Tables A2-A6 and Figures A1-A17 are in Appendix 1.

1.2 The OECD productivity slowdown in long-run comparative context

Turning to developments at the country-level, Figure 3 provides a long-run comparative perspective on cross-country productivity developments since 1950, whereby growth in labour productivity is decomposed into four key periods that broadly align with the structural breaks in United States productivity (see Fernald, 2013, for example). Countries and regional aggregates – the latter used for presentation purposes[2] – are ranked in terms of their initial labour productivity gap with the United States (Panel B), which had the highest aggregate productivity level in 1950.[3] In general, there is evidence of conditional convergence during the 1950-1995 period, whereby in economies that started further behind the US productivity level, productivity grew relatively fast. Of course, the experience of Latin America suggests that this process is not automatic, while New Zealand is noteworthy given that it was relatively close to US levels in 1950, but fell further behind over time. However, the process of convergence halted after 1995, underscoring two ideas: *i*) as economies converge toward the frontier, the ability to capitalise on innovations in the most advanced countries or industries – such as ICT – becomes more important (Chapter 2);[4] *ii*) the potential for digital technologies to unleash winner-take-all dynamics, which allows technological leaders to increase their productivity gap with laggards (Brynjolfsson and McAfee, 2011).[5]

Figure 3. Labour productivity performance in long run comparative perspective



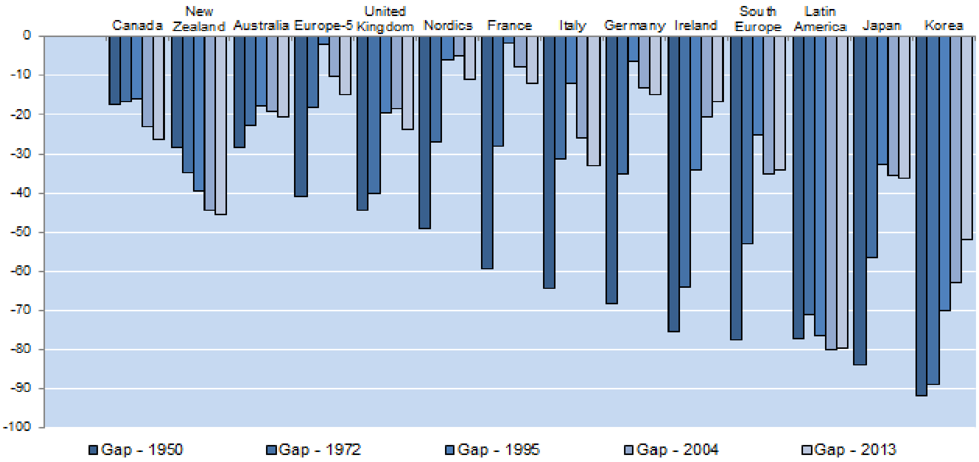
2 The corresponding country-specific data can be found in Appendix 1.

3 In this book, the country, industry or group of firms with the highest productivity level is called "the frontier". This frontier can be national or global.

4 See Conway et al., (2006) for discussion and empirical evidence.

5 Digital technologies – which allow the replication of informational goods and business processes at near zero marginal cost – enables the top-quality provider to capture most, or all, of their market, while only a tiny fraction of that revenue may accrue to the next-best (even if they are almost as good as the best provider).

B: Per cent gap in GDP per hour worked with the United States



Notes: Growth rates for the period ranges are the annual averages. Country groupings are aggregated using GDP-PPP weights. Europe-5 includes: Austria, Belgium, Luxembourg, the Netherlands and Switzerland; Nordics includes: Denmark, Finland, Iceland, Norway and Sweden; Southern Europe includes: Greece, Portugal and Spain; and Latin America includes: Brazil, Chile and Mexico. The corresponding country-specific data are contained in Table A1 in Appendix 1.

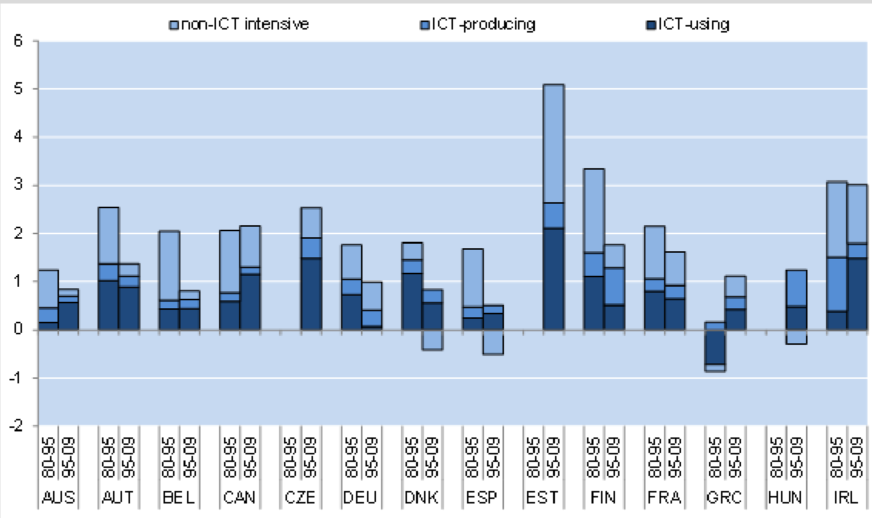
Source: OECD calculations based on the Conference Board Total Economy Database.

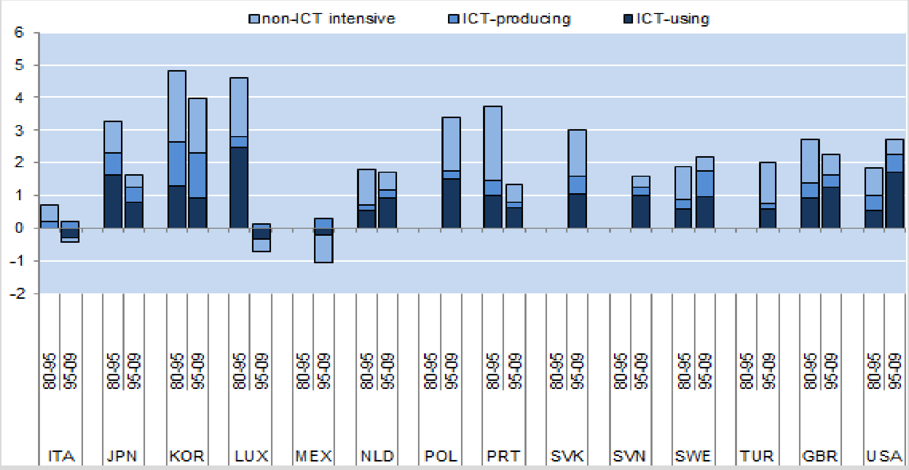
Box 1. ICT and productivity

The acceleration in productivity growth in the United States from the mid-1990s largely reflected the rapid diffusion of ICT, but these benefits were not necessarily realised in all economies, with Europe in particular falling behind. While this was reflected in the direct contribution of ICT capital to labour productivity growth (Figure A2), several key factors related to ICT are also embodied in MFP growth: *i*) the MFP growth in ICT-producing sectors themselves; *ii*) the growing share of these sectors in OECD economies; and *iii*) the productivity improvements in ICT-using industries, such as high-tech manufacturing and, especially, some service industries (Arnold et al., 2008). Figure B1 shows that the contribution of ICT-using sectors – such as retail and wholesale, finance and real estate and other business services (see Figure A3) – to aggregate productivity growth rose significantly in the United States and other English speaking economies after 1995, but this pattern was less evident in some European economies.[1]

Figure B1. Labour productivity growth in ICT producing, ICT using and non ICT sectors

Percentage point contribution to non-farm business sector labour productivity growth, selected OECD countries





Notes: The industries are coded according to ISIC Rev. 4 industry classification. ICT-producing sectors: 30-33, 64; ICT-using sectors: 21-22, 29, 34-35, 50-52, 65-67, 71-74; non-ICT intensive: 15-16, 17-19, 20, 23-25, 26, 27-28, 34-35, 40-41, 45, 55, 70. Industry groupings are aggregated using value-added weights.

Source: OECD calculations based on the EU-KLEMS and WIOD Databases.

1. According to national statistics, the contribution of some ICT-using sectors (e.g. retail and wholesale and finance) to aggregate labour productivity in New Zealand also increased after 1997, compared to the 1990-97 period (Meehan, 2014).

More specifically, labour productivity initially grew rapidly following 1950, reflecting significant scope for catch-up and the rebuilding of war-ravaged capital stocks. Productivity growth decelerated from the early 1970s, but convergence continued in many economies. From the mid-1990s, productivity growth accelerated in the United States, largely reflecting the large productivity gains associated with rapid diffusion in ICT (Box 1). While these benefits were partly realised in other English speaking and Nordic countries, some economies – particularly in Europe – began to fall behind. From 2004, the benefits from the ICT revolution began to wane (in the US) and labour productivity growth in the most recent period has been the weakest on record in most OECD countries since 1950. As discussed below, the slowdown reflected a mixture of structural and cyclical factors.

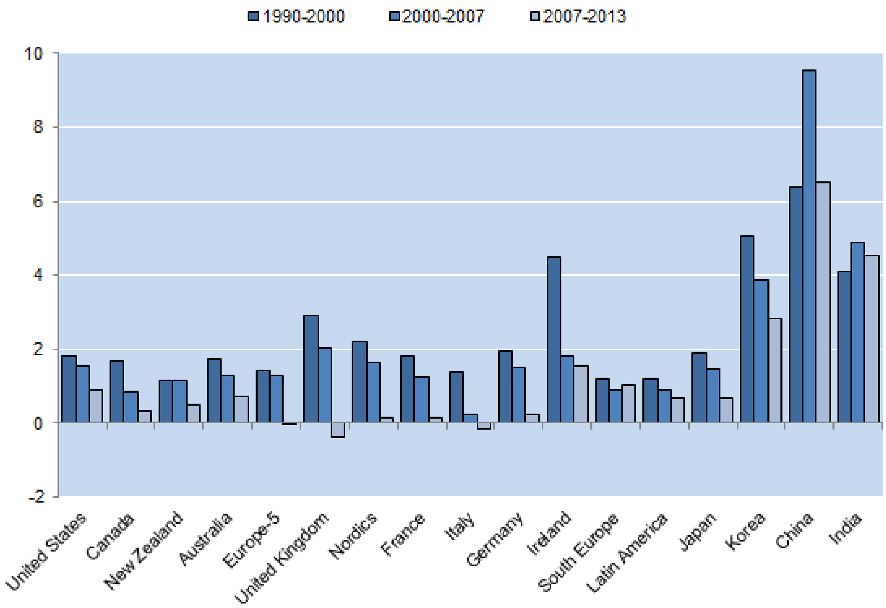
1.3 Structural dimensions to the productivity slowdown

The crisis left a legacy of slower productivity growth in many economies, but labour productivity had slowed in a number of OECD countries even before the crisis (e.g. during the 2000-2007 period; Figure 4). To understand the sources of these developments, Figure 5 decomposes GDP growth in the periods: 1990-2000, 2000-2007 and 2007-2013 into the separate contributions of labour quantity, labour composition (*i.e.* human capital accumulation), capital deepening and MFP. A number of key points emerge:

- After 2000, a broad-based decline in the contribution of labour composition (i.e. human capital accumulation) to GDP growth is observed across OECD countries – a pattern which is expected to continue into the future (Chapter 1.5).
- The contribution of capital deepening slowed after 2000 in the United States, Europe, Korea and Japan (Figure 5 and Figure A2), and this pattern was accentuated during the post-2007 crisis period. Capital accumulation remained robust in Australia and Canada, partly reflecting the significant ramp-up in mining sector investment to fuel the capital-intensive boom in China and India.
- Between 2000 and 2007, MFP slowed in most economies depicted in Figure 5 – save for Korea, Japan, China and India – and MFP actually contracted in Australia, Canada, New Zealand, Southern Europe and Latin America.

Figure 4. Labour productivity growth since 1990

Growth in GDP per hour worked (unless otherwise noted)



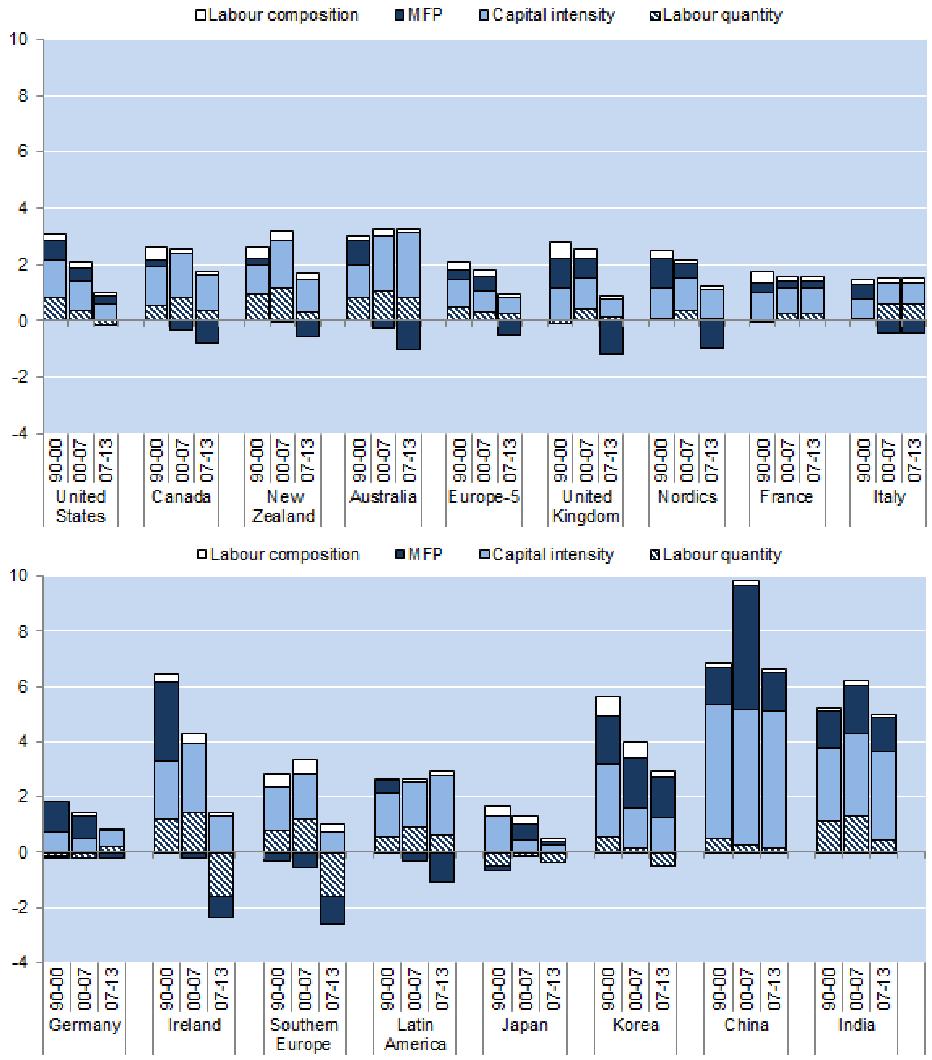
Notes: Labour productivity data for China and India refer to GDP per worker and thus are not shown in Figure 3. See Figure 3 for details on the country groupings. The corresponding country-specific data are contained in Table A2 in Appendix 1.

Source: OECD calculations based on the Conference Board Total Economy Database.

These pre-2007 developments in MFP suggest that there may be structural dimensions to the slowdown. When interpreting MFP data, it is important to recognise that innovation is underpinned by investments in knowledge-based capital (KBC), including: R&D, firm specific skills, organisational know-how, databases, design and various forms of intellectual property. While incorporating KBC into growth accounting reduces the contribution of (the residual) MFP, KBC is often only partially excludable, which gives rise to knowledge spillovers (see Appendix 1). This raises the possibility that the productivity slowdown may partly reflect the pull-back in the pace of KBC accumulation observed in many OECD economies during the early 2000s (Figure 6, Panel A), and this factor has been cited as an important contributor to the productivity slowdown in the United States and the United Kingdom (Fernald, 2014; Goodridge et al., 2013). More broadly, this is significant in light of the important role that KBC plays in facilitating the diffusion of technologies and knowledge from the global frontier (Chapters 2 and 3).

Figure 5. Drivers of GDP growth since 1990

Contribution of production factors to GDP growth



Notes: Multi-factor productivity (MFP) growth measures the growth of GDP over and above the combined contributions of total hours, workforce skills, machinery and structures and ICT capital. See Figure 3 for details on country groupings. The corresponding country-specific data are contained in Table A3 in Appendix 1.

Source: OECD calculations based on the Conference Board Total Economy Database.

Box 2. Multi Factor Productivity: concepts and measurement issues

Multi-factor productivity (MFP) relates output to a suitably defined combination of inputs and is often used to capture technological progress and efficiency of production. MFP is measured as a residual and therefore can often be a measure of our ignorance (Abramowitz, 1956; Solow, 1957) and capture more than technology and efficiency. In fact, developments in measurement and a broadening of research into factors of production, such as knowledge-based capital (KBC) and natural resources have raised important issues related to both the measurement and trends in MFP.

Amongst the measurement issues, the correct estimation of the quality adjusted-capital and labour inputs needs to be considered.

- First, the labour input measure should ideally account for both the hours worked and the skill composition of the labour force. While differences in hours worked and education levels of the workforce are accounted for in the aggregate productivity estimates shown in this Chapter, this exercise is particularly difficult to perform at the firm level, on a consistent basis across countries.
- Second, the measure of capital input should capture the services flowing from the capital stock and be adjusted for the capital stock composition, including the use of information and communication technology (ICT) capital. Services from KBC, such as R&D and innovative property more generally, databases, management and organizational capital, should be included as inputs. Accurate measurement of these inputs, however, is still a work in progress. For example, the switch from System of National Accounts (SNA) 1993 to SNA 2008, which was implemented by almost all OECD countries between 2009 and 2015, improved the reporting of expenditures on R&D by treating them as gross fixed capital formation instead of intermediate consumption. This change implies on average a 2.2 percentage point increase in GDP across OECD countries (van de Ven, 2015), while the cumulative impact of the switch to SNA 2008 on GDP growth rates are minor. Nevertheless, there is room to further broaden the scope of the measurement of intangible investment and IPR, and estimates at the firm and industry level are not yet widely available. Incorporating KBC into growth accounting leads to an increase of both output and inputs but generally reduces the measured contribution of MFP to growth. It is important to note that Figures 2-5 are based on the old SNA.
- Finally, linked to the assumptions of the production function and to data constraints hampering a precise measurement of inputs, MFP also captures factors such as adjustment costs, changes in capacity utilization, economies of scale, effects from imperfect competition and measurement errors (OECD, 2001).

Additional inputs that have not been generally considered but are used in production are environmental services and emissions both as inputs to and as (“bad”) outputs of the production process (Brandt et al., 2014). The main measurement challenge for this approach based on growth accounting is the assumption on explicit shadow prices and the choices of which environmental inputs and outputs to focus on (Brandt et al., 2013).

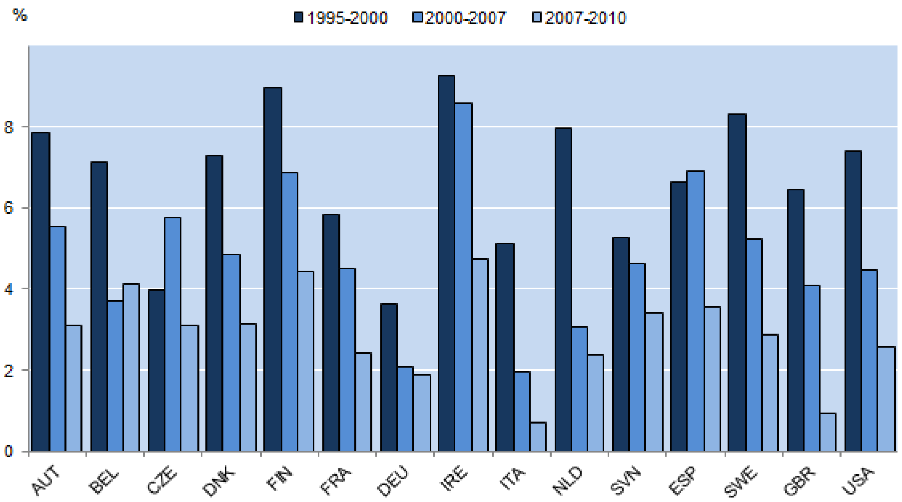
Finally, the standard approach generally assumes that the factors of production are flexible; i.e. can be adjusted instantaneously and are fully employed. However, most inputs are characterized by adjustment costs, such as hiring and firing costs or the installation and effective operation of new machinery and equipment. If it is costly to adjust inputs, firms may respond to short-run fluctuations in demand by varying the rates at which their existing capital and labour are utilized, for example by hoarding labour at the time of a crisis waiting for the recovery or underutilizing the existing capital stock without shedding it. This leads MFP to behave pro-cyclically.[1]

1. For example, the recent weakness in MFP in the United Kingdom has been attributed to the transient labour hoarding of firms facilitated by the weakness in real wages relative to the cost of capital (Oulton and Sebastiá-Barriel, 2013).

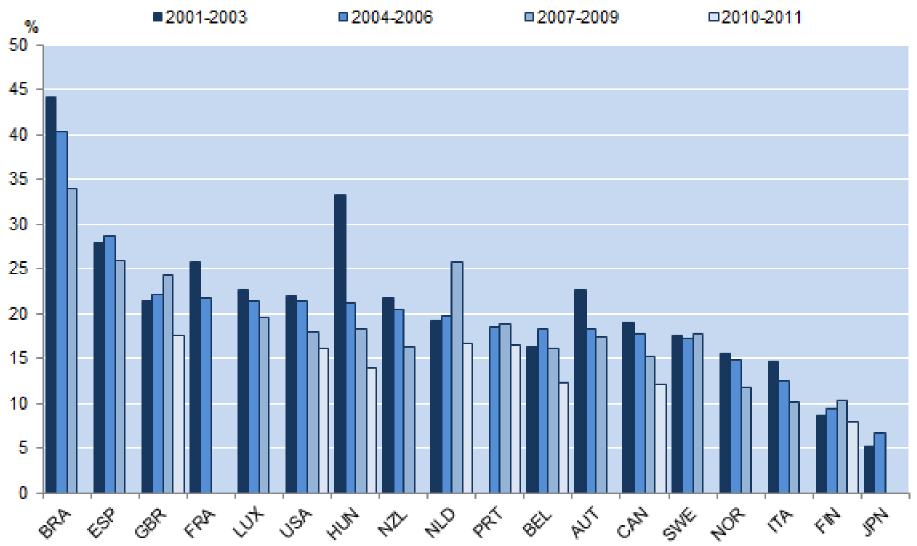
While the factors shaping the slowdown in KBC accumulation are not well understood, one factor may be the decline in business start-ups rates – observed in many OECD countries even before the crisis (Figure 6, Panel B) – given the key role of entrants in the formation of new ideas. A satisfactory explanation for this development remains elusive (Decker et al., 2014), but at least part of the slowdown in MFP growth can be accounted for by this decline. For example, evidence from eight European economies suggests that MFP growth over the 2000s was weaker in sectors that recorded larger declines in the share of young firms (under 6 years), and in particular start-ups (under 3 years) (see Andrews, Bartelsman and Criscuolo, 2015; Box 4). At the same time, increases in the share of old and small firms (over 6 years and fewer than 50 employees) were associated with weaker MFP growth. Simulations suggest that had the share of young firms not declined from 2002 levels, average annual MFP growth over 2002-10 would have been at least a ¼ percentage point higher than the baseline on average across countries, which is significant given the weakness in MFP over this period (Table A2).

Figure 6. Business dynamism is declining in OECD countries

A: Investment in KBC; annual average growth



B: Share of start-ups in all firms; average over period



Notes: Panel B reports start-up rates (defined as the fraction of firms which are from 0 to 2 years old among all firms) averaged across three-year periods for the manufacturing, construction, and non-financial business services sectors. Data refer to 2001-2010 for AUT, BRA, ITA, LUX, NOR, ESP and SWE; 2001-2009 for JPN and NZL; 2001-2007 for FRA; and 2006-2011 for PRT. Owing to methodological differences, figures may deviate from officially published national statistics. For Japan, data are at the establishment level. Data for Canada refer only to organic employment changes and abstract from M&A activity.

Source: Panel A is sourced from Corrado et al., (2012); Panel B is sourced from Criscuolo, Gal and Menon (2014).

1.4 The impact of the crisis

The legacy of the crisis on productivity performance in OECD countries is particularly noticeable. Part of this presumably reflects the pro-cyclicality of MFP (Box 2). Yet, even by 2013, average MFP in the OECD remained almost 2% below the pre-crisis level of 2007, reflecting particular weaknesses in the Euro Area, but also in the United Kingdom, Australia, Canada and New Zealand, while labour productivity performance has also been weak (see Table A4). This raises questions about the longer run productivity consequences of the crisis – and macroeconomic conditions observed in its wake – which are reviewed in this section focusing on: *i*) physical capital accumulation; *ii*) KBC and skills; and *iii*) creative destruction.

1.4.1 Tangible investment was hit hard during the crisis and remains weak

The onset of the financial crisis resulted in a very sharp decline in tangible investment in many countries and the subsequent recovery has been sluggish compared to recovery from past recessions (Figure 7, Panels A and B). While most of the fall in business investment reflected weak demand, financial factors and the pre-crisis build-up of corporate leverage have also played a role in the initial phase. The impact of the latter has since waned and only continues to be a constraint on credit supply in countries with weak financial systems (e.g. some euro area countries), especially for SMEs (Lewis et al., 2014).

Going forward, higher demand and lower uncertainty will be important for closing investment gaps and raising potential output. The high level of uncertainty regarding the level and growth of potential output during the recession may have contributed to the decline in business investment (Davis, 2010; Baker et al., 2013; EC, 2013b).[6] When investment decisions are costly to reverse (e.g. due to fixed costs), high uncertainty gives agents an incentive to postpone or cancel their decisions until uncertainty is resolved and more information is available, effectively freezing-up reallocation (Bernanke, 1983).

1.4.2 ... while investment in KBC and skills was more resilient

Investment in KBC (Figure 7, Panel C) was somewhat more resilient to the crisis than tangible investment. This might reflect the long term nature of R&D investments and the large sunk costs that might be borne at the initial stages of the investment, which might act as buffers to the transmission of cycles. Moreover, to the extent that investments in R&D and worker training divert resources from current production but only generate future benefits, their opportunity costs are likely to be lower during downturns because there is potentially less revenue to be forgone from normal productive activities than otherwise (López-García et al., 2013). Thus, all else equal, KBC investment is potentially countercyclical but the presence of credit constraints can reverse this result: if firms depend on external finance, their ability to borrow in order to fund innovative activity will decline during downturns, due to the drop in current earnings (Aghion et al., 2014).[7] Consistent with this, the sharp disruption in the availability of external finance during the Great Depression in the United States temporarily reduced patenting rates (Nanda and Nicholas, 2014).[8]

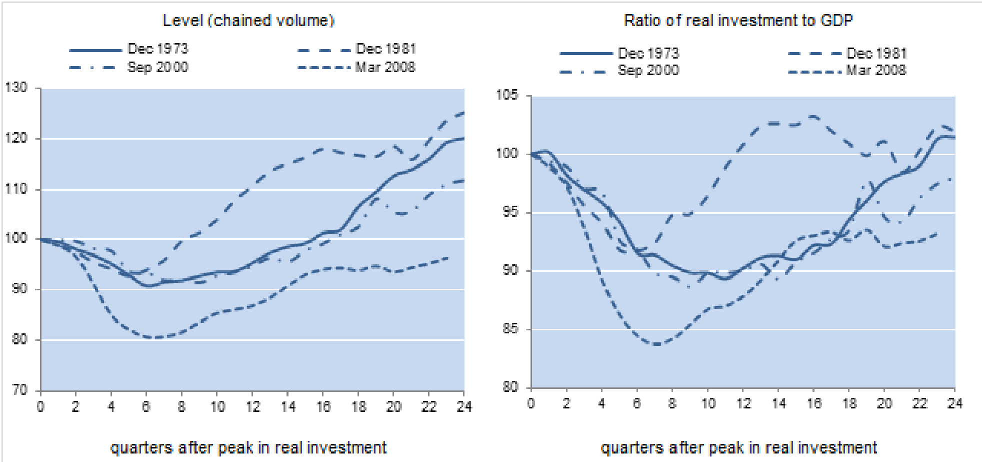
6 Although a reduction in uncertainty should quickly translate into activity measures, this may have changed given that some measures of uncertainty (e.g. news searches, dispersion of economic forecasts and tax code expirations) have been elevated for a long time (Haddow et al., 2013).

7 R&D might be pro-cyclical, even in the absence of credit constraints. If R&D is only partially excludable, there is only a short window of time for firms to appropriate profits from innovation, which makes firms more inclined to introduce innovations in boom-times in order to extract the highest benefit (see Barlevy, 2007).

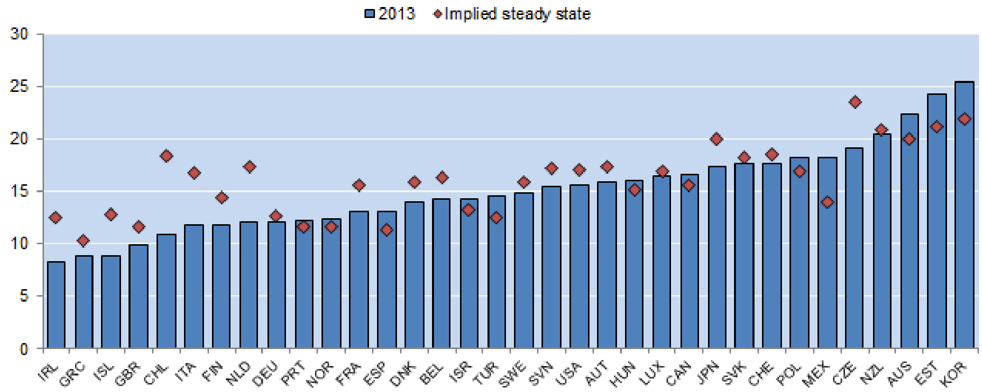
8 It also shifted the trajectory of innovation away from more experimental, radical innovations to incremental innovations, particularly in small firms in capital intensive industries reliant on bank lending.

Figure 7. Business investment and the crisis

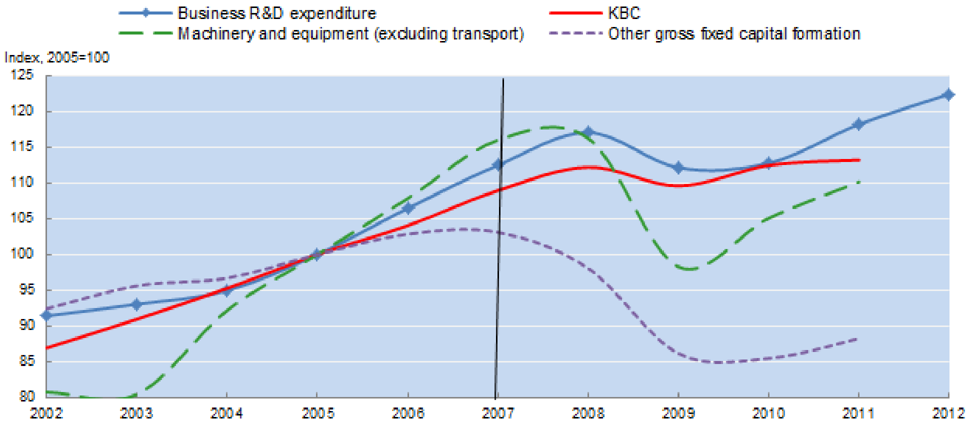
A: Real business investment growth compared to previous cycles (peak =100)



B: Comparison between actual and steady state non-residential investment as a percentage of potential GDP



C: Business investment in knowledge assets weathered the crisis better and recovered earlier; OECD



Notes: Panel A: Data are for OECD countries for which the breakdown of investment is available. Panel B:The steady-state level of investment to (potential) output is given by $i^* = \frac{k^*(g+\delta)}{(1+g)}$, where k* is the steady-state capital-output ratio, δ is the depreciation rate which is assumed constant over time, and g is the endogenous potential growth rate, which is dependent upon labour utilisation, physical and human capital intensity and multi-factor productivity (based on OECD long-term projections) . An important caveat is that changes in potential output growth could change the steady-state capital-output ratio both indirectly and directly by raising the equilibrium real interest rate in proportion to the rise in the potential growth rate.

Source: Panel A and B: Lewis et al. (2014) based on the OECD Economic Outlook 95 Database. Panel C: OECD (2014a).

The long term impact of the crisis on human capital will only become evident over time. Preliminary evidence suggests that so far the negative impact on skills may be somewhat contained. While low-skilled workers have been more at risk of job displacement, most of them have subsequently found jobs using similar skills to their pre-displacement jobs (OECD, 2013a). Furthermore, there has been an increase in individuals returning to full-time education or staying in education longer, which might increase the average quality of labour in the long run (OECD, 2011a).[9] However, the negative impact of the crisis on earnings might have adverse consequences going forward. The wage moderation observed since the start of the crisis has been disproportionate due to the wages of new hires, as opposed to that of incumbents (OECD, 2014b).

1.4.3 Productivity-enhancing reallocation during the crisis

The process of creative destruction and reallocation can be significantly affected by the economic cycle. On the one hand, recessions can be a solid breeding ground for productivity-enhancing reallocation and firm restructuring, and pave the way for economic recovery.[10] On the other hand, recessions – particularly when associated with financial crises – might have long-term scarring effects if: *i*) they reduce the availability of finance for entrepreneurs (Caballero and Hammour, 2005) and thus scope for experimentation (Ziebarth, 2012; Buera and Moll, 2013); and *ii*) surges in job destruction are not matched by surges in employment creation, as was the case in the recent crisis.

Cross-country evidence on how job creation and destruction of different firms have been affected by the crisis is still scarce. Nonetheless, new OECD evidence is consistent with the notion that productivity-enhancing reallocation was the main source of productivity growth during the crisis. Figure 8 (Panel A) shows average employment growth differentials across the quartiles of firm productivity, in 11 European countries. If reallocation is productivity-enhancing, more productive firms should grow larger, and less productive firms should shrink (or exit). Indeed, this pattern is observed over the pre-crisis period, with the two most productive quartiles of firms expanding relative to the least productive quartiles (2002-07). Interestingly, however, the pace of productivity-enhancing reallocation intensified once the crisis set in (2008-10), with job losses particularly concentrated amongst the least productive firms. A similar story is also evident in Figure 8 (Panel B), whereby old firms – which are often less productive than young firms (see Chapter 1.3) – shed more jobs during the crisis, even though this occurred through their downsizing, rather than exit (Criscuolo et al., 2014).

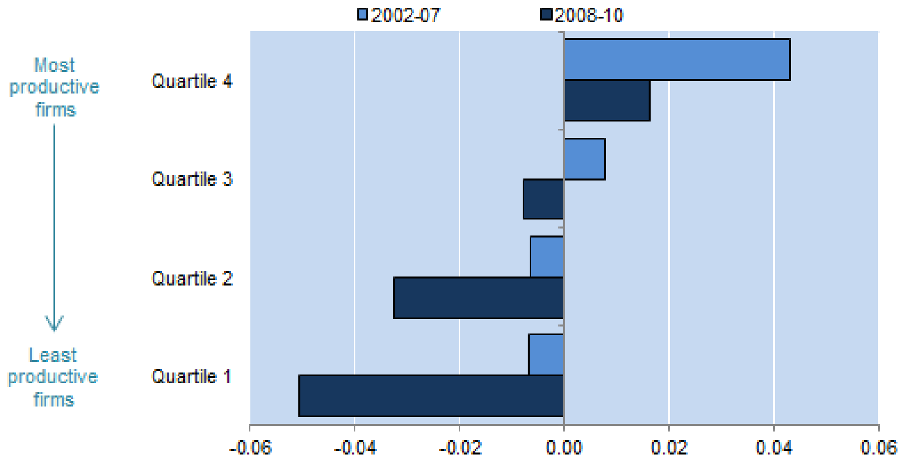
While these patterns may augur well for future productivity performance in Europe, it is not clear – owing to data limitations – whether the Great Recession was more cleansing than other recessionary episodes. Recent evidence from the United States suggests that the pace of reallocation during the crisis picked up relative to normal times, but it was less productivity-enhancing than during previous recessionary episodes (Foster et al., 2014). This is consistent with the notion that financial crises may mitigate the potential cleansing effects of recessions if less finance is available to facilitate the growth of the most productive firms. However, there is no evidence – for the European countries analysed in Figure 8 (Panel A) – that the cleansing effects of the crisis were lesser in industries more dependent on external financing (Andrews, Bartelsman and Criscuolo, 2015).

9 Between 2007 and 2012 across OECD economies, the share of 15-29 year-olds in education rose from 45.2% to 48.8% and expected years in education rose from 6.8 to 7.3 years.

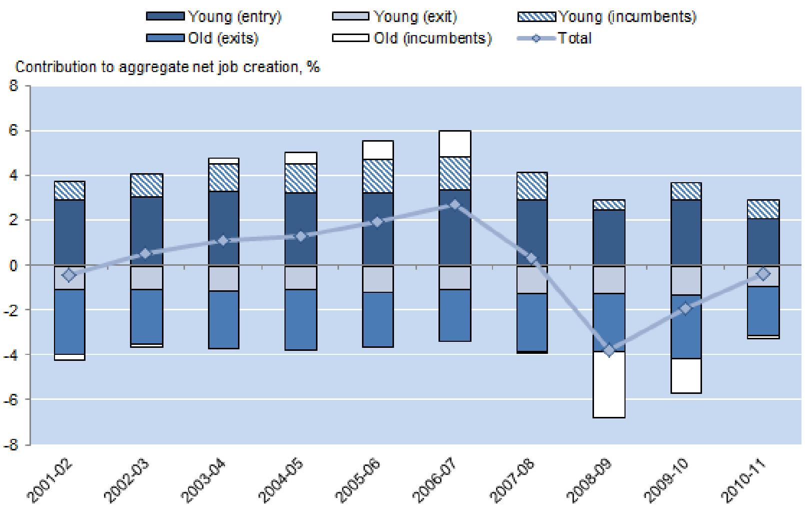
10 See: Hall, (1993) and Caballero and Hammour (1994). Of course, in the event of a demand shock, some labour hoarding may be desirable – despite its initial dampening effect on productivity – if it provides the ability to return to higher productivity, once market conditions improve.

Figure 8. The crisis accelerated the pace of productivity-enhancing reallocation in Europe

A: Average employment growth across the firm MFP distribution; deviation from 2002-10 average



B: Contributions to aggregate net job creation by entrants, young/old exitors, and young/old incumbents



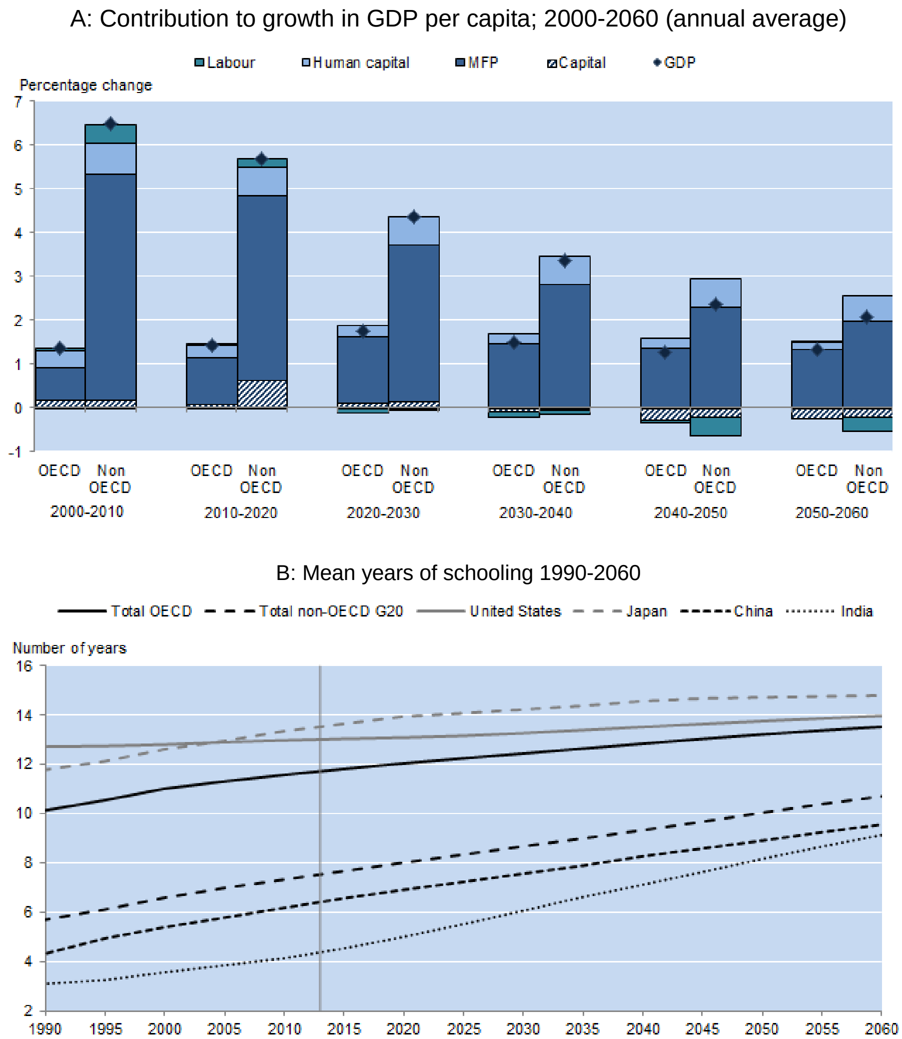
Notes: Panel A shows average employment growth across the lagged distribution of MFP for firms in the business sector (i.e. NACE 15-74), based on an unweighted average of 11 European countries: AUT, DEU, DNK, FIN, FRA, ITA, NOR, NLD, POL, SWE, GBR. A common (European) industrial structure is employed to aggregate 2-digit industries to the business sector level. Panel B: Average across all available countries. Contributions are calculated as the net job creation by age groups and by incumbent status over total average employment. See notes to Figure 6 for more details on the sample coverage.

Source: Panel A is based on the calculations in Andrews, Bartelsman and Criscuolo (2015), performed on production survey data from ESSLait. Panel B is sourced from Criscuolo, Gal and Menon (2014).

1.5 The sources of future growth

Over the period to 2060, potential global growth is projected to slow in most countries, even though a rising share of fast growing non-OECD economies in global output should dampen the slowdown at the global level (Figure 9, Panel A). Besides population ageing, this reflects the slowing in growth of the labour force and education (Figure 9, Panel B) – which is consistent with roughly constant returns to investment in education (Johansson et al., 2013) – and decreasing potential for catching-up. Growth is set to become increasingly dependent on improvements in MFP, reflecting: *i*) continuing investments in KBC as well as pro-competition reforms in countries where regulations are relatively restrictive; and *ii*) the continued dissemination of new discoveries made at the technological frontier.[11] These trends will imply a rising demand for skills, which given the projected slowdown in human capital accumulation implies rising wage inequality within countries.

Figure 9. MFP as an increasingly important driver of future growth



Notes: Non-OECD G20 countries are Argentina, Brazil, China, India, Indonesia, Russian Federation, Saudi Arabia and South Africa.

Source: Braconier, Nicoletti and Westmore (2014).

Nevertheless, the pace of future MFP growth is highly uncertain, in large part due to uncertainty in the outlook for frontier growth. Indeed, there are strongly contrasting views on the most likely pace of future frontier growth, with much of the discussion revolving around the potential of ICT to continue to propel growth (Box 3). To be sure, the techno-pessimists have on their side the recent productivity slowdown but

11 Even so, average annual MFP growth in the OECD is anticipated to fall from 1.1% in the decade to 2030 to 1.0% to 2040 and 0.9% to 2050. MFP growth in some non-OECD countries that have grown rapidly in recent years through catching-up is likely to slow more sharply as incomes in these countries converge closer to OECD levels.

this ignores: *i*) that the big payoffs from general purpose technologies are only realised once organisational structures are reconfigured to fully exploit the flexibility provided by these new technologies (David and Wright, 2005)[12]; and *ii*) the tendency for innovations to arise from the combination and recombination of previous innovations (Weitzman, 1998). Even so, it is remarkable how little is actually known about the characteristics of firms that operate at the global productivity frontier and whether the productivity growth of these firms has slowed over time, thus motivating an analysis of these factors in Chapter 2.1.

Box 3. The debate on the future prospects for productivity and innovation

The slowdown in productivity in advanced economies over the past decade has led to a fierce debate about the outlook for future productivity growth, which has manifested itself in two polar views.

1. The techno-pessimists

> *"You are required to make a choice. With option A you are allowed to keep 2002 technology, including your Windows 98 laptop accessing Amazon, and you can keep running water and indoor toilets; but you can't use anything invented since 2002. Option B is that you get everything invented in the past decade right up to Facebook, Twitter, and the iPad, but you have to give up running water and indoor toilets. … Which option do you choose?" – Gordon (2012).*

There is a pessimistic view, which holds that the recent slowdown is a permanent phenomenon and that the types of innovations that took place in the first half of the 20th century (e.g. electrification etc.) are far more significant than anything that has taken place since then (e.g. ICT), or indeed, likely to transpire in the future (Gordon, 2012; Cowen, 2011). These arguments are reinforced by the slowdown in business dynamism observed in frontier economies such as the United States (see Chapter 1.3). Gordon also argues that several headwinds will further slowdown future productivity growth in the US, including ageing population, deterioration of education, growing inequality, globalization, sustainability, and the overhang of consumer and government debt. Finally, the more technology advances and ideas cumulate, the more costly it becomes for researchers to innovate from a time perspective (Jones, 2012).

2. The techno-optimists

Technological optimists argue that the underlying rate of technological progress has not slowed and that the IT revolution will continue to dramatically transform frontier economies. According to Brynjolfsson and McAfee (2011), the increasing digitalization of economic activities has unleashed four main innovative trends: *i*) improved real-time measurement of business activities; *ii*) faster and cheaper business experimentation; *iii*) more widespread and easier sharing of ideas; and *iv*) the ability to replicate innovations with greater speed and fidelity (scaling-up). While each of these trends is important in isolation, their impacts are amplified when applied in unison. For example, measurement is far more useful when coupled with active experimentation and knowledge sharing, while the value of experimentation is proportionately greater if the benefits, in the event of success, can be leveraged through rapid scaling-up. However, significant changes to organisational structures are required to fully realise the productivity benefits of new technologies and to share the resulting prosperity more broadly.

Similarly, Joel Mokyr[1] argues that economic history shows no evidence of diminishing returns with respect to technological progress. In fact, science and technology's main function in history is to make taller and taller ladders to get to the higher-hanging fruits (and to plant new and possibly improved trees). With respect to future developments, Mokyr emphasised three key factors: *i*) artificial revelation – whereby technological progress provides the tools that facilitate scientific advances, which then feed back into new technologies in a virtuous cycle (e.g. advances in ICT technologies raises the productivity of R&D); *ii*) access costs; and *iii*) a good institutional set-up for intellectual innovation. For instance, advances in computing power and information and communication technologies have the potential to fuel future productivity growth by making advances in basic science more likely (i.e. via artificial revelation) and reducing access costs. However, Mokyr warned of the potential for bad institutions and policies to interfere. In this regard, he identified a number of key risks: *i*) outright resistance by entrenched interests which could lead to excess regulation and lack of entrepreneurial finance; *ii*) a poor institutional set up of research funding which favours incremental as opposed to radical innovation; and *iii*) new forms of crime and insecurity (e.g. cyber insecurity).

1. See Joel Mokyr's remarks at the OECD-NBER Conference on *Productivity and Innovation in the Long-Run*.

12 While electrification of US factories began in the 1890s, productivity did not start to increase significantly until 30 years later, with the arrival of a new generation of managers that invented new work practices and redesigned factories in order to fully exploit electricity's possibilities (Brynjolfsson and McAfee, 2011).

Box 4. Empirical approaches

The empirical research underpinning this book exploits cross-country, industry- and firm-level data to explore structural dimensions of productivity and the multiple channels through which policies affect productivity. This Box briefly outlines the various approaches and data sources used in these analyses.

Structural analysis (Chapters 1-3)

What's happening at the global productivity frontier?

Using harmonised cross-country firm level data, Andrews, Criscuolo and Gal (2015) identifies the globally most productive firms in each 2 digit industry based on a number of definitions (e.g. the top 100 firms in each industry etc.) from 2001-2009. The analysis then highlights: *i*) cross-sectional differences in a range of economic indicators – e.g. labour and multifactor productivity, size, age, patenting activity and MNE status – between global frontier (GF) firms and non-frontier firms in 2005; and *ii*) the evolution of these indicators over the 2000s, for GF and non-frontier firms.

The underlying data source for this analysis (and the productivity indicators in Adalet McGowan and Andrews, 2015a) is the commercial database ORBIS. Prior to the construction of firm level productivity indicators (e.g. MFP), these data have been significantly transformed by Gal (2013) along of number of dimensions, including harmonisation to improve cross-country comparability. As discussed elsewhere in the book, ORBIS has a number of drawbacks including the fact that is a selected sample of larger and more productive firms, which tends to result in smaller and younger firms being under-represented in some economies. Accordingly, firms with less than 20 employees are dropped in the analysis in Andrews, Criscuolo and Gal (2015), while sampling weights estimated by Gal (2013) are applied to improve representativeness in Adalet McGowan and Andrews (2015a).

At the same time, while the coverage of ORBIS is less satisfactory for the United States than many European countries, its coverage of US affiliates abroad is still good. A priori, it is not clear in which direction this will bias the analyses given: *i*) the focus is only the global frontier and thus country boundaries are less relevant; and *ii*) the United States is excluded from the firm level policy analysis given that a differences-differences estimation procedure is employed (whereby the US is the benchmark country).[1] Finally, the key trends in Figure 10 are robust to excluding firms that are part of a multi-national group (i.e. headquarters or subsidiaries) where profit-shifting activity may be relevant.

Firm dynamics and productivity

Andrews, Bartelsman and Criscuolo, 2015 explores the link between MFP growth and the share of each firm dynamics class (e.g. young firms, starts-up, old and small firms etc.) with respect to the total employment and the number of firms, using a panel econometric specification that controls for country*year and industry fixed effects. This analysis utilises data from the ESSLimit project from 2001-2010, which aggregates micro-data from Production Surveys for the non-farm business sector (i.e. NACE Rev.1.1 15-74) for eight European countries: Denmark, Finland, France, Italy, the Netherlands, Norway, Sweden and the United Kingdom. The paper also contains some descriptive analysis into the impact of the crisis on resource reallocation for these eight economies plus Austria, Germany and Poland.

This analysis uncovers a statistically significant positive relationship between the share of young firms and productivity growth at the industry level, which in turns motivates a more detailed analysis of firm and employment dynamics for a broader set of OECD countries.

Firm and employment dynamics

Criscuolo, Gal and Menon (2014) explore the dynamics of employment using an innovative methodology that aggregates confidential firm-level data from national sources (e.g. national business registers) to produce new cross-country indicators on: *i*) the share of each size; age and status class (e.g. start-ups, small and young, small and old firms; large firms; and incumbents, entrants and exitors) with respect to the total number of firms and employment; *ii*) job dynamics and their contribution to aggregate job creation and destruction. The paper provides evidence on the asymmetric impact of the crisis on employment growth (with respect to young and old firms) and the sources of aggregate employment growth, which highlights the importance of young firms to job creation. The data contain longitudinal information on 3 sectors (Manufacturing, Services and Construction) over 2001-2011 for 17 OECD countries plus Brazil. See the Dynamics of Employment Growth for details.

Calvino et al., (2015) extends the above analysis and reports descriptive evidence on cross-country differences in employment dynamics and in post-entry employment growth performance based on micro-aggregated data for 2-digit industries for 12 OECD countries over the period 2001-2012. The analysis investigates: *i*) the role of high–growth firms; *ii*) the performance of cohort of firms 3; 5 and 7 years after entry; and *iii*) within industry employment growth dispersion. The paper also examines the impact of the crisis and employs a difference-in- difference approach to study the contribution of policies to the observed differences in post-entry growth performance across countries.

Skill mismatch and labour productivity

Adalet McGowan and Andrews (2015a) utilise cross-country data to regress industry-level labour productivity indicators – constructed from firm level data (ORBIS) – on measures of skill and qualification mismatch, aggregated from PIAAC micro-data for 2011/12. Three productivity indicators are utilised: *i*) industry level labour productivity; *ii*) average differences in within-firm productivity – measured by the unweighted average of firm productivity, irrespective of each firm's relative size – which is increasing in the ratio of high productivity to low productivity firms within an industry; and *iii*) the extent to which, all else equal, it is the more productive firms that command a larger share of industry employment (i.e. allocative efficiency). The specification controls for country and industry fixed effects, and other possible determinants of productivity, including market concentration and managerial quality. The sample is based on data for 19 OECD countries for which mismatch and productivity data are available.

Policy analysis (Chapter 4)

A key issue identified in this book is the relationship between policies and the diffusion of: i) new technologies from the GF to NF firms; and ii) existing technologies from the NF to laggard firms. While a number of steps have been taken to the harmonised the firm-level data across countries (see Gal, 2013), these data are still not ideal for addressing some of these policy questions. This is particularly the case for the analysis of the least productive firms, since ORBIS is generally a selected sample of the most productive and larger firms (i.e. small firms are under-represented). Given this, analysis at the industry level is conducted in parallel to firm level policy research and an attempt is then made to interpret the results from industry-level analysis through the firm-level framework developed in Chapter 2.

The diffusion of new technologies from the global frontier to national frontier

Besides providing a descriptive analysis of firms at the global productivity frontier, Andrews, Criscuolo and Gal (2015) uses harmonised cross-country firm level data[1] to explore the link between policies and the magnitude of the productivity and size gaps between NF and GF firms within each industry (see Figure 17 for an example). A differences-in-differences estimator is used to identify the impact of policies on these gaps, while the specification also controls for country and industry fixed effects. The sample is based on data for 19 OECD countries in 2005.

The question of how policies shape the diffusion of new technologies from the GF to NF firms is also addressed indirectly using industry-level data. For example, when MFP growth spillovers from the global frontier (i.e. the most productive economy in each sector) to laggard economies in a given sector, this is likely to reflect the process of NF firms adopting new technologies from the global frontier. Accordingly, Saia, Andrews and Albrizio (2015) employ a neo-Schumpeterian growth framework to explore the extent to which spillovers from the global productivity frontier onto (country*industry) MFP growth varies with selected framework and innovation-specific policies. This is done by interacting policy (and structural variables) with the industry global frontier MFP growth term, using a differences-in-differences estimator. The regression specification controls for country*year and industry fixed effects and policy interactions with the lagged distance to the frontier term. This paper also analyses how policies shape the impact of GVC participation on MFP growth, by employing a differences-in-differences specification whereby national policies are interacted with industry level GVC participation for the United States. The sample is based on a dataset of 20 industries for 15 OECD countries over the period 1984-2007.

The diffusion of existing technologies from the national frontier to laggard firms

Andrews, Criscuolo and Gal (2015) also uses firm level data[1] to explore the link between policies and the speed of catch-up to the NF within each industry (the NF is defined as the most productive 5% of firms in each country*industry cell). A differences-in-differences estimator is used to identify the impact of policies and the policy term is interacted with the lagged productivity quartile of each firm relative to the NF (see notes to Figures 25 and 27 for more details). The specification also controls for country and industry fixed effects. The sample is based on data for 20 OECD countries in 2005.

As discussed above, this issue is also addressed indirectly in Saia et al., (2015) using industry-level data by including policy interactions with the lagged distance to the frontier term.

Skill mismatch and public policy

Using a logit regression framework, Adalet McGowan and Andrews (2015b) exploits micro-data from PIAAC to assess the relationship between different policy settings (framework, housing and labour market and education) and the probability of skill mismatch, controlling for relevant individual and country level characteristics in 2011/12. Heterogeneous effects of policies are also explored by allowing the impact of the policies to vary with age and managerial quality. The sample is based on data for 22 OECD countries for which mismatch data are available.

1. The choice of the US as the benchmark country in the differences-in-differences specification reflects data constraints and identification assumptions regarding the industry exposure variables. For example, data on firm turnover and job layoff rates at the industry level are often only available for the US. In theory, the benchmark should also provide an estimate of the frictionless economy.

CHAPTER 2. THINKING ABOUT PRODUCTIVITY

Growth accounting can help describe productivity developments but does not shed much light on the economic forces that shape them. If technology and knowledge flows freely across borders, aggregate productivity growth in less advanced economies and firms will be a positive function of growth in those that operate at the global technological frontier as well as of the gap between the level of productivity at this frontier and the productivity of the less advanced (Acemoglu et al., 2006; Aghion and Howitt, 2006). Put differently, economies and firms lagging behind the global frontier can improve their productivity by benefiting from the spillovers from frontier innovations and the adoption of technologies and knowledge already in use at the global frontier. This creates scope for some cross-country convergence in productivity levels as those that start further behind the global frontier can grow relatively faster, since the marginal (productivity) benefit of implementing technological and organisational innovations will be higher the less sophisticated is the technology embedded in existing capital. In the long-run, countries will converge not necessarily to the same productivity level but instead to a common productivity growth rate, which is pinned down by the rate of productivity growth in the most advanced economies. The extent of convergence in productivity levels will be conditional on country-specific factors, including policies.

But the process of productivity convergence is not to be taken for granted and history suggests that a lot can go wrong along the way (Pritchett, 1997). In fact, while adoption lags for new technologies across countries have fallen, there has been a divergence in long-run penetration rates once technologies are adopted, with important implications for cross-country income differences (Comin and Mestieri, 2013). In other words, new technologies developed at the global frontier do not immediately and automatically spread to all firms within any economy, and many existing technologies may remain unexploited by a non-trivial share of firms in an economy. Thus, in order to understand the forces shaping aggregate productivity one needs to go beyond aggregates to understand the dynamics of knowledge diffusion and productivity catch-up across industries and firms.

Accordingly, Figure 10 sketches an analytical framework that combines different types of firms – e.g. firms that are at the global frontier, those that are at the national (but not at the global) frontier and laggards – and technologies, i.e. new *vs* existing. Innovation at the global technological frontier leads to the discovery of new technologies and organisational innovations. These new (global) frontier technologies do not immediately diffuse to all firms. At first, they are only accessible to the most productive firms in an economy (i.e. national frontier firms; NF). Then, over time they can represent a source of technological diffusion to laggards, but presumably only once they have been adapted to national circumstances by national frontier firms. This is consistent with evidence that the productivity growth of laggard firms within a country is more strongly related to productivity developments of the most advanced domestic firms as opposed to those of the globally most advanced (Andrews, Criscuolo and Gal, 2015; Bartelsman et al., 2008; Iacovone and Crespi, 2010).[13]

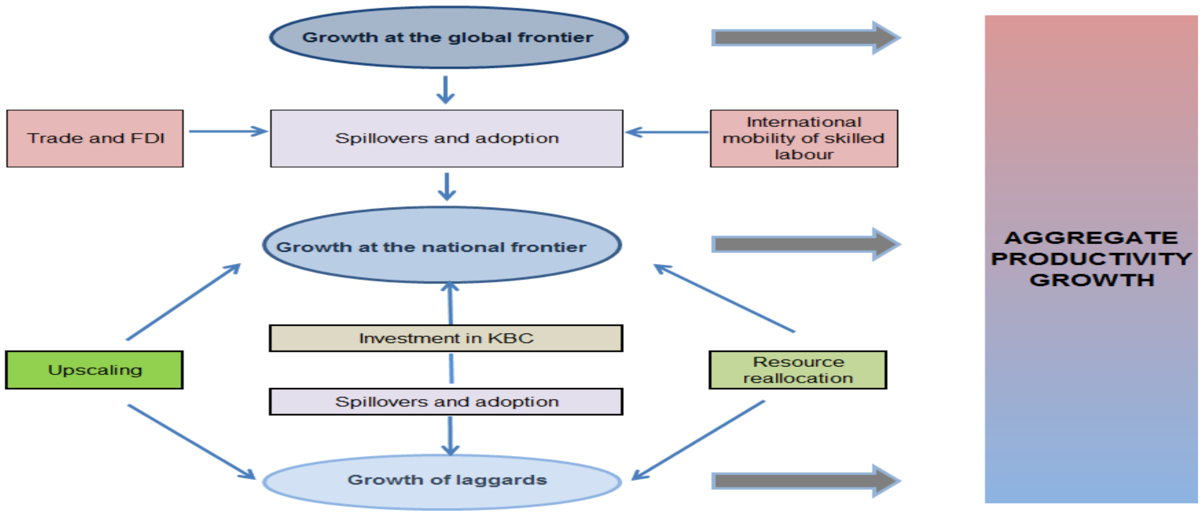
13 This tendency is exacerbated for larger technological lags of non-frontier firms that might not have the absorptive capacity to learn from a foreign knowledge base.

As discussed below, the extent to which new technologies and knowledge diffuse to NF firms and in due course to laggards will depend on a host of policy and structural factors. In this context, aggregate productivity will be shaped by two main factors:

- Productivity-enhancing investments *within* each firm, particularly in knowledge based capital (KBC) such as R&D and organisational capital; and
- A market environment that facilitates the growth of the most productive firms.

These two factors interact since firms' productivity-enhancing investments (especially in KBC) will also be shaped by their perceptions of the costs and benefits of implementing and commercialising new ideas, the ability to scale-up activity if successful or to exit at low cost if unsuccessful, which each depend on the ease of reallocating resources to their best use.[14]

Figure 10. A stylised depiction of the factors shaping aggregate productivity growth



Source: OECD Secretariat

The remainder of this Chapter elaborates on this framework, and discusses: *i*) developments at the global productivity frontier; *ii*) the diffusion of innovations and best practices; and *iii*) firm heterogeneity and reallocation.

2.1 The global productivity frontier

Research on the global frontier (GF) is scarce – *e.g.* most existing studies take developments at the GF as a given – and industry level MFP studies (see Bourles et al., 2013) often assume that one country (i.e. the United States) occupies the position of the global leader.[15] However, new OECD evidence – which

14 If the costs of reallocation are too high, firms may be discouraged from productivity enhancements or focus merely on incremental improvements, rather than experiment with risky technologies, because it will be more difficult to realise the benefits when successful and contain losses when unsuccessful (Bartelsman, 2004). Put differently, policies may provide direct incentives for within-firm productivity improvements but such incentives may also be enhanced by policies that facilitate between-firm reallocations (see Andrews and Criscuolo, 2013).

15 For example, in the Bourles et al., (2013) dataset comprising 15 OECD countries and 20 industries over the period 1984-2007, the United States occupied the leader position in almost 60% of cases.

identifies the 100 most globally productive firms in each industry at the frontier each year – shows that the global productivity frontier is actually comprised of firms from different countries, reflecting varying patterns of comparative advantage and natural endowments. Moreover, they are very much "global firms" in the sense that they operate in different countries (often part of a MNE group[16]), and are interconnected with suppliers/customers from different countries along global value chains (GVCs). This carries important policy implications, as discussed in Chapter 4.1.

Given the difficulties in measuring technology, the globally most productive firms are also assumed to operate with the globally most advanced technologies but it should be recognised that very technologically advanced firms might not necessarily appear as the globally most productive or the most successful in terms of profits.[17]

Firms at the global productivity frontier are on average 4-5 times more productive than non-frontier firms in terms of MFP, while this difference is more than 10 times with respect to labour productivity (which includes capital intensity).[18] Figure 11 charts the evolution of labour productivity for firms at the global productivity frontier, non-frontier firms and all firms for the years for which comparable data are available. GF firms have become relatively more productive over the 2000s, expanding at an average annual rate of 3½ per cent in the manufacturing sector, compared to an average growth in labour productivity of just ½ per cent for non-frontier firms. While data limitations make it difficult to say whether growth has slowed relative to earlier periods, it is interesting that frontier growth remained robust after 2004, when aggregate productivity in advanced economies (e.g. the United States) began to slow.

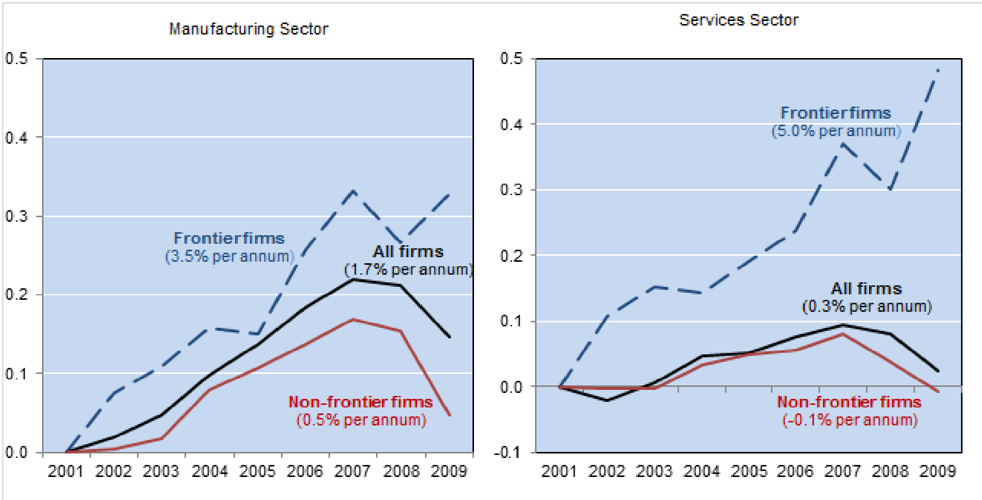
16 Based on the definition in Figure 11, the probability that a GF firm is part of a MNE group structure is around 0.42, compared to 0.29 for non-frontier firms. This difference is statistically significant at the 1% level.

17 This might be driven by high levels of R&D investments that are not (yet) matched by high sales values.

18 This difference is statistically significant at the 1% level and is based on a sample of 3657 frontier firms and 294031 non-frontier firms in 2005.

Figure 11. Solid growth at the global productivity frontier but spillovers have slowed down

Labour productivity; index 2001=0



Notes: "Frontier firms" corresponds to the average labour productivity of the 100 globally most productive firms in each 2-digit sector in ORBIS. "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 2001-2009 for each grouping of firms is shown in parentheses. The broad patterns depicted in this figure 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.

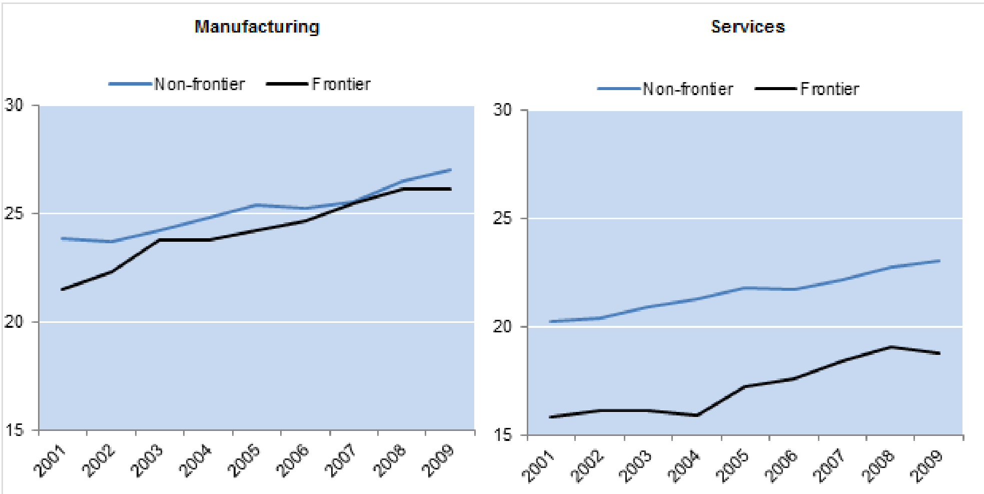
Source: Andrews, Criscuolo and Gal (2015).

More importantly, the rising gap in productivity growth between firms at the GF and other firms since the beginning of the century suggests that the capacity of other firms in the economy to learn from frontier may have diminished. This is consistent with: *i*) longer run evidence on the penetration rates of new technologies (e.g. Comin and Mestieri, 2013); *ii*) winner takes all dynamics (Gabaix and Landier, 2008); and *iii*) the rising importance of tacit knowledge. With respect to the latter, it is likely that the competitive advantage of GF firms arises not only from their investments in KBC, but how they tacitly combine different types of intangibles – e.g. computerized information; innovative property and economic competencies – in the production process.

Firms at the global productivity frontier are typically larger, more profitable, and more likely to patent, than other firms. Moreover, they are on average younger, consistent with the idea that young firms possess a comparative advantage in commercialising radical innovations (Henderson, 1993; Baumol, 2002) and firms that drive one technological wave often tend to concentrate on incremental improvements in the subsequent one (Benner and Tushman, 2002). However, the average age of firms in the global frontier has been increasing since 2001 (Figure 12). To the extent that this reflects a slowdown in the entry of new firms at the global frontier, it could also foreshadow a slowdown in the arrival of radical innovations and productivity growth.[19]

Figure 12. Firms at the global productivity frontier have become older

Average age (years) of firms in the frontier and non-frontier groups



Notes: Frontier is measured by the top 100 firms in each 2-digit industry and each year, based on Solow residual-based MFP. The difference in firm age between 2001 and 2009 is statistically significant, for frontier and non-frontier firms alike.

Source: Andrews, Criscuolo and Gal (2015).

19 An alternative explanation is that this reflects the emergence of a market for innovation whereby incumbents buy innovations via merger and acquisitions with young firms.

2.2 Diffusion of innovations and best practices

It is important to understand the factors which shape the ability of firms that are the most advanced at home to learn from the globally most advanced firms. This learning creates scope for the diffusion of technologies and business practices from the home frontier firms to laggard firms within the same country.[20] Moreover, given that cross-country differences in penetration rates of new technologies have increased over time (Comin and Mestieri, 2013), understanding barriers to the diffusion of unexploited existing technologies from national frontier firms to laggards is key in understanding cross-country differences in aggregate performance. Besides being good for growth, more effective diffusion may also promote inclusiveness. Recent evidence suggests that the observed rise in wage inequality appears to at least reflect the increasing dispersion in average wages paid across firms (Card et al., 2013). Thus, raising the productivity of laggard firms, via diffusion, could contain increases in wage inequality. Diffusion also reduces the cost and increases the quality and variety of goods and services, thereby raising real incomes and broadening access to better health care and education.

The working hypothesis in Figure 10 is that the capacity of home frontier firms to capitalise on new technologies developed abroad is enhanced by three key factors: *i*) openness to trade and global factor mobility; *ii*) the potential for up-scaling; and *iii*) competitive pressures to invest in KBC.

2.2.1 Openness and global factor mobility

An economy's ability to sustain productivity growth via learning from the global frontier will depend on trade and international investment. More specifically, it will hinge on its degree of interconnectedness with countries that are at the global frontier in the traded goods and services or investment areas. Firms that make it to the global market, via trade and foreign direct investment, are a group of "selected" companies that are larger, more innovative and more skill-intensive (i.e. they belong to the national frontier).[21] Exposure to trade and FDI entails exposure to knowledge and know-how of the "best" foreign and domestic firms (Alvarez et al., 2013). Learning takes place from competing global firms but even more along GVCs from suppliers and customers, and will also be facilitated by closer geographical proximity, particularly in high-tech sectors where knowledge is tacit (see Box 5 for details on the channels linking trade and productivity).

Migration – particularly of high-skilled individuals – may also push the frontier, enhance diffusion and propel innovation more generally (Alesina and La Ferrara, 2005; Kerr 2008; OECD 2008). In particular, birthplace diversity enhances variety in ability and knowledge, which in turn supports innovation (Alesina et al., 2013). Using data on cross-country flows of scientists, Appelt et al., (2015) find evidence which supports the circular nature of knowledge flows, as opposed to the traditional brain gain/drain paradigm. More specifically, brain circulation – which might stimulate knowledge flows, collaboration and ultimately high impact research – tends to be enhanced by a countries' degree of physical proximity, service trade connections and common language and scientific subject specialisation, while it might be hindered by visa restrictions.

20 Assigning relative importance to the role of frontier innovation versus diffusion is difficult since their specific relevance will depend on an economy's distance from the global productivity frontier, distribution of firm productivity and allocation of resources across firms.

21 See Eaton et al., (2011) for evidence on goods traders and Breinlich and Criscuolo (2011) on services traders.

Box 5. Trade and productivity

There is a vast literature documenting the positive effects of trade on productivity performance. In general, these effects are realized through three key channels:

- Trade openness leads to tougher product market competition, which in turn promotes productivity-enhancing reallocation via the expansion of the most productive firms into foreign markets and exit of low productivity firms (Melitz, 2003; Melitz and Ottaviano, 2008; Melitz and Trefler, 2012).
- Trade and foreign direct investment enhance knowledge flows from global customers and suppliers (Crespi et al., 2008; Duguet and MacGarvie, 2005) and from the activities of multinational firms. Enhanced knowledge exchanges will take place within the multinational firm itself (Criscuolo et al., 2010), both from the headquarters to their affiliates and vice versa, via reverse technology transfer (Griffith et al., 2006), and from the multinationals to local economic agents and vice versa (Puga and Trefler, 2010). Moreover, domestic firms that trade are put in touch with the most efficient foreign and domestic producers that are able to compete on international markets and thus get them closer to the global frontier (Alvarez et al., 2013).
- Trade openness increases the effective market size, which magnifies the expected profits arising from the successful adoption of foreign technologies (Schmookler, 1966; Acemoglu and Lin, 2004).

Although trade plays a key role in facilitating learning from the frontier (Alvarez et al., 2013), geographical distance remains an important obstacle to sharing knowledge given its tacit and non-codifiable nature and the local nature of spillovers. This is true for embodied and even more so for disembodied knowledge transfer (Keller and Yeaple, 2013). Recent evidence from the timing of patent citations, which captures the time it takes for a patented innovation to be used in subsequent patents (Griffith et al., 2011; Aldieri, 2011) and evidence from knowledge sharing through patent transactions (Mowery and Ziedonis, 2001; Drivas and Economidou, 2014) show that proximity is still important for market and non-market transacted knowledge diffusion, even though its importance has been decreasing recently.

2.2.2 Up-scaling

While trade can facilitate learning, firms must overcome a number of hurdles before they can trade. A key barrier is insufficient scale to the extent that international trade entails a number of fixed costs that must be met (Melitz, 2003).[22] Firm size tends to grow with the effective market size, implying that small and geographically isolated economies will be at a natural disadvantage in this regard. This disadvantage will be compounded by the fact that participation in trade results in larger market size, which in turn raises the returns to investments in R&D (Acemoglu and Lin, 2004; de Serres et al., 2013). Reaching sufficient scale takes on heightened importance given rising global integration. All else equal, tougher global competition implies that the 'minimum' level of performance in terms of size (and productivity) at which firms are able to compete on global markets may have risen over time (Altomonte et al., 2011).[23] Reaping the benefits of firm growth will depend on potential barriers to up-scaling and up-grading, underscoring the importance of efficient reallocation and the significant opportunity costs of high rates of skill mismatch in some OECD economies, which are factors that are strongly influenced by the policy environment.

2.2.3 Knowledge-based capital and competition

The diffusion of ideas from the global frontier firms to home frontier firms also requires complementary investments in KBC, to facilitate the absorption and implementation of new ideas. In this regard, a strong domestic R&D sector is important for countries' ability to benefit from new discoveries by facilitating the adoption of foreign technologies (Griffith et al., 2004). Some aspects of new technologies are difficult to codify and require practical investigation before they can be properly incorporated into production

22 This is consistent with the finding that a relatively small share of large firms accounts for the lion's share of an economy's exports (Eaton et al., 2011; Breinlich and Criscuolo, 2011).

23 This argument should not be overstated given the rise of: i) "micro-multinationals" – i.e. start-up firms that start global; and ii) ICT, which enables firms to outsource and establish a global presence more quickly.

processes and thus the availability of researchers that can de-mystify "tacit" knowledge plays a crucial role. Moreover, implementing and realising the full productivity benefits from new technologies (such as ICT) entails significant organisational restructuring, which requires considerable managerial skill (Bloom et al., 2012a).

The diffusion of existing technologies from the most advanced national firms to the rest of the economy will be shaped by the degree of competitive pressure and barriers to the diffusion of investment in KBC. Increases in competition induced by international trade shocks reduces the market share and profits of low productivity (or import-competing) firms, which increases these firms' incentives to adopt better technologies (Perla et al., 2015; Bloom et al., 2011).[24] Technological adoption will also be swifter in institutional settings that are less susceptible to lobbying by producers of incumbent technologies (Comin and Hobjin, 2009). Even so, persistent barriers to the diffusion of existing technologies remain, including the role of technological knowledge – *i.e.* "knowledge about technology and how to use it productively". Put differently, knowledge is accumulated by using new technologies but using new technologies is what facilitates the absorption of technological knowledge.[25] Increases in the complexity of technologies over time may have also increased the amount and sophistication of complementary investments required for technological adoption.[26]

While these hurdles to technological adoption are significant, they may be partly overcome by removing barriers to improvements in managerial quality. Indeed, aggregate level evidence suggests that an economy's speed of convergence to its long-run steady state level of MFP is positively related to the quality of its managerial capital (Andrews and Westmore, 2014). This is likely to reflect the aforementioned complementarity between technological adoption and managerial capital, but also the tendency for better managed firms to be more effective in matching workers to jobs (*i.e.* they are less susceptible to skill mismatch; Chapter 4.4). Greater R&D collaboration between firms and universities might also facilitate the technological diffusion to laggards by providing smaller and less productive firms with access to sources of knowledge – *e.g.* the necessary set of advanced machinery and skilled scientists and personnel – that typically require large upfront investments.

2.3 Firm heterogeneity and reallocation

An economy's potential to have global frontier firms or to adopt frontier innovations will also depend on its ability to reallocate scarce resources to the most productive firms (Andrews and Criscuolo, 2013). The widespread heterogeneity in firm performance that is evident within even narrowly defined sectors has important aggregate consequences (Syverson, 2011). Aggregate productivity could be lower than otherwise due to a technological gap of the national relative to the global frontier (e.g. country A and B to varying degrees); a weak market selection, which enables too many bad performers to survive in the market (country C); or both (Figure 13). For example, average productivity is identical in both countries B and C, despite the presence of global frontier firms in the latter but the long tail of low productivity firms weighs on aggregate productivity in Country C.

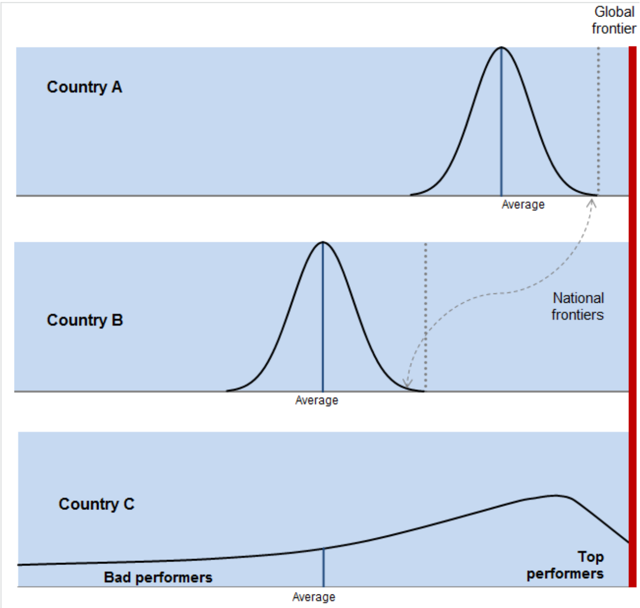
24 Similarly, evidence from Spain shows that firms with an initially low productivity increase their productivity in response to increased import competition, whereas firms with an initially high productivity increase their productivity as response to access to export markets (Steinwender, 2015).

25 Diego Comin's comments at the OECD-NBER Conference on Productivity and Innovation in the Long-Run.

26 Chad Syverson's comments at the OECD-NBER Conference on Productivity and Innovation in the Long-Run.

Coexistence of poorly performing firms with star performers can be due to a number of factors, but barriers to exit and skill mismatch clearly play a role. The opportunity cost of such barriers and mismatch can be large as – at least in the short to medium-run – firms' innovation activities draw from a scarce and fixed pool of contestable resources, particularly skilled labour. Thus, trapping resources in relatively small and low productivity firms (Chapter 3.2) can hinder the growth prospects of more innovative firms (Acemoglu et al., 2013). Similarly, the significant incidence of skill mismatch – particularly over-skilling – is harmful to aggregate productivity because it constrains the growth of the most productive firms (Chapter 3.3). These frictions may explain why national frontier firms are undersized in some economies, greatly diminishing their aggregate impact (Chapter 3.2)

Figure 13. Stylised depiction of how differences in productivity spreads matter for policy



Source: Adapted from Bartelsman et al., (2008).

CHAPTER 3. ENHANCING PRODUCTIVITY IN A GLOBALISED WORLD

This Chapter examines some key factors that are likely to increasingly affect future productivity performance, which centre on: *i*) facilitating global learning spillovers; *ii*) allowing productive firms to thrive; and *iii*) making the most of human capital.

3.1 Facilitating global learning spillovers

Consistent with the framework laid out in Figure 10, the ability to learn from the global frontier is stronger in economies that are more connected with the global frontier via trade; are more integrated in global value chains (GVCs); allocate skills more efficiently and invest more in KBC, such as R&D and managerial capital, and ICT readiness, as proxied by the E-government readiness index (Figure 14).[27] The role of trade is particularly important: assuming a 2% acceleration in MFP growth at the frontier, the estimated gain to annual MFP growth would be around 1/3 percentage points higher in a country which trades very intensively with the frontier economy (e.g. Canada), than in one where such trade is relatively weak (e.g. Austria).

The strong link between trade, globalisation and productivity growth (Box 5) carries significant implications for future productivity. While globalisation is likely to continue in the future, this may take place at a slower pace than observed recently (Braconier et al., 2014).[28] The intensity of fragmentation of GVCs may also slow down as there are likely physical limits on how much a product and task can be fragmented (Fontagné and Fouré, 2013).[29] Thus, on the one hand, rising trade integration is projected to boost MFP growth over coming decades, by improving: *i*) the returns to innovations at the frontier due to market size effects; *ii*) the speed of convergence to economies' long-run steady states (Johansson et al., 2013); and *iii*) the effectiveness of learning from the frontier for those economies that trade more intensively with frontier economies. On the other hand, with the positive effects on productivity of the globalisation shock – triggered by the emergence of China – likely to fade and uncertainties regarding the further fragmentation of GVCs,[30] a key issue for future productivity is how to best capitalise on the benefits of GVC participation.

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27 Better ICT infrastructure increases the countries' ability to adopt and capitalize ICT innovation. The E-government readiness index measures the capacity of governments to deliver e-government services for citizens and businesses. Similar results are obtained using as alternative measure of ICT readiness the World Economic Forum's Networked Readiness Index.

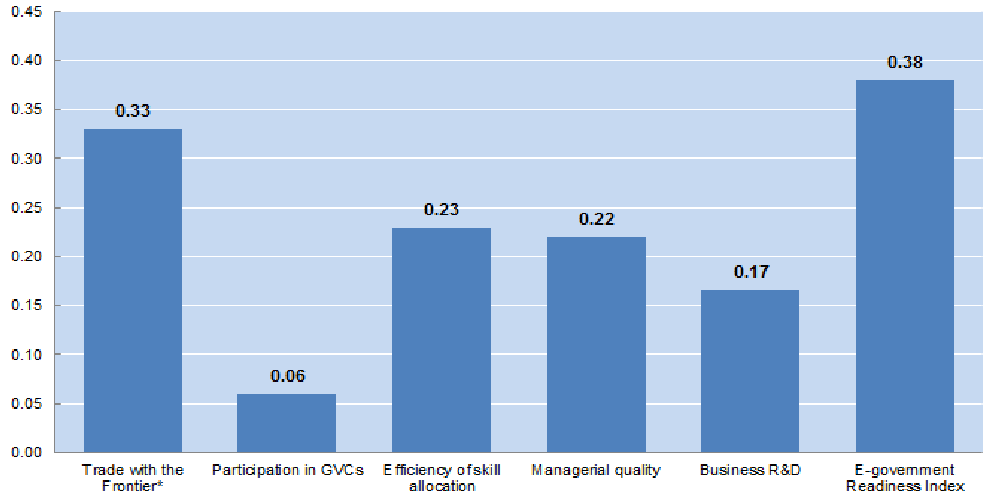
28 World trade estimated to grow by 3.5% annually over the next 50 years, compared with 6.9% over 1990-2007, since the gains from the global integration of large emerging economies (e.g. China) will not be repeated.

29 However, there is more uncertainty surrounding this development, given: i) scope to increase GVC participation in some countries; ii) the potential for reshaping of GVCs along regional dimensions as the centre of global economic gravity shifts; and iii) possible re-shoring as the cost advantages of emerging countries dissipate.

30 The removal of product-specific quotas (on Chinese imports into Europe) following China's accession to the WTO triggered a significant increase in R&D, patenting and productivity in European firms (Bloom et al., 2011).

Figure 14. Learning from the global frontier is shaped by key structural factors

% difference in frontier spillover effect between maximum and minimum value of each structural variable, assuming 2% MFP growth at the frontier



Notes: Trade with the global frontier measures the intensity of trade with the productivity leader in each manufacturing industry and is based on OECD calculations using OECD, STAN database (Minimum: Austria, Maximum: Canada). GVC Participation is based on the measure in Figure 15 (Minimum: Canada, Maximum: Belgium). Efficiency of skill allocation (Minimum: Italy, Maximum: Belgium) and managerial quality (Minimum: Italy, Maximum: Finland) are sourced from Adalet McGowan and Andrews (2015a). Business R&D is defined as the ratio of business R&D expenditures to value added and sourced from OECD, Main Science and Technology Indicators (Minimum: Australia, Maximum: Sweden). E-government readiness index (Minimum: Greece, Maximum: the Netherlands) is from OECD, Internet Economy Outlook 2012.

Source: Saia, Andrews and Albrizio (2015).

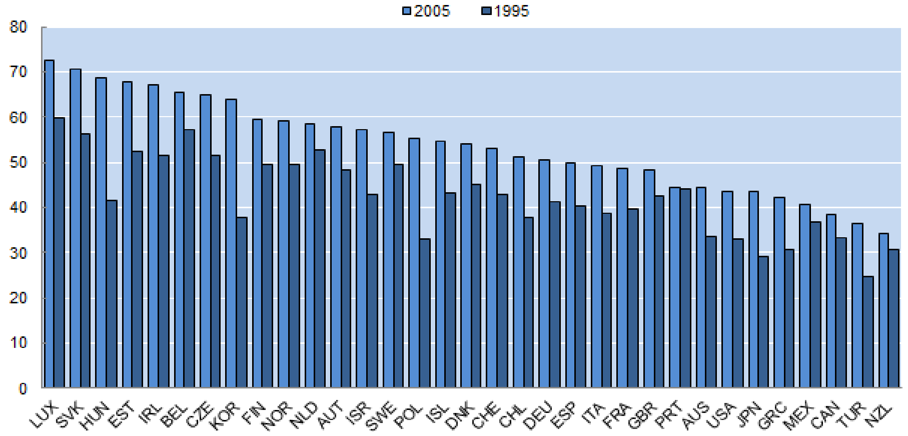
3.1.1 The rise of global value chains

Economies participate in GVCs both as users of foreign inputs and as suppliers of intermediate goods and services that can be used in other economies' exports (OECD, 2013b). GVC participation has risen in most economies since the mid-1990s, although important cross-country differences remain (Figure 15, Panel A). GVC participation tends to be higher in small open economies – such as Luxembourg and Eastern Europe – than in economies with large domestic markets such as the United States and Japan. In contrast, GVC participation falls as the reliance on primary exports and distance to market increase – two relevant factors for Australia and New Zealand.

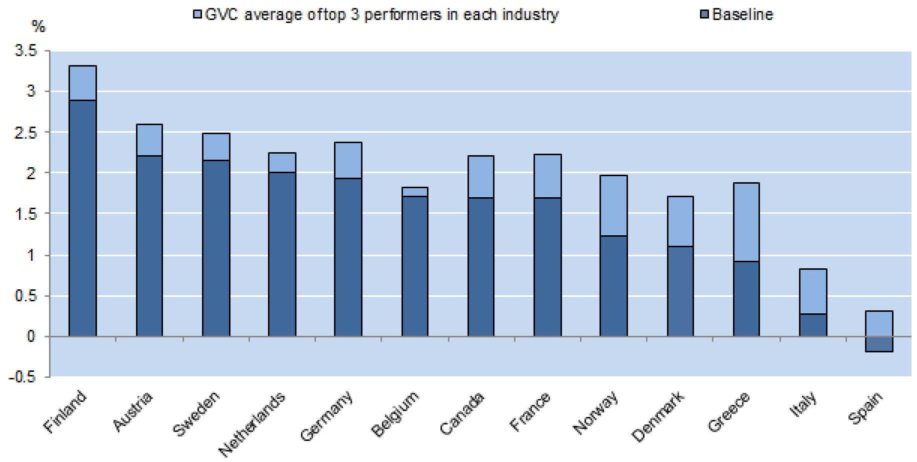
GVC participation may boost productivity via a number of channels, including stronger competitive pressures that reduce the cost of intermediate inputs and access to a wider variety of foreign inputs that embody more productive technologies. Indeed, MFP grew more quickly in those industries that experienced larger increases in GVC participation (Saia et al., 2015) and suggests that raising GVC participation to higher levels would be associated with significant productivity gains in a number of OECD countries (Figure 15; Panel B). These potential gains to productivity come on top of the more effective learning from the frontier that is also associated with higher GVC participation (Figure 14). Of course, the likelihood that more productive firms self-select into GVC participation makes causality difficult to establish and thus these numbers should be interpreted with caution.

Figure 15. Rising GVC participation and links with productivity growth

A: GVC participation



B: Estimated gains to MFP growth associated with raising GVC participation



Notes: Panel A: GVC participation is defined as the sum of the share of imported inputs in a country's exports (backward) and of its exports used as inputs in other countries' exports (forward). Data are available for 2009 but are not shown in order to abstract from the effects of the crisis on trade. Panel B shows the predicted average MFP growth (baseline based on actual GVC participation) and a counterfactual average MFP growth based on raising GVC participation in each country to the average GVC participation for the top 3 performers in each industry for any given year for the manufacturing sector. Industry level productivity is aggregated using country-specific industry value added shares. The estimates are calculated from a regression that controls for country*year and industry fixed effects and is based on a sample of 15 countries for the period 1990-2007.

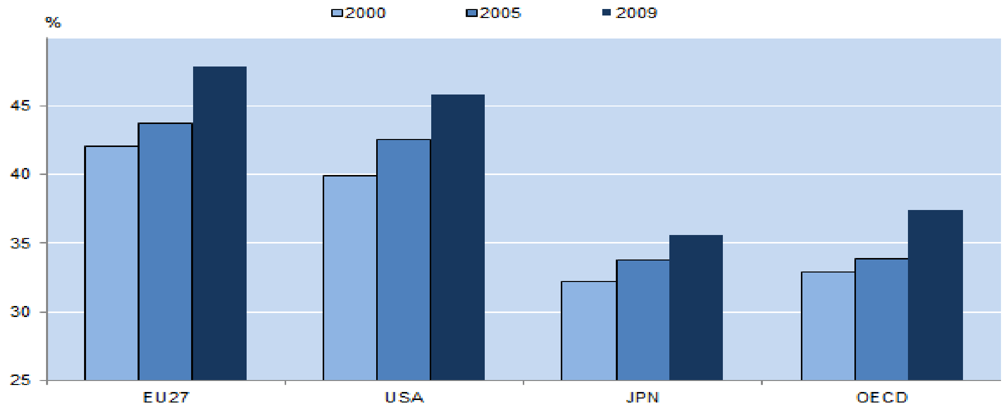
Source: Panel A: OECD, TiVA database. Panel B: see Saia, Andrews and Albrizio (2015).

3.1.2 The importance of an efficient services sector in a globalized world

Global production networks rely on well-functioning transport, logistics, communication and other business services to move goods and coordinate production along the value chain. In fact, the domestic services content of economies' gross exports has risen over time (Figure 16), underscoring the importance of open and efficient markets for services, to underpin participation in GVCs, and hence facilitate the diffusion of new technologies. In turn, such diffusion (and an increasing use of ICT) can improve the tradability – and thus exposure to competition – of some services. Such tradability, for instance, has been shown to increase productivity in New Zealand (Conway and Zheng, 2014), where distance to market is an issue. However, a key risk is that low productivity in some domestic services sectors indirectly constrains productivity growth in more dynamic downstream sectors, and this may also carry direct consequences for future productivity (Box 6).

Figure 16. Global production networks increasingly rely on the domestic services sector

Value-added share of domestic services in gross exports



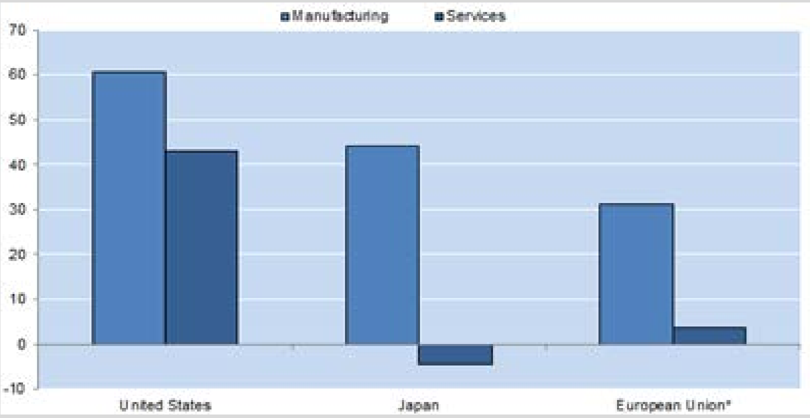
Source: OECD TiVA database.

Box 6. Structural transformation and productivity

The share of services in economic activity has risen over time, and population ageing is likely to underpin a further shift in demand towards services. This carries important implications for future productivity to the extent that productivity in domestic services is generally low, consistent with lower competitive pressure, relatively inefficient resource allocation (Figure B2) and low managerial quality (Chapter 4.3).[1] While over the short to medium term, the impact of inter-sectoral reallocation on aggregate productivity is relatively modest (Mora-Sanguinetti and Fuentes, 2012; Meehan, 2014), the rising share of services may also weigh on aggregate productivity via input-output linkages. Moreover, over the longer run, models of structural transformation suggest that while most countries have experienced substantial productivity catch-up in agriculture and industry relative to the United States, the productivity gap in most services has remained high (Duarte and Restuccia, 2010). This is consistent with the firm level analysis in Figure 11, which shows that the rising gap in the productivity growth of GF firms and other firms is stronger in services than manufacturing. Thus, as economies move through the process of structural transformation, they can initially experience a period of catch-up driven growth but then later stagnate, due to the low productivity in the services sector.

Figure B2. Resources are allocated less efficiently in the services sector

Contribution of the allocation of employment across firms to the level labour productivity; per cent



Notes: The estimates show the extent to which firms with higher than average labour productivity have larger employment shares. For example, productivity in the manufacturing sector in the US is around 60% higher due to the actual allocation of employment, compared to a baseline in which labour is allocated randomly across firms (index=0).

Source: Andrews and Cingano (2014).

1. The measurement of productivity in services is clearly an issue and there is also heterogeneity within the services sector, with some business services increasingly exposed to international competition, thus raising their productivity.

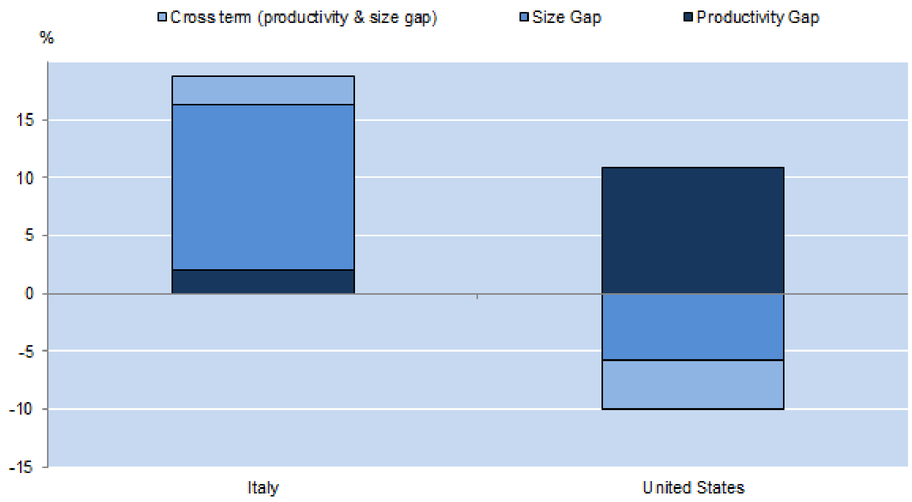
3.2 Allowing productive firms to thrive

3.2.1 Significant productivity gains from improving the performance of national frontier firms

One way to raise aggregate productivity is to improve the performance of national frontier firms towards the global productivity frontier. By way of illustration, Figure 17 shows that overall manufacturing sector labour productivity would be around 20% higher in Italy but little changed in the United States if national frontier firms were as productive and large as the global frontier benchmark (Andrews, Criscuolo and Gal, 2015). More specifically, in Italy, approximately three-quarters of this productivity gap can be explained by the fact that national frontier firms – while actually quite productive in global terms – are relatively small compared to those at the global frontier. A similar phenomenon is also observed in the auto-parts manufacturing sector in Mexico (Bolio et al., 2014). By contrast, while national frontier firms in the United States are larger than those at the global frontier, aggregate productivity could rise by around 10% if they were also as productive as those at the global frontier.[31]

Figure 17. Performance gaps between the national and global frontier: a two-country example

How much would overall manufacturing sector productivity rise if firms at the national frontier were as productive and large as firms at the global frontier?



Notes: The productivity (size) gap shows how much higher manufacturing productivity would be relative to baseline if the national frontier firms (NF) were as productive (large) as the global frontier (GF) benchmark. The cross term shows the impact on aggregate productivity of simultaneously closing the productivity and size gaps. The estimates are constructed by taking the difference between counterfactual labour productivity and actual labour productivity. The counterfactual gaps are estimated by replacing the labour productivity (employment) of the top 10 NF firms with the labour productivity (employment) of the 10th most globally productive firm in each two-digit sector. The industry estimates are aggregated using US employment weights.

Source: see Andrews, Criscuolo and Gal (2015).

Overall, these differences in the size of national frontier firms are consistent with recent firm-level research for the broader economy which highlights that: *i)* the share of small firms is much higher in Italy, than in the United States and other OECD countries (Criscuolo et al., 2014); and *ii)* the United States is much more successful than Italy at channelling scarce resources to the most productive firms (Andrews and Cingano, 2014) and to innovative firms (Andrews et al., 2014). They are also informative from a policy

31 This sizeable productivity gap effect reflects the relative efficient allocation of resources in the United States – i.e. the most productive firms command a high share of resources – which effectively magnifies the aggregate gains of aligning the productivity of the national frontier with the global benchmark.

perspective, and suggest that policy reforms in Italy should focus on improving the efficiency of resource reallocation mechanisms, while in the United States, policies that can improve within-firm productivity decisions could yield a greater marginal benefit. The types of policies that might be effective in closing these performance gaps are discussed in Chapter 4.

3.2.2 But achieving these gains is difficult when market selection and post-entry growth are weak

The significant differences in the size of national frontier firms across countries extend to the whole population of businesses and intensify with the age of the firm. To a certain extent, these differences reflect barriers to up-scaling after firm entry. Indeed, cross-country differences in the post-entry performance tend to be more marked than differences in entry and exit patterns (Bartelsman et al., 2003). While there are different ways to investigate differences in up-scaling across countries,[32] this section focuses on: *i*) the share of small firms that are relatively old, which is negatively related to aggregate MFP and employment growth (see Chapters 1.3 & 2.3; Criscuolo et al., 2014); and *ii*) post-entry growth patterns, which reveal important cross-country differences in the ability of firms to achieve sufficient scale to enter global markets (Chapter 2.2).

If small firms are (on average) old, this might reflect barriers to post-entry growth and weak market selection mechanisms. For instance, only 22% of small firms in Finland – which account for 41% of total employment – can be classified as “young” (i.e. less than 5 years old), against more than 50% in the United States and other countries (Figure 18, Panel A). There are also significant cross-country differences in the relative sizes of old and new businesses: while old businesses in the United States are more than seven times larger than start-ups, this ratio drops to just above two in Italy and Norway, and below two in France, Finland or the Netherlands (Figure 18, Panel B).

Similar differences can be observed following cohorts of firms across countries. A key message is that creative destruction and up-or-out dynamics are central: entry matters but what happens next is crucial – all else equal, young firms should grow rapidly or exit (i.e. “up-or-out”) but not linger and become small-old firms. In this regard, comparing countries with similar survival rates but significantly different post-entry growth patterns – *e.g.* Sweden *vs* Italy and Finland *vs* New Zealand – is instructive (Figure 19).

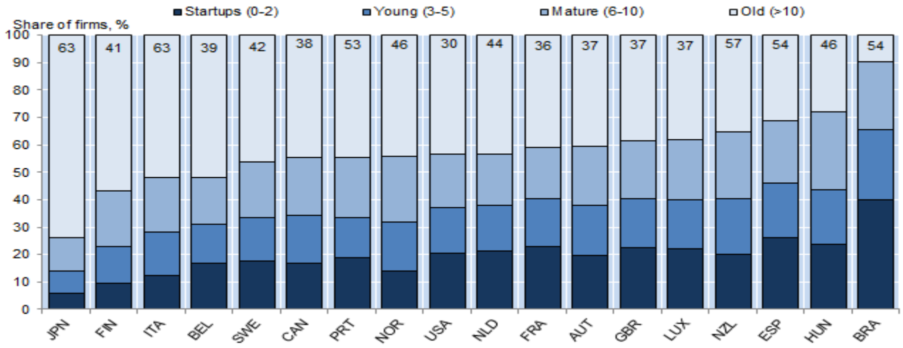
Survival rates are relatively high in both Sweden and Italy – i.e. above 50% after 7 years. However, post-entry employment growth tends to flatten out in Italy in the years following initial market entry, while surviving firms in Sweden on average are more than 200% larger 7 years after entry, which is more than double the growth observed in Italy. In Sweden, high survival rates might be symptomatic of an efficient selection of firms at entry, which results in a high proportion of firms with strong growth potential. By contrast, it is more likely to reflect a weak selection process in Italy, which might result in resources being used by a larger proportion of less productive firms that do not exit and thus stifle the growth opportunities of more productive firms.

By contrast, survival rates are relatively low in both Finland and New Zealand (about 40% of an entry cohort survives after 7 years) and post-entry growth exhibits monotonic patterns over time. At first glance, this suggests a healthy creative destruction process that facilitates experimentation and firm growth (exit) in the event of success (failure). However, the magnitude of post-entry growth rates in New Zealand is about one-half of that observed in Finland, possibly reflecting the barriers to up-scaling related to geographical remoteness and small market size in New Zealand.

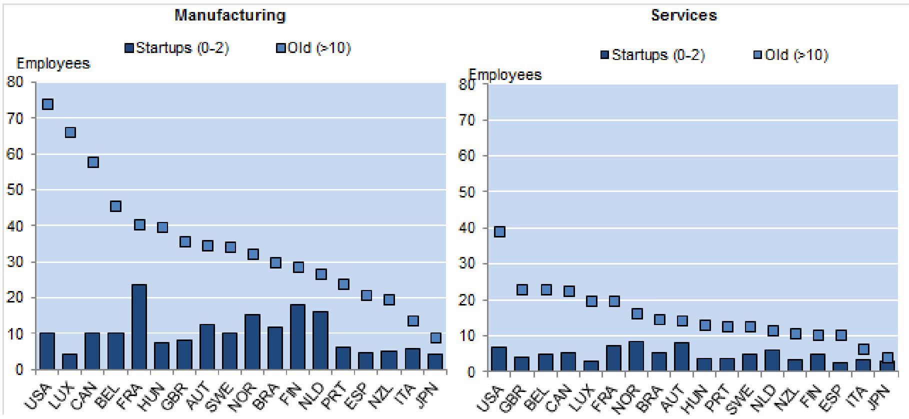
32 Focusing on size per se might be misleading because a large share of small firms (or small average firm size) might reflect a large share of start-ups experimenting at small scale due to low entry costs.

Figure 18. The strength of market selection and post-entry growth varies across countries

A: Many small and old firms suggest less intense market selection in some countries



B: Post-entry growth – average size of young and old firms

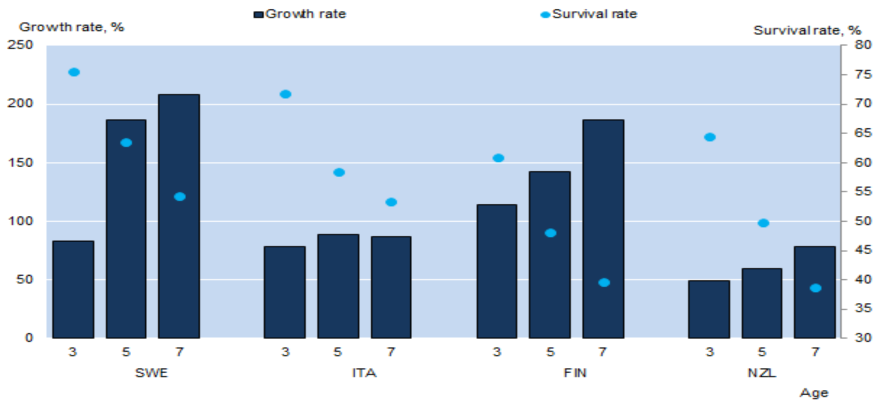


Notes: Panel A shows the share of firms by age group in the total number of micro and small firms (below 50 employees). The numbers at the top of the chart shows the share of small firms in the overall population of firms. Panel B reports the average size of start-up firms (from 0 to 2 years old) and firms more than 10 years old. See notes to Figure 6 for details on the sample.

Source: Criscuolo, Gal and Menon (2014).

Figure 19. Up-or-out dynamics vary across countries

Firm growth and survival rates, by firm age



Notes: Based on preliminary data from the Dynemp v.2 project. The dots report the average survival rates after 3, 5 and 7 years for start-ups (less than 10 employees) of the 2001; 2004 and 2007 cohorts. The bars report average growth rates relative to their initial size. Values are averaged across all available years. See Figure A6 for a broader set of countries.

Source: Calvino et al., (2015).

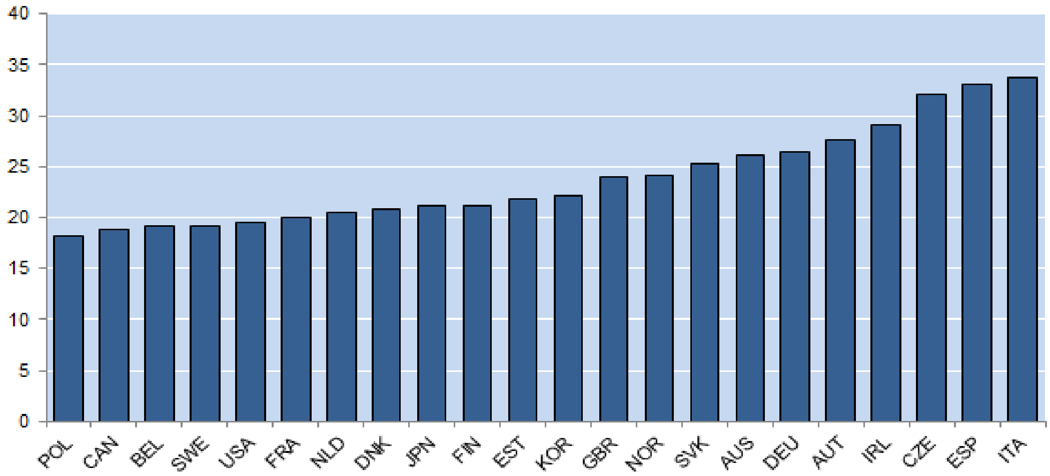
3.3 Making the most of human capital

While increases in the number of highly educated workers have significantly boosted labour productivity over the past 50 years, the rate of increase in the stock of human capital is projected to slow. At the same time, the increasing economic importance of knowledge is projected to raise the returns to skills, thus underpinning further increases in wage inequality within countries (Braconier et al., 2014). In order to mitigate this unfavourable combination of slowing growth and rising inequality, it will become increasingly important to allocate skills efficiently.[33] This is also important since the benefits of human capital-augmenting policies take a long time to be realised, while improving the allocation of skills will enhance the 'bang-for-the-buck' (i.e. productivity impact) of such policies.

Indicators of skill mismatch, constructed from the OECD *Survey of Adult Skills* (see Box 7 for details), suggest that there is considerable scope to improve the efficiency of human capital allocation and labour market matching more generally. On average across countries, roughly one-quarter of workers report a mismatch between their existing skills and those required for their job – *i.e.* they are either over or under-skilled. Moreover, important cross-country differences emerge, with the incidence of skill mismatch ranging from around one-third in Italy, Spain and the Czech Republic, to less than one-fifth in a diverse set of countries, including Poland, Sweden and the United States (Figure 20). Over-skilling is generally more common than under-skilling, with being over-skilled on average roughly two and a half times more widespread than being under-skilled (Figure A7).

Figure 20. Cross-country differences in skill mismatch are significant

Percentage of workers with skill mismatch; selected OECD countries, 2011-12



Note: The figure shows the percentage of workers who are either over- or under- skilled (see Box 7 for definitions), for a sample of 11 market industries: manufacturing; electricity, gas, steam and air conditioning supply; water supply; construction; wholesale and retail trade; transportation and storage; accommodation and food service activities; information and communication; real estate activities; professional, scientific and technical activities, and administrative and support service activities. In order to abstract from differences in industrial structures across countries, the 1-digit industry level mismatch indicators are aggregated using a common set of weights based on industry employment shares for the United States.

Source: See Adalet McGowan and Andrews (2015a), which is based on the *Survey of Adult Skills* (2012).

33 Rising inequality might also reduce the effective human capital pool if it undermines the education opportunities for disadvantaged individuals (Cingano, 2014). While this issue is beyond the scope of this book, it suggests that a range of education and social welfare policies may also matter for long term productivity.

Box 7. Measuring skill mismatch from the OECD Survey of Adult Skills

The *Survey of Adult Skills* assesses the proficiency of adults aged between 16 and 65 in literacy, numeracy and problem solving in technology-rich environments in 22 OECD countries.[1] Besides the level of skills, information was collected on the background of respondents, their education and labour market experience, their skill use at work and at home plus indicators of well-being. The Survey, conducted in 2011-12, has a number of advantages over comparable datasets as it extends the number of countries, sample size per country and the range of assessed skills.

As discussed in Adalet McGowan and Andrews (2015a), skill mismatch can be measured in several ways, each with their advantages and disadvantages. One is through self-assessment by asking workers to compare their skill level and that required for their job. Another approach is to compare the skill levels – as measured by proficiency scores – to skill use at work. A final approach, developed in OECD (2013c) and employed in this analysis, combines information on self-reported skill mismatch and quantitative information on skill proficiency by:

1. The (literacy) proficiency scores of workers who report themselves as well-matched – i.e. those who neither feel they have the skills to perform a more demanding job nor feel the need for further training in order to be able to perform their current job satisfactorily – are used to create a quantitative scale of the skills required to perform the job for each occupation (based on 1-digit ISCO codes).[2]
2. Using this scale of proficiency scores of well-matched workers, minimum and maximum threshold values – based on the 5th and 95th percentile, for example – are identified, which effectively provide the bounds that define what it is to be a well-matched worker.[3]
3. Respondents whose scores are lower (higher) than this minimum (maximum) threshold in their occupation and country, are classified as under- (over-) skilled. By contrast, respondents whose proficiency scores reside within these bounds are not counted as mismatched, regardless of whether they self-report as being well-matched or mismatched.

1. AUS, AUT, BEL, CAN, CZE, DNK, EST, FIN, FRA, DEU, IRL, ITA, JPN, KOR, NLD, NOR, POL, SVK, ESP, SWE, GBR and USA.

2. Literacy is defined as the ability to understand, evaluate, use and engage with written texts to participate in society, to achieve one's goals, and to develop one's knowledge and potential.

3. The analysis here uses different threshold values based on the 10th and 90th percentiles.

New OECD research uses cross-country data to explore the *direct* relationship between mismatch and industry-level labour productivity indicators, constructed from firm level data (Adalet McGowan and Andrews, 2015a). Skill mismatch and aggregate productivity could be related through two channels: lower (or higher) within-firm productivity and a less efficient allocation of labour across firms. Higher skill mismatch is found to be associated with lower labour productivity via the channel of less efficient resource allocation. Furthermore, this largely reflects the strong negative correlation between over-skilling and productivity. One explanation for this could be that as firms draw from a scarce and fixed pool of skilled labour, trapping resources in relatively low productivity firms – which tends to occur in industries with a high share of over-skilled workers – can make it more difficult for more productive firms to attract skilled labour and gain market shares at the expense of less productive firms.[34]

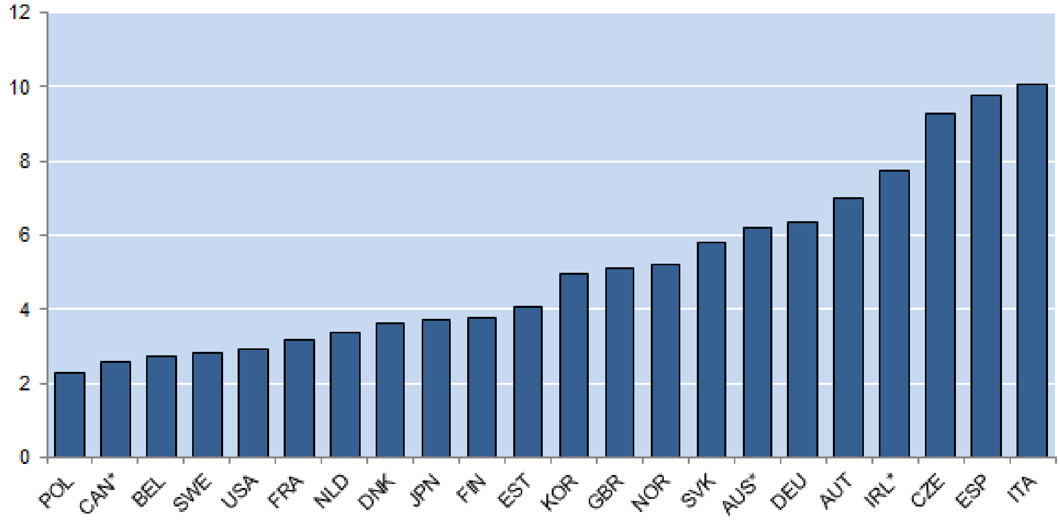
Based on these results, Figure 21 illustrates the potential gains to labour productivity from reducing skill mismatch in each country to the lowest cross-country level in each industry.[35] If interpreted causally, reducing skill mismatch in countries such as Italy and Spain to the lowest level would be associated with an increase in allocative efficiency of around 10%. This accounts for about one-fifth of the gap in non-farm business sector allocative efficiency between Italy and the United States (or Sweden). Hence, skill mismatch can potentially account for a non-trivial share of cross-country labour productivity gaps, thus motivating an analysis of the link between policies and mismatch.

34 Moreover, these effects of mismatch on resource allocation are sizeable enough to more than offset any private productivity benefit that may accrue to the firms that actually employ these over-skilled workers.

35 This exercise primarily focuses on allocative efficiency as opposed to overall labour productivity to the extent that fewer cross-country or cross-sector comparability issues arise with respect to the former.

Figure 21. Counterfactual productivity gains from reducing skill mismatch

Simulated gains to allocative efficiency from reducing skill mismatch to the lowest level; per cent



Note: The chart shows the difference between the actual allocative efficiency and a counterfactual allocative efficiency based on lowering the skill mismatch in each country to the best practice level of mismatch, which implies a productivity gain of around 10% in Italy and 3% in the United States. 1-digit industry level mismatch indicators are aggregated using a common set of weights based on the industry employment shares for the United States. The estimated coefficient of impact of mismatch on productivity is based on a sample of 19 countries for which both firm level productivity and mismatch data are available. While mismatch indicators are available for AUS, CAN and IRL, the estimates for these three countries should be interpreted with caution to the extent that they are not included in the econometric analysis due to insufficient productivity data.

Source: Adalet McGowan and Andrews (2015a)

CHAPTER 4. THE ROLE OF PUBLIC POLICY

Table 1 summarises the key channels through which different public policies shape productivity performance, in the context of the framework for analysis and relevant issues identified in Chapters 2 and 3. Column 1 points to three key sources of aggregate productivity growth to be promoted: *i*) experimentation with new knowledge and technologies in the globally most advanced firms and their subsequent diffusion to the most advanced firms at the national level; *ii*) the diffusion of globally available knowledge and technologies to both advanced and laggard firms at home; and *iii*) the efficient reallocation of resources to enhance the aggregate impact – and further encourage – the *within-firm* productivity improvements that will be realised from the previous two key channels. Columns 2 to 4 contain the relevant policies, channels through which these sources of growth can be promoted and the outcome that the policy at hand, if well-designed, can achieve. The final three columns provide an indication of their relevance to the three groups of firms identified in Chapter 2.

Table 1. Synoptic table on the channels through which policies shape aggregate productivity

Key dynamics to be promoted	Relevant policies	Channels	Outcomes	*Relevance to performance of various firms:*		
				Global frontier (GF)	National frontier (NF)	The laggards
1. Experimentation with new knowledge and technologies	Innovation policies (e.g. basic research, R&D fiscal incentives, IPR)	Promoting an efficient balance between applied and basic research.	Pushing the global technological frontier via more radical innovation and knowledge absorption from the science base.	VV	V	
	International co-ordination of innovation policy	Compensating firms for market failures in the provision of innovative effort.		VV	V	
	Framework policies (e.g. PMR, EPL, Bankruptcy & Judicial Efficiency, Financing and Openness)	Competitive pressures and creative destruction.	More experimentation. Innovative entrants bring new ideas and pressures incumbents to innovate.	VV	V	
			Enhanced market size to raise the returns to innovation.	V	V	
		Efficient resource allocation (see 3).	Entry into global markets enables interactions with the GF	V	VV	
			Lower skill mismatch, which increases the effective pool of skills to supply innovation	V	VV	
2. Diffusion of existing knowledge and technologies	Framework policies (especially PMR)	Competitive pressures	Greater market discipline incentivises technology adoption		VV	VV
			Presence of complementary KBC assets to facilitate technological diffusion		VV	V
	Basic research	Compensating firms for market failures in the provision of innovative effort.	Knowledge externalities from public research leads to more applied innovation in the private sector		VV	
	R&D fiscal incentives				V	V
	R&D collaboration between firms and universities	Knowledge transfer and spillovers	Allows new entrants, experimenting at small scale, to access research facilities.		V	VV
3. Efficient resource allocation (capital, labour and skills) and supply of skills	Framework policies	Channelling scarce resources to the most productive and innovative firms; exit/downsizing of inefficient firms.	Higher returns to commercialisation and implementation of new ideas, leading to more experimentation (see 1)	VV	V	V
			Lower the cost of business failure and exit to encourage risk-taking and experimentation (see 1)	VV	V	V
			Facilitates up-scaling and entry into global markets (see 1)	V	VV	V
	Housing policies		Lower skill mismatch (particularly over-skilling), which increases the effective pool of skills to supply innovation (see 1)	V	VV	V

Source: OECD Secretariat.

Notes: In the final three columns, “V” denotes “relevant” and “VV” denotes “highly relevant” for the particular firm at hand.

This Chapter first discusses the potential for policy to promote growth at the global technological frontier, and then turns to the links between policies and other aspects of productivity performance, including the diffusion of frontier technologies. In this regard, Chapter 4.2 discusses the role of innovation policies, while Chapters 4.3 and 4.4 show that well-designed framework policies can create the conditions for: *i*) productive firms to thrive and learn from the frontier; and *ii*) societies to allocate skills more efficiently. The latter also requires policy-makers to cast a wider net, such as addressing the potentially adverse effects of housing policies on skill mismatch.

4.1 Public policy and the global productivity frontier

Since firms at the productivity frontier are inherently global in nature, assessing how policies shape frontier growth is difficult as it is not clear which countries' policies are most relevant for these firms. Nevertheless, policy framework that promotes more effective international co-ordination in certain areas and facilitates experimentation within firms might incentivise frontier innovation which has public good characteristics to the extent that the benefits can spillover to other firms.

4.1.1 International policy co-ordination

Innovation at the frontier partly depends on basic research, which drives fundamental advances in technological knowledge and in turn opens up windows of opportunity for future research (Nelson, 1959; Aghion and Howitt, 1996). However, basic research may be underprovided due to difficulties in appropriating the full benefits, which tend to spillover across various sectors and create larger social benefits than applied research (Akcigit et al., 2014). Publicly-funded research often plays a crucial role in the development of new general purpose technologies (Sheehan and Wyckoff, 2003). More generally, evidence suggests that government, both as a buyer of technology – *e.g.* through defence projects – and as funder – *e.g.* of research in universities and public research centres – provides significant knowledge spillovers. This tends to underpin significant increases in R&D expenditures and patents of private companies (Draca, 2012; Moretti et al., 2014 and Azoulay et al., 2014) pushing the frontier both directly and indirectly.

Rising international connectedness and the key role of MNEs in driving frontier R&D imply that the benefits from public basic research and support to private R&D will become more widespread globally. This may weaken incentives for national governments to support these activities (Braconier et al., 2014) while at the same time pushing them to compete to attract mobile investments by MNEs. Thus, global mechanisms to support basic research – *i.e.* joint funding and mechanisms to facilitate cross-border and cross-field collaboration – will become increasingly desirable in the future. A global coherence of intellectual property rights (IPR) regimes – *e.g.* via the continued international harmonisation of national patents systems and subsequent enforcement of these measures[36] – may also need to be fostered. The global nature of frontier firms also suggests a need to co-ordinate R&D fiscal incentives and corporate taxation to ensure a level playing field. Indeed, with the anticipated rise in globalisation, there may be increasing instances of multinational enterprises using cross-border tax strategies to shift profits generated by KBC across countries (OECD, 2013d). This may lead to unintentionally high levels of total tax support for R&D and place domestic ‘stand-alone’ firms that perform R&D at a competitive disadvantage. Recent OECD work highlights the potential benefits of international co-operation to limit unintended tax relief for R&D stemming from cross-border tax planning (OECD, 2013d).

4.1.2 Policies to promote experimentation

Experimenting with new products and processes is a defining feature of innovation at the firm level.[37] Moreover, the innovation process is inherently uncertain and the highly skewed nature of the returns on venture capital (VC) investments suggest that the rapid success of frontier firms in some IT markets is impossible to predict *a priori*, even amongst the savviest VC investors (Kerr et al., 2014). In this environment, experimentation allows agents to assess and commercialize projects without investing the full amount and terminate projects quickly if they are not successful (Nanda and Rhodes-Kopf, 2012). While advances in ICT technologies have significantly lowered the cost of experimentation for frontier firms (Box 3), policies that can reduce the costs of experimentation on the entry (regulations affecting product and financial markets) and exit (EPL and bankruptcy law) margins will be important (see Chapter 4.3). In

36 Since the Trade-related Aspects of Intellectual Property Rights agreement in 1994 – which established common standards for patent law and scope for international sanctions against offending states – patent laws have been strengthened worldwide, especially in developing countries (Martinez and Guellec, 2004). Even so, the lack of enforcement remains a point of contention between developed and emerging economies (OECD, 2010).

37 For instance, every year, about 25% of consumer goods for sale are either new or will be discontinued the next year, at least 40% of new goods are sold only for a single year, and plants adopt only between half and a third of the technologies they try (see Gabler and Poschke, 2011).

parallel, the uncertainty highlighted above demonstrates the dangers for governments using industrial policies to promote national champions.[38]

4.2 Innovation-specific policies are important but trade-offs emerge

4.2.1 Fiscal incentives for R&D

R&D tax incentives, a non-discriminatory tool that aims to reduce firms' marginal cost of R&D activities, are present in the majority of OECD member countries, and also in Brazil, China, the Russian Federation and South Africa.[39] Support for business R&D through the tax system is typically combined with a broader set of direct support policies (e.g. grants, loans, loan guarantees) that are also intended to address market failures related to investment in innovation. While significant cross-country differences exist in the policy mix (Figure 22, Panel A), there has recently been a general shift away from direct support (Figure A8) and R&D tax incentives have become more generous.

This shift in the composition of fiscal support should be cast against evidence suggesting that while more generous R&D fiscal incentives stimulate additional business R&D, their impact on productivity growth is less clear-cut (see Box A1 in Appendix 1). New OECD research also finds little evidence that economies with more generous R&D tax incentives are more able to learn from the global frontier (Saia et al., 2015). Furthermore, while more generous R&D tax subsidies for SMEs might raise the productivity of national frontier firms towards the global frontier benchmark, these effects are offset by the fact that such policies may reduce the relative size of national frontier firms (Andrews, Criscuolo and Gal, 2015).

Recent OECD research also underlines the potential for R&D tax incentives to stifle reallocation (see Bravo-Biosca et al., 2013) and highlights potential policy complementarities between innovation policies and framework policies that shape the exit margin (e.g. bankruptcy legislation). For example, Acemoglu et al., (2013) show that policy intervention such as R&D tax subsidies are only truly effective when policy-makers can encourage the exit of low-potential incumbent firms, in order to free-up R&D resources (i.e. skilled labour) for innovative incumbents and entrants. This reflects the idea that low-potential firms – despite their lack of innovativeness – still employ skilled labour to cover the fixed costs of operation, such as management and back-office operations.[40]

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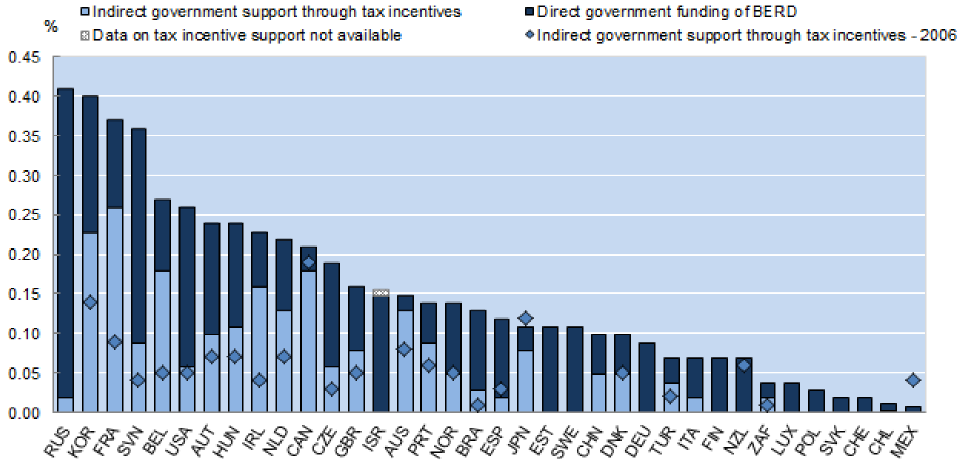
38 Although agglomeration economies have been found to be an important source of productivity growth, existing evidence suggests that it is extremely difficult for governments to replicate such agglomeration economies through active cluster policies. Removing land use restrictions might be more effective (Aghion et al., 2013a).

39 Details can be found in Table A5 and on http://www.oecd.org/sti/rd-tax-stats.htm.

40 One implication is that a R&D subsidy will be fully capitalised into the high skilled wage rate – without a concomitant rise in innovation output (see Goolsbee, 1998) – unless the effective supply of high skilled labour can rise to meet additional demand via the downsizing and/or exit of "low-type" firms.

Figure 22. Direct government funding of business R&D (BERD) and tax incentives for R&D

A: Cost to public budgets as per cent of GDP; 2012 and 2006



Notes: These are experimental indicators. International comparability may be limited. For more information and for country specific notes see www.oecd.org/sti/rd-tax-stats.htm. Estimates do not cover sub-national and income-based R&D tax incentives and are limited to the business sector (excluding tax incentive support to individuals).

Source: OECD R&D Tax Incentives Indicators, based on 2013 OECD-NESTI data collection on tax incentives support for R&D expenditures and OECD, National Accounts and Main Science and Technology Indicators, 15 September 2014. Direct funding estimates for Brazil are based on national sources.

In any case, as discussed at length in Andrews and Criscuolo (2013), design features of such R&D incentive schemes are crucial in order to avoid their unintended negative consequences and costs to the tax payer:

- R&D tax incentive schemes should be refundable, contain carry-over provisions or allow for payroll withholding tax credits on R&D wages so as to avoid overly favouring incumbents at the expense of young firms (Table A5). The implicit subsidy rate of R&D tax incentives typically increases with the profitability of the firm (Figure A9) and many young innovative firms are typically in a loss position in the early years of an R&D project.
- Recent improvements in the design of schemes that provide direct government support to R&D may explain why, in contrast with earlier empirical research, there is now clearer evidence of a positive association with innovation (Westmore, 2013).[41]

4.2.2 The primacy of basic research

The shift in the composition of fiscal support towards R&D tax incentives may accentuate the misallocation of research effort between basic and applied research.[42] Basic research results in significantly

41 For example, the structure of public support has become more focused on subsidies for commercial R&D activities and matching grants (for private investments) have become more common.

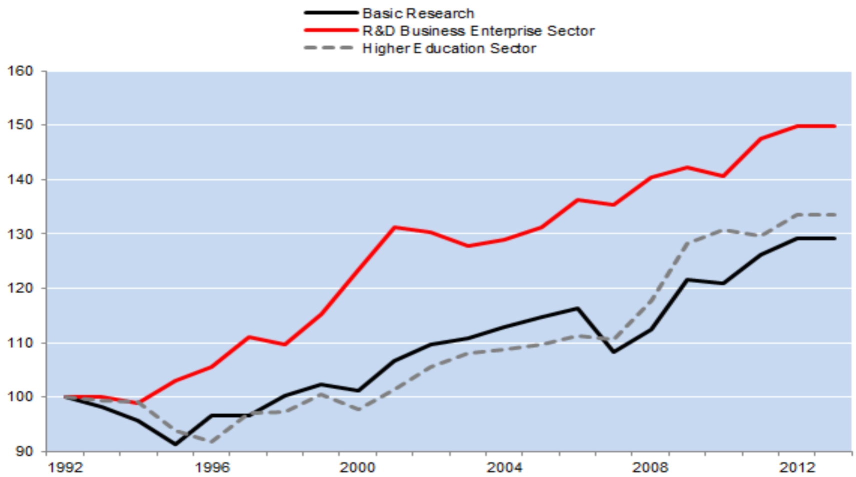
42 According to the Frascati Manual (OECD 2002), basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view. Applied research is also original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective.

larger knowledge spillovers than applied research and basic research also makes applied innovation 60% more productive (Akcigit et al., 2014). The largely non-rival nature of basic research is likely to lead to an excessive devotion of private research effort towards applied research – which entails significant costs to aggregate welfare. R&D tax subsidy policies that do not take into account this asymmetric externality are likely to accentuate the over-investment in applied research.

Over recent decades, the developmental and applied stages of research have represented the largest share of the research expenditure of industry across OECD economies. Moreover, business R&D (BERD) has significantly outgrown higher education sector R&D and more generally basic research (Figure 23), while investment in scientific research by publicly traded US companies has actually fallen over time (Arora et al., 2015). At the same time, cross-country differences in basic research investment are significant (Figure A10).[43]

Figure 23. Investment in BERD has grown more quickly than basic research

Average across selected OECD countries; index 1992=100



Notes: Basic research includes research performed by the public and private sectors, and thus some basic research will be included in the BERD category. The data are based on the following countries: AUS, AUT, CHL, CZE, DNK, EST, FRA, DEU, GRC, HUN, ISL, IRL, ISR, ITA, JPN, KOR, MEX, NLD, NZL, NOR, POL, PRT, SVK, SVN, ESP, SWE, CHE, GBR and USA.

Source: OECD calculations based on Main Science and Technology Indicators.

Yet, higher public spending on basic research enhances the ability of economies to learn from new innovations at the global frontier (Saia et al., 2015; Figure 24). Assuming a 2% acceleration in MFP growth in the frontier economy – roughly equivalent to what was observed during the late 1990s boom – annual MFP growth is estimated to be around 0.2 percentage points higher in a country where public expenditure on basic research is high (e.g. France), than in one where such spending is relatively low (e.g. Belgium). These gains from more effective learning are significant, given that MFP growth in the OECD averaged only ½ per cent between 1995 and 2007.

Despite emerging evidence of a positive link between basic research and productivity, the question on how best to support basic research remains. Given the high social value of basic research, which is maximised when accompanied by full public disclosure, governments often perform (as well as fund) research themselves through universities or public laboratories. One concern is that government research

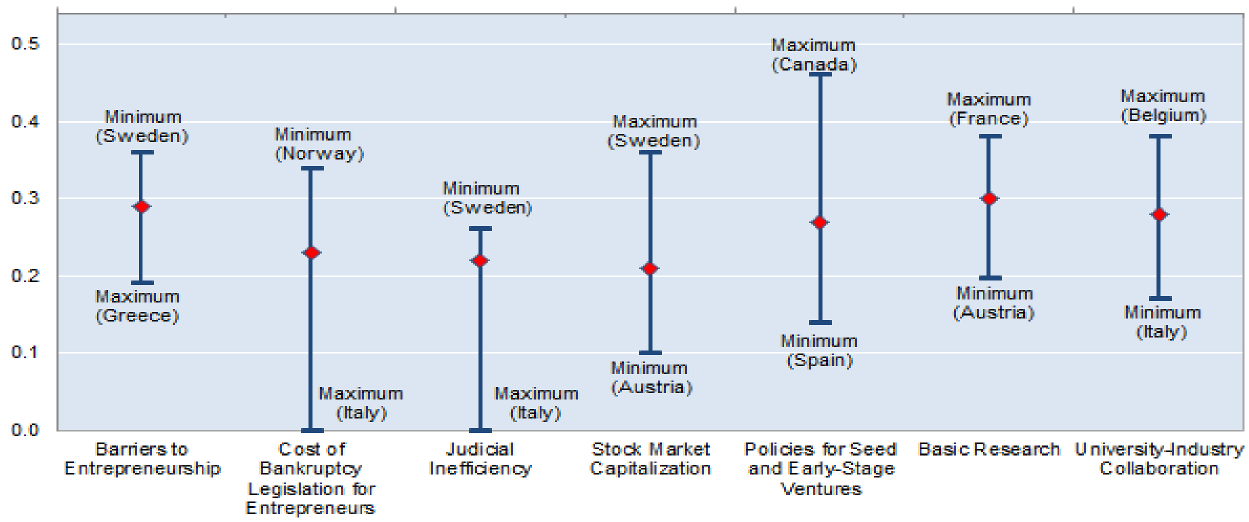
43 For example, spending on basic research ranges from less than 0.1% of GDP in Chile to 0.8% of GDP in Korea.

expenditure might crowd-out rather than spur private sector research. While evidence on this issue is mixed, recent research suggests that public funding of basic research at the National Institutes of Health in the United States results in significant spillovers, crowding-in private sector innovation and patenting activity (Azoulay et al., 2014).

Incentivizing creativity and risk taking by researchers and entrepreneurs alike also requires a long-horizon structure with tolerance for early failure associated with reward for long-term success (Manso, 2011; Ederer, 2009). Funding models based on grants that are not based on short review cycles or strictly predefined deliverables but are rather forgiving of (early) failure and focus on experimentation and creativity are associated with more novel and higher impact research output (Azoulay et al., 2011).[44] However, while a high tolerance of early failure raises the researchers' and entrepreneurs' willingness to experiment, it may also lower the willingness of (private profit making) financiers to fund experimentation and push them to fund less radical innovations that are more likely to have positive expected Net Present Values (Nanda and Rhodes-Kopf, 2012).

Figure 24. Public policies and learning from the global frontier

Estimated frontier spillover (% per annum) associated with 2% point increase in MFP growth at the global frontier



Notes: The chart shows how the sensitivity of MFP growth to changes in the frontier leader growth varies with different levels of framework and innovation policy variables. The diamond refers to the estimated frontier spillover effect associated with a 2% MFP growth at the frontier around the average level of the policy. The label "Minimum" (Maximum) indicates the country with the lowest (highest) value for the given policy indicator in a given reference year.

Source: Saia, Andrews and Albrizio (2015).

4.2.3 R&D collaboration between firms and universities

To enhance the contribution from academic research to business innovation, governments in several OECD countries promote the transfer of knowledge from academia to industry and the commercialization of academic inventions. This is typically done by allowing patented inventions from academic staff to be commercialized exclusively by university Technology Licensing Offices (TLOs) and the license royalties to be shared between the academic institutions and the academic inventor. Evidence on whether academic research and inventive activity respond to the introduction of monetary incentives is still scarce but when

44 Similarly, evidence from corporate R&D suggests that, to foster innovation, businesses should also have a long term horizon, for example by offering contracts with a long-term commitment and protection from failure.

available, suggests a positive response (Lach and Schankerman, 2008). Therefore, monetary incentives in academic institutions (e.g. royalty shares, bonuses and career advancements) and university TLOs might raise productivity growth.

R&D collaboration between private firms and public research entities has also become increasingly common (OECD, 2002).[45] OECD evidence suggests that more intensive collaboration between firms and universities – as proxied by the share of higher education R&D financed by industry (Figure A11) – is associated with more diffusion of foreign advanced technologies (Figure 24) and may also facilitate the mobility of skills. Accordingly, the productivity gap between national and global frontier firms tends to be lower in countries where there is more intensive R&D collaboration ((Andrews, Criscuolo and Gal, 2015). This may reflect the fact that university researchers might be more connected to the global knowledge frontier, which increases the speed of technological diffusion, while financial support from industry might increase research possibilities and scope for international collaboration (by increasing the mobility of human talent), further enhancing knowledge spillovers.

R&D collaboration can also facilitate the diffusion of existing technologies from the national frontier to laggard firms. Higher R&D collaboration is associated with a faster catch-up process of laggards firms very far from the national frontier, while firms close to this frontier (i.e. Quartile 1) keep pace with it (Figure 25). R&D collaboration with universities might facilitate the technological diffusion by providing smaller and less productive firms with access to sources of knowledge – e.g. advanced machinery and skilled scientists – that typically require large upfront costs. To the extent that small firms collaborate with universities to develop technologies core to their business (Santoro and Chakrabati, 2002), the benefits to productivity will be realised relatively quickly. By contrast, larger and more productive firms are more likely to collaborate with universities on speculative leading-edge technologies, which are at the pre-competitive stage and less readily applicable to the firm's core business (Santoro and Chakrabati, 2002). While this form of R&D collaboration is likely to push the frontier forward over time, the gains to productivity may be less immediate.

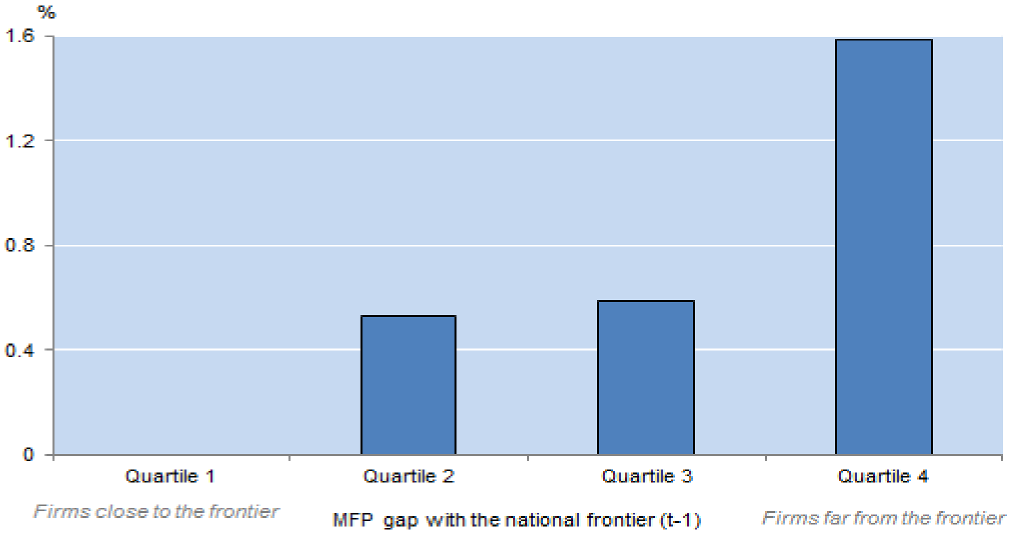
While some countries provide firms with fiscal incentives for R&D collaboration (Table A5), it is unclear whether this can be justified in terms of typical market failure arguments and evidence on their effectiveness is scarce (Criscuolo et al., 2009).[46] One concern is that subsidies for collaboration may distort university investment towards applied research, at the expense of basic research (Dasgupta and David, 1994). However, the lack of evidence of a crowding-out effect from higher patenting activity relative to academic publications suggests possible complementarities between basic research activities of academics and applied research. A related concern is that university-industry collaboration might reduce knowledge spillovers from academic research. Evidence on the issue is scarce but this could occur if: *i*) part of the spillovers are internalised through the university-business partnership, and *ii*) spillovers to third parties are likely to be smaller, given the strong incentives for the partner firm to avoid leaking information about the research to competitors.

45 Collaboration between private firms and public research entities might be especially important for young firms, which are less likely to have access to their own research facilities.

46 Public support is often justified on the basis that: i) cooperative projects are more akin to basic research; ii) firms underestimate the value of knowledge produced in universities; and iii) translating basic research into knowledge useful for practical applications is costly and risky (Prinz et al., 2011; Ioannidis, 2011).

Figure 25. R&D Collaboration and MFP convergence to the National Frontier, 2005

Impact of increasing R&D Collaboration on firm MFP growth; % difference between high and low knowledge intensive industries



Notes: The chart simulates how increasing R&D collaboration from the relatively low level in FRA to the OECD average could affect firm MFP growth in an industry with high knowledge intensity (e.g. Manufacture of rubber and plastic products), relative to an industry with low knowledge intensity (e.g. Manufacture of textiles). The identification approach assumes that (country level) R&D collaboration will be more strongly related to firm MFP growth in industries that have high knowledge intensity (proxied by the share of labour compensation of personnel with tertiary education), than in other industries. For firms far from the NF (i.e. Quartile 4), an increase in R&D collaboration would be associated with an increase in firm MFP growth of around 1½ percentage points in an industry with high knowledge intensity, relative to an industry with low knowledge intensity. This size of this impact declines for firms closer to the NF.

Source: see Andrews, Criscuolo and Gal (2015).

4.2.4 The role of patent protection

Patents provide firms with the incentive to innovate, but maximum effects are obtained when they are coupled with pro-competition policies (Westmore, 2013; Aghion et al., 2013b). However, in some emerging KBC sectors where the innovation process is typically fragmented (e.g. software), the patent system may unduly favour incumbents at the expense of young firms (Cockburn et al., 2009), thus undermining productivity. Indeed, in more R&D intensive sectors, stronger protection for patent holders is associated with a lower productivity gap between national and global frontier firms, relative to other sectors, while the reverse is true in more dynamic sectors (Andrews, Criscuolo and Gal, 2015).[47] One key factor to ensure that IPRs do not become a significant obstacle to entry and further technological development is the transparency of the patent system (Box 8).

47 This is consistent with evidence from the United States suggests that the cost of litigation exceeded the profit from patents in the late 1990s in industries outside pharmaceuticals and chemicals (Bessen and Meurer, 2008). Indeed, the increasing emergence of "non-practicing entities" that accumulate software patents with the sole objective of extracting rents from innovators may challenge innovation activities.

Box 8. The importance of transparency in the design of patent systems

An important factor in ensuring that IPRs do not impose barriers to entry and further technological development is the transparency of the patent system. Ideally, the social benefits of a transparent patent system would arise from the increased rate of innovation, due to: *i*) the provision of guaranteed rewards to the inventor if successful; *ii*) the facilitation of knowledge transmission; and *iii*) a lower risk of duplication of innovation efforts owing to the disclosure of the detailed technical information. Lack of transparency in the technical content of the patent document in the breadth and scope of the patent rights and/or in the ownership of that right would undermine these social benefits.

In some patent systems, it might be difficult or excessively costly – particularly in high-technology fields – to unambiguously identify the scope and validity of patents (Bessen and Meurer, 2008). This would reduce the likelihood of a level playing field between firms with varying degrees of internal funding or access to external finance (e.g. young/small vs large/mature applicants). These problems might be particularly acute for complex products bundling several patented inventions, as in the case of "smart" IT equipment. The transaction costs and the fear of strategic behaviour by incumbents (holding the patent) might hinder the entry of new products in the market. This might inhibit the knowledge diffusion and follow-up innovation (see Heller and Eisenberg, 1998 and Ziedonis, 2004). This so-called the "tragedy of the anti-commons" might have long-term consequences on the development of new products especially if it happens in upstream research as it will affect the pace of innovation in downstream products.

4.3 Well-designed framework policies allow productive firms to thrive

4.3.1 Anti-competitive product market regulations have pervasive effects

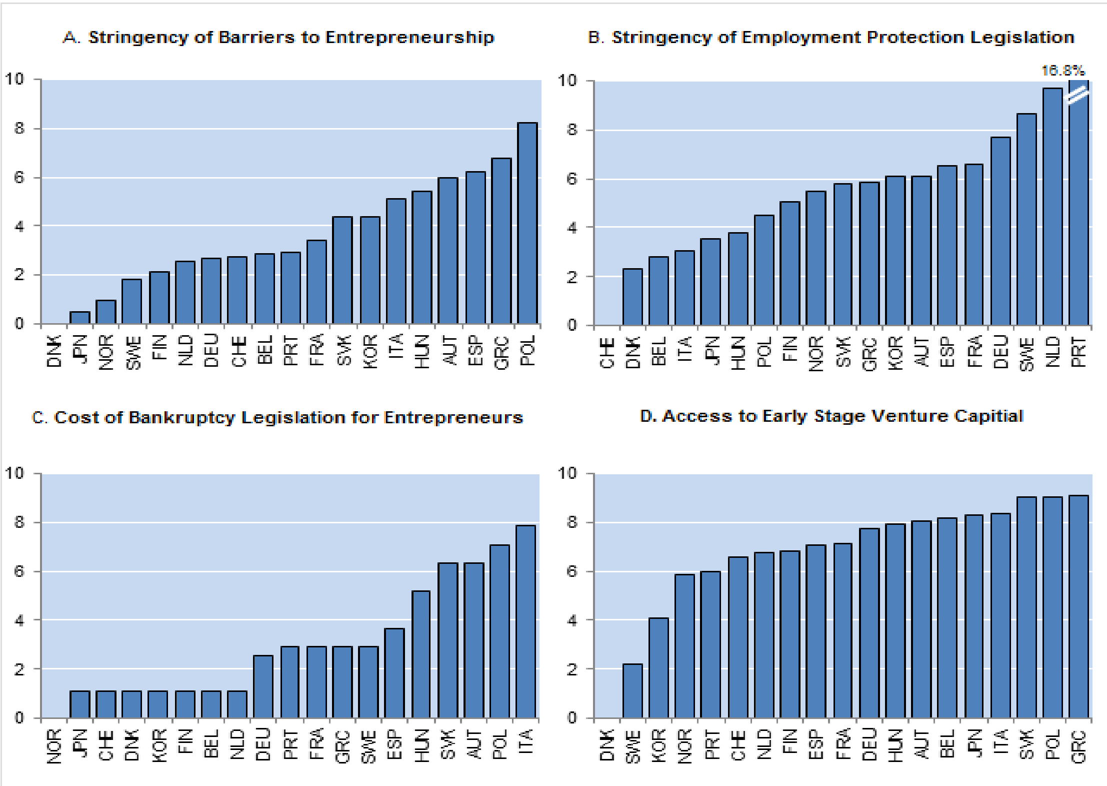
Lifting anti-competitive product market regulations can spur productivity growth via: *i*) more entry, which raises productivity directly given that young firms have a comparative advantage in radical innovations and indirectly if more entry pressures incumbents to innovate;[48] *ii*) greater market discipline, which improves management performance and scope for technology adoption; and *iii*) easier and cheaper access to inputs, which – because of easier reallocation – raises the returns to investing in KBC. This contributes to stronger market selection and post-entry growth, thereby enhancing the ability of firms to achieve sufficient scale to enter global markets.

Reforms to product market regulations (PMR), particularly those reducing entry barriers, can facilitate more effective learning from the global frontier, given the comparative advantage of young firms in commercialising and adopting new technologies. Given a 2 percentage point acceleration in frontier growth, the estimates in Figure 24 imply a gain to annual MFP growth of around 0.2 percentage points higher in a country with low administrative barriers to entrepreneurship (e.g. Sweden), than in one where such barriers are relatively high (e.g. Greece). Pro-competition policies are associated with improvements in the performance of national frontier firms relative to the global frontier benchmark (Andrews, Criscuolo and Gal, 2015). For example, less cumbersome barriers to entrepreneurship disproportionately increases the size of national frontier firms in knowledge intensive industries relative to other industries, reflecting more efficient resource allocation (Figure 26, Panel A).

48 However, the nature of this effect will vary with a firm's distance to the frontier given there is evidence of an inervted U-shaped relationship between competition and innovation (Aghion and Griffith, 2005).

Figure 26. Impact on industry productivity of policy reforms that enhance the ability of national frontier firms to attract resources and grow, 2005

Impact of policy reforms on the level of labour productivity; % difference between industries with high and low exposure to the policy



Notes: The chart estimates the gains to industry labour productivity from reforms to the best practice level for policy variables that may partly explain cross-country industry differences in the size of national frontier (NF) firms, relative to global frontier (GF) benchmark (i.e. the size gap in Figure 17). The identification approach assumes that a country level policy (e.g. EPL) will have a stronger impact on firm size of NF firms in industries that are more exposed to the policy (e.g. those with relatively high job layoff rates), than in other industries. For barriers to entrepreneurship, bankruptcy law and venture capital, the corresponding industry exposure variable is knowledge intensity (see Figure 25 for details). Panel B shows that a reduction in EPL on regular contracts from the average level in GRC to the lowest level in the sample (i.e. CHE) would be associated with an increase in the level of labour productivity of around 6% in an industry with high job layoff rates (e.g. manufacture of machinery and equipment), relative to an industry with low layoff rates (e.g. Manufacture of other transport equipment).

Source: Andrews, Criscuolo and Gal (2015).

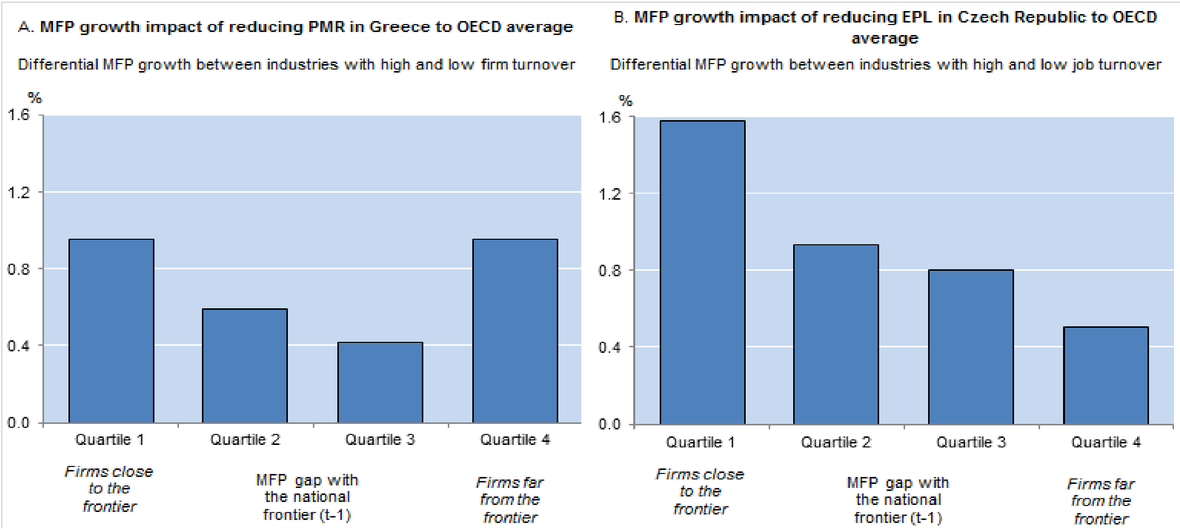
Product market regulations also shape the diffusion of existing technologies from the national frontier to laggard firms. Figure 27 (Panel A) suggests that reducing the stringency of product market regulations – e.g. from the relatively high level in Greece to the OECD average – is associated with disproportionately higher MFP growth for firms in industries with high firm turnover rates, than in other industries. The strength of this effect also varies according to a firms' initial distance to the national productivity frontier. While less stringent PMR would facilitate the catch-up of all firms to the national frontier, the reform appears to disproportionately boosts MFP growth for firms that are either close to the frontier (i.e. Quartile 1) or very far from it (i.e. Quartile 4). The latter is consistent with research showing that higher competition sharpens the incentives of low productivity firms to adopt better technologies (Perla et al., 2015).[49]

49 Other factors such as geographical isolation (Syverson, 2004) will also matter and may explain why economies with relatively lax regulation (e.g. New Zealand) exhibit a long tail of low productivity firms (Conway 2014).

A reduction in barriers to international trade and investment can also stimulate aggregate productivity (Box 5). These effects are magnified in sectors characterised by long cross-border value-added chains, because trade barriers at the border are cumulative when intermediate inputs are traded across borders multiple times (OECD, 2013b). More generally, given the increasing reliance of GVCs on domestic services (Chapter 3.1), reducing the burden of professional services regulation disproportionately raises MFP growth in industries with high GVC participation (Saia et al., 2015).

Figure 27. Reforms to market regulations and MFP convergence to the national frontier, 2005

Impact of reducing market regulations on firm MFP growth; % difference between industries with high and low exposure to the regulation



Notes: The chart simulates how reducing PMR (and EPL) from the high level in GRC (CZE) to the OECD average could affect MFP growth, according to a firm's distance to the national productivity frontier (measured in quartiles). The estimation approach is identical to that in Figure 25, except the identifying assumption is that PMR (EPL) will be more strongly related to firm MFP growth in industries that have high firm turnover rates (job layoff rates), than in other industries. Panel A shows that for firms closest to the NF, easing regulation would be associated with an increase in firm MFP growth of around 1 percentage point in an industry with high firm turnover (e.g. construction), relative to an industry with low firm turnover (e.g. Manufacture of other transport equipment). The same is true for firms far from the NF (i.e. Quartile 4).

Source: see Andrews, Criscuolo and Gal (2015).

4.3.2 Mechanisms to insure workers against labour market risk

Employment protection legislation (EPL) might raise worker commitment and firms' incentives to invest in firm-specific human capital and thus within–firm productivity (Autor, 2003; Wasmer, 2006). While evidence for this hypothesis is scarce (Andrews and Criscuolo, 2013), one concern is that the asymmetric liberalisation of employment protection for temporary contracts while leaving in place stringent regulations on permanent contracts may undermine the accumulation of firm-specific human capital (Martin and Scarpetta, 2012).[50]

A key challenge in designing EPL is how to favour productivity-enhancing reallocation, while minimising the costs borne by firms and workers. In this regard, well-designed social safety nets and portable health and pension benefits are necessary to support transitions between jobs, while there is also a case for

50 This might occur if firms substitute temporary for regular workers and temporary workers are less likely to participate in job-related training.

retraining and other active labour market policies.[51] These flanking policies are crucial since EPL that imposes heavy or unpredictable costs on hiring and firing slows down the reallocation process and aggregate productivity growth (Bassanini et al., 2009; Andrews and Cingano, 2014). Similarly, by raising exit costs in the case of business failure, stringent EPL makes it less attractive for firms to experiment with uncertain technologies.

Stringent EPL is significantly associated with lower ability of innovative firms to attract the complementary tangible resources that are required to implement and commercialise new ideas, and the burden of this effect falls disproportionately on young firms, which are more likely to experiment with radical innovation (Andrews et al., 2014). Moreover, in sectors with higher job layoff rates (where reallocation needs are likely to be more intense), stringent EPL disproportionately reduces the size of national frontier firms in sectors with higher job layoff rates, relative to other sectors (Figure 26, Panel B). This is consistent with the finding that stringent EPL might adversely affect the growth potential of more productive firms (Figure 27, Panel B) and weaken post-entry growth.[52]

4.3.3 Bankruptcy legislation and judicial efficiency shape the exit margin

Bankruptcy regimes can foster experimentation with risky technologies if they do not sanction business failure too severely. Lowering the cost to close a business increases the ability of economies to learn from new innovations at the frontier (Figure 24) and the size of national frontier firms, with the benefits particularly large in Italy and some Eastern European economies (Figure 26, Panel C). A lower cost of winding-down a business also makes it less likely that (inefficient) firms with low growth potential will continue to operate – which is a problem in some countries (Figure 18) where exit costs are also high (Figure A12), such as Italy and Spain. This in turn releases resources to underpin the reallocation of capital toward more innovative business ventures (Andrews et al., 2014; Bravo-Biosca et al., 2013). Such arrangements could, however, also discourage risk taking if credit conditions are tightened as a result of reduced loss recovery in case of bankruptcy. Striking the right balance between these two forces makes the design of bankruptcy provisions complicated.

The swift reallocation of resources from failed ventures will also be affected by the time required for the full completion of all legal procedures to wind up a business and the obstacles to the use of out of courts arrangements. In this regard, well-designed legal systems can raise the returns to innovation (Nunn, 2007; Andrews et al., 2014), thereby enhancing the ability of economies to learn from new innovations at the frontier (Figure 24).[53]

4.3.4 Risk capital markets

While a vast literature demonstrates the importance of financial development for productivity performance (Rajan and Zingales, 1998), financing constraints tend to be more acute for young firms to the extent that they have limited internal funds and lack a track record to signal their "quality" to investors. This financing

51 Such social expenditures generally provide an effective way to insure workers against labour market risk to the extent that the costs of the higher general taxation required to finance them are not concentrated on a single margin of adjustment (like EPL), but are shared throughout the economy (Bozkaya and Kerr, 2013).

52 For example, in more R&D-intensive industries, less stringent EPL raises productivity growth to the extent that it is associated with a more dynamic firm growth distribution – that is, a lower share of static firms and higher share of growing and shrinking firms (Bravo-Biosca et al., 2013).

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

gap is partly bridged by venture capitalists or business angels, who address informational asymmetries by intensively scrutinising firms before providing capital and subsequent monitoring (Hall and Lerner, 2009).

Venture capital (VC) financing has a sizeable positive impact on innovation and growth (Kortum and Lerner, 2000; Samila and Sorenson, 2011). The productivity and size of national frontier firms also increases with the depth of markets for seed and early stage VC (Andrews, Criscuolo and Gal, 2015; Figure 26, Panel D). The same is true concerning the ability of economies to learn from the frontier, while learning is also positively associated with the extent of policy support for seed and early stage VC (Figure 24), as proxied by the number of tax and equity policy instruments provided to nurture this market (Table A6).[54]

4.4 Making the most of human capital requires a range of policies

Making the most of human capital requires a range of policies to reduce skill mismatch. Skill mismatch is associated with aggregate productivity through two channels: within-firm productivity and the allocation of labour across firms (Chapter 3.3). Accordingly, the relationship of skill mismatch and policies that shape productivity via both channels is explored. Since the primary aim is to highlight skill mismatch as a new channel through which policies may affect productivity, rather than additional productivity impacts to those identified in Chapter 3.3, the estimates in Table 2 should be interpreted with caution and a causal interpretation should not be applied.[55]

4.4.1 Well-designed framework policies might lower skill mismatch

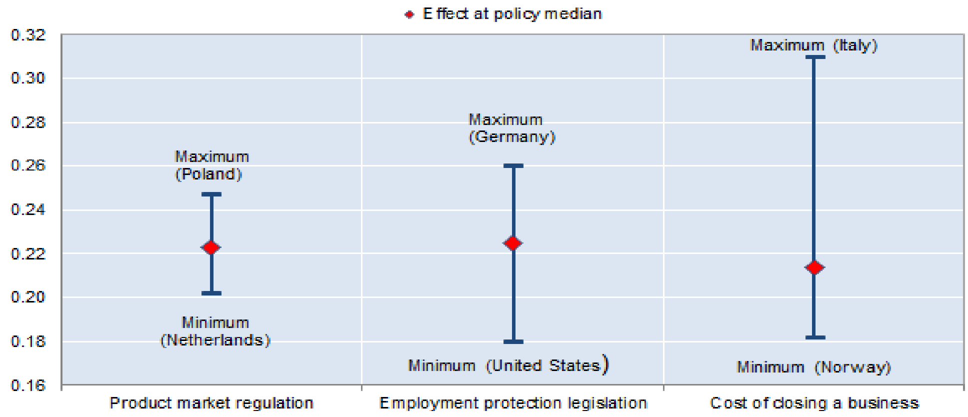
Reallocation-friendly framework policies are associated with lower skill mismatch, after controlling for individual and country-specific characteristics (Figure 28).[56] Reducing the stringency of product and labour market regulations from the maximum levels to the median levels is roughly associated with a 3 percentage point reduction in mismatch and 1 percentage point gain in labour productivity (Table 2). Similarly, bankruptcy legislation that does not excessively penalise business failure can reduce the likelihood that valuable skills are trapped in inefficient firms. For example, reducing the stringency of bankruptcy legislation from its most restrictive level in Italy (where mismatch is very high; Figure 20) to the median level in Canada is associated with a 10 percentage point decrease in mismatch. Given that the average level of mismatch is 22%, the implied gains to labour productivity from improving bankruptcy legislation are also large (3.6 percentage points).

54 This is consistent with research showing that: i) greater policy support for seed and early stage VC (SES-VC) is associated with a lower age at which firms receive such financing (Andrews and Criscuolo, 2013); and ii) countries with more developed markets for SES-VC tend to invest more heavily in KBC (Andrews et al., 2014).

55 This section covers a subset of potentially relevant policies but a range of other – more difficult to measure – policies (e.g. vocational education and training) may also matter. Of course, policies to increase human capital accumulation, such as investment in higher education, are also crucial (Braconier et al., 2014).

56 Results with respect to over-skilling and under-skilling are presented in Adalet McGowan and Andrews, 2015b. Most of the relationship between policies and over-skilling continue to hold, while the results are less robust for under-skilling. This is not surprising since the share of under-skilled workers is quite low across OECD countries (Figure A7).

Figure 28. The probability of skill mismatch and framework policies



Notes: The dot is the average probability to have mismatch evaluated at the median level of the policy and individual characteristics, which include age, marital and migrant status, gender, level of education, firm size, contract type, a dummy for working full-time and working in the private sector. The distance between the Min/Max and the median is the change in the probability of skill mismatch associated with the respective policy change.

Policies that distort reallocation mechanisms – *e.g.* stringent EPL – tend to disproportionately raise the incidence of skill mismatch amongst young people (Adalet McGowan and Andrews, 2015b). Indeed, labour market fluidity is particularly important for the job prospects of youth, since it provides scope to improve the quality of job-worker matching, which is naturally lower amongst young people due to their lack of experience (Davis and Haltiwanger, 2014).

Table 2. Estimated gains to labour productivity from policy reforms that reduce skill mismatch

Percentage point increase in the level of labour productivity from reducing policy from sample maximum to median value

Policy experiment	Implied gain in labour productivity
Framework policies	**% pts**
Reducing PMR from the maximum level (in Poland) to the sample median level (in Italy)	0.9
Reducing EPL from the maximum level (in Germany) to the sample median level (in Norway)	1.3
Reducing the cost of closing a business from the maximum level (in Italy) to the sample median level (in Canada)	3.6
Housing policies	
Decreasing transaction costs from the maximum level (in Belgium) to the sample median level (in Finland)	2.5
Decreasing rent control from the maximum level (in Sweden) to the sample median level (in Canada)	1.6
Decreasing tenure security (*i.e.* tenant-landlord regulations) from the maximum level (in Austria) to the sample median (in Japan)	1.6
Decreasing the days to obtain a building permit from the maximum level (in the Netherlands) to the sample median level (in Australia)	0.7
Labour market and education indicators	
Reducing the coverage rate of collective bargaining agreements from the maximum level (in Austria) to the sample median level (in the Czech Republic)	1.8
Increasing participation in lifelong learning from the minimum level (in Italy) to the sample median level (in Estonia)	2.2
Managerial quality	
Increasing managerial quality from the minimum level (in Italy) to the sample median level (in Canada)	2.5

Notes: Policy experiments are roughly equivalent to the impact of a 1 to 1.5 standard deviation change in the policy variables of interest on the probability of mismatch, except for PMR, EPL, participation in lifelong learning and managerial quality which are equivalent to the impact of a 2 to 2.5 standard deviation change. Estimates are based on: *i*) logit regressions of probability of mismatch controlling for age, marital and migrant status, gender, education, firm size, contract type, a dummy for working full-time and working in the private sector (see Figures 28 and 29) and; *ii*) OLS regressions of labour productivity on skill mismatch.

Source: Adalet McGowan and Andrews (2015b).

4.4.2 Barriers to mobility in housing markets may exacerbate skill mismatch

Housing market policies vary significantly across countries (Figures A13-A15), and in turn shape residential mobility, which is positively correlated with worker reallocation rates (Caldera Sánchez and Andrews, 2011; Figure A16) and the efficiency of job matching (Henley, 1998). Lower residential mobility and higher home-ownership rates are associated with higher skill mismatch, and the same housing policies which impede residential mobility might also amplify skill mismatch:

- *Lowering transaction costs could reduce skill mismatch*. By creating lock-in effects, transaction costs affecting the buying and selling of dwellings – *e.g.* transfer taxes (stamp duties, acquisition taxes), registration and notarial fees – can reduce residential mobility. The estimates in Figure 29 imply that reducing transaction costs from the highest level (Belgium) to the median level (Finland) is associated with a 7 percentage point reduction in mismatch, implying potential gains to labour productivity of 2.5 percentage points (Table 2).

- *Strict rent controls and rules excessively favouring tenants over landlords are associated with higher skill mismatch:* Reducing rent controls from the most restrictive country (Sweden) to the median (Canada) is associated with a reduction in skill mismatch of 5 percentage points (Figure 29), while reforms making rules governing tenant-landlord relations more landlord-friendly have similar effects. The implied gain in labour productivity from implementing these policies are 1.6 percentage points (Table 2).

- *Policies that restrict housing supply are associated with higher skill mismatch:* A low price responsiveness of housing supply can reduce labour mobility by affecting the average availability of housing. The elasticity of housing supply is lower in countries where it takes longer to acquire a building permit, underscoring the importance of efficient land-use regulations (Andrews et al., 2011). Indeed, reducing the number of days to obtain a building permit from its maximum level (Slovak Republic) to the median (the Netherlands), is associated with a two percentage points decrease in skill mismatch (Figure 29) and a 0.7 percentage point implied gain in labour productivity.

Moreover, high transaction costs and strict rental market regulations are associated with disproportionately higher mismatch amongst youth. Such policies might be more relevant for young people since they have a naturally higher propensity to move (Caldera Sánchez and Andrews, 2011) and may have fewer resources to finance the higher moving costs that these policies imply.

4.4.3 Labour market and education policies can improve the matching of skills to jobs

The returns to skills are lower in countries with more centralised wage bargaining systems, which make it more difficult for employers to adjust wages according to skills. This may be the case because wage decisions are more likely to be based on observable characteristics, such as formal qualifications in such wage-setting systems (OECD, 2014b). Adding some degree of flexibility to at least allow scope for wage bargaining around some centrally-agreed standards to take place at the firm level may be desirable from the perspective of reducing mismatch (Figure 29). Skills can be gained beyond formal qualifications through both on the job-training and opportunities for lifelong education and training, which may also raise labour productivity via lower mismatch (Figure 29, Table 2).

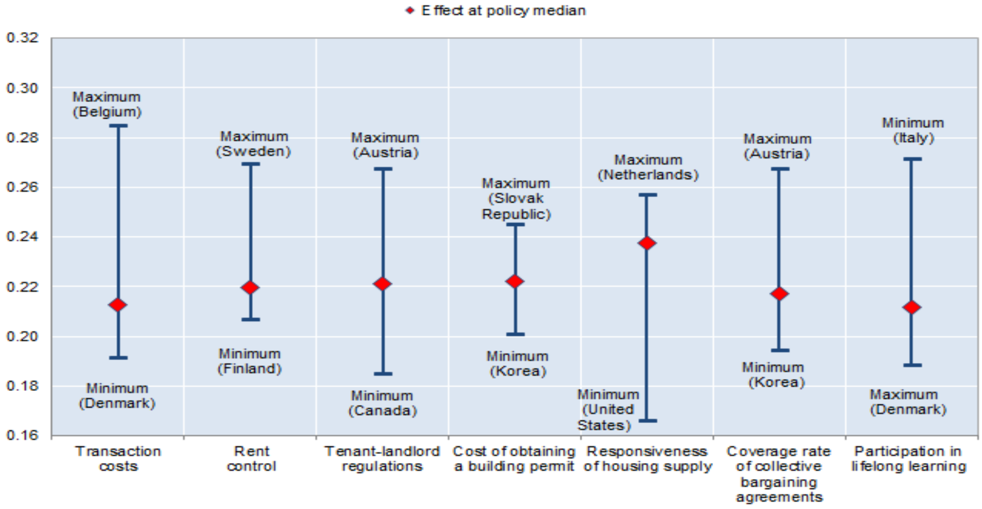
4.4.4 Better managerial quality could reduce skill mismatch

Higher managerial quality raises within-firm productivity (Bloom et al., 2012b) while better managed firms may also be less susceptible to mismatch if they are more effective at: *i*) screening job applicants; *ii*) developing new work practices; *iii*) internally reallocating over-skilled workers; and *iv*) retraining or removing under-skilled workers. Indeed, differences in managerial quality can account for part of the association between skill mismatch and labour productivity: raising managerial quality from its minimum levels in Italy to the median in Canada is associated with a 7 percentage point decline in skill mismatch and a 2.5 percentage point implied gain in labour productivity (Table 2).

While product market regulations are a key determinant of managerial quality, competition may be less effective at facilitating the exit of poorly managed family-owned firms to the extent that they are subsidised by their family owners through cheap capital (Bloom et al., 2014).[57] Through this channel, inheritance tax exemptions with respect to family firms might contribute to lower managerial quality. Indeed, in countries where inheritance tax exemptions for family firms are generous – e.g. the United Kingdom, France, Germany and Italy – the share of family-managed firms tends to be higher than in the United States, which has no substantial family firm exemptions (Bloom and Van Reenen, 2007). Hence, reducing such exemptions could increase the likelihood that badly managed family-owned firms change ownership, potentially raising aggregate productivity and intergenerational social mobility.

57 Family-owned firms are typically less well-managed, especially those managed by the oldest son of founders (Bloom and van Reenen, 2007). Selecting the CEO from among the small group of potential family members reduces the available pool of managerial ability and the incentives of the children to acquire human capital.

Figure 29. The probability of skill mismatch and other policies



Notes: The dot is the average probability of mismatch evaluated at the median level of the policy and individual characteristics (see Figure 28). The distance between the Min/Max and the median is the change in the probability of skill mismatch with the respective policy change. The results are robust to controlling for measures of country size.

Source: Adalet McGowan and Andrews (2015b) based on the Survey of Adult Skills (2012).

4.4.5 Reallocation-friendly policies can leverage the benefits managerial quality

Independent of the level of managerial ability, policies may also shape the leeway for managers to reduce mismatch within firms. For example, stringent EPL is found to thwart the ability of managers to reduce mismatch for any given level of managerial quality (Adalet McGowan and Andrews, 2015b), possibility reflecting excessive protection for incumbent workers in a firm, who might not be the best match for their job. Reallocation-friendly policies can also magnify the gains to aggregate productivity from a given improvement in managerial quality by ensuring that the most effective managers are responsible for a larger share of the economy's resources (Bloom et al., 2013; Figure A17).

CONCLUSIONS AND FUTURE RESEARCH

Economic growth will increasingly depend on improvements in productivity, but the future of productivity is highly uncertain. In this context, countries should look to tap sources of productivity growth where there is potentially large and sure scope for improvement. A key conclusion of this book is that future growth will depend on re-harnessing the forces of knowledge diffusion, which propelled productivity growth for much of the 20th century. In this regard, framework policies are crucial, but there is also a role for carefully-designed innovation policies, particularly with respect to the funding of basic research.

Reforms centred on improving the efficiency of resource allocation, which is far from optimal in many OECD countries, may also revive growth by making it easier for productive firms to thrive. More specifically, there is much scope to boost productivity and reduce inequality simply by more effectively allocating human talent to jobs. Since the knowledge economy increasingly requires skills that our education systems struggle to provide, the growth and equity benefits of policies that more effectively allocate human talent will rise. Achieving aggregate productivity gains via more efficient resource allocation requires well-designed framework policies accompanied by a range of flanking policies – including adult learning policies, well-designed social safety nets and portable health and pension benefit – to ensure that these gains are distributed more evenly than otherwise. But policy-makers also need to cast a wider net and recognise the potentially adverse effects of housing policies that restrict worker mobility on productivity via the channel of skill mismatch.

While this book has identified a number of key issues with respect to long-run productivity growth, a key limitation to further research is the lack of suitable data to conduct cross-country comparisons and policy analyses. These concerns pertain to both the outcomes of interest – *e.g.* productivity indicators – as well as the measurement of the policy environment.

Ongoing efforts within the OECD *Directorate for Science, Technology and Innovation* to collect harmonised cross-country micro-aggregated data from official sources hold out the prospect that some of the issues identified in this book can be more deeply explored. The efforts by the OECD to build a new database that is both representative and comparable across countries will allow a more robust cross-country analysis of the processes of technology diffusion to laggard firms and firm entry and exit – two issues that commercial databases (e.g. ORBIS) are less than ideal for. The DYNEMP project will provide the data needed to understand the policy drivers of entry and exit rates and post-entry growth performance. These data combined with productivity data from the MULTIPROD project will shed light on: *i*) the efficiency of resource allocation using multiple approaches *ii*) the contribution of business dynamics and creative destruction to aggregate productivity growth; *iii*) the effects of the crisis on within-firm productivity growth and reallocation (e.g. cleansing vs scarring effects); *iv*) the sources of the cross-country differences in aggregate productivity; *v)* the relationship between productivity and wage dispersion, gauging to what extent heterogeneity in productivity has contributed to wage inequality; and *vi*) last but not least, the influence of policies on these aforementioned factors.

The OECD has a long-standing experience in providing internationally comparable industry level data on output, employment, investment, R&D investment, trade and GVC participation. However, given the increasing importance of emerging economies, improving the coverage of non-OECD industry level data (within and across countries) – especially for BRIICS – is a priority. Given the importance of knowledge-based assets, improvements in the measurement of human capital, skills, ICT use and intangible assets would also be valuable. More generally, the widespread heterogeneity in firm performance within industries makes it important to go beyond the paradigm of the average firm. However, this requires databases that include different moments of the firm productivity distribution and more detailed information on firm size, age, location and trade and ownership status.

This research agenda could also benefit from more refined policy indicators to shed light on the optimal design of policy in three key areas.

First, while firm exit is central to productivity growth, currently available indicators regarding the cost of regulation and legislation for failing businesses to exit, in particular those related to bankruptcy proceedings have a number of limitations. Thus, the development of more refined indicators may shed light on how bankruptcy legislation can be best designed to strike a balance between leniency (to encourage risk taking) and protection of creditors (to avoid adverse effects on credit supply). This could also facilitate analysis into economic resilience and questions related to the optimal level of risk-taking in an economy.

Second, the ability of IPR regimes to effectively balance the incentive to innovate with the broad diffusion of knowledge is receiving increasing attention, but the inability of existing policy indicators to adequately measure the quality of IPR regimes presents a key barrier to research. However, ongoing efforts within the OECD to assemble indicators on economically-relevant features of patent systems will facilitate more extensive analysis on the consequences of IPR regimes for innovation and productivity.

Third, more analysis of the optimal design of innovation policies would also be useful. While progress has been made collecting more granular information on the features of R&D tax incentive systems, future measurement and analytical efforts could focus on the design of other areas of innovation policies, including the funding of basic research.

These multiple efforts are essential in order to further build the evidence base regarding the impact of policy reforms on productivity growth. Indeed, it is only with evidence-based policymaking will the future of productivity be truly assured.

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APPENDIX 1: ADDITIONAL CHARTS AND TABLES

The use of the Conference Board Total Economy Database largely reflects practical considerations, particularly the wide country and time coverage (122 countries, 1950-2013). The availability of data on hours worked and a breakdown of the ICT and non-ICT capital contribution for a larger number of countries than in other databases is also appealing. One drawback is that the estimates may not always be directly comparable to previous studies based on OECD data due to the use of different sources and definitions. For example, the Total Economy Database draws data from OECD National Accounts, Eurostat, WIOD and EU-KLEMS. For more information, see: http://www.conferenceboard.org/data/economydatabase/downloads/Methodological_Notes.pdf.

Table A1. Labour productivity performance in long run comparative perspective

Annual average growth within each period

	1950-1972	1972-1995	1995-2004	2004-2013
Australia	2.8	1.6	2.1	0.9
Austria	5.8	2.7	1.5	1.2
Belgium	4.2	2.6	1.2	0.2
Canada	2.5	1.3	1.3	0.6
CzechRepublic			3.1	1.9
Denmark	3.7	2.7	1.1	0.5
Estonia				2.8
Finland	4.5	3.0	2.3	0.6
France	5.0	2.6	1.5	0.6
Germany	5.7	2.9	1.5	0.8
Greece	6.3	1.8	2.8	0.1
Hungary			2.8	0.9
Iceland	4.3	1.9	2.9	1.2
Ireland	4.1	3.9	4.1	1.5
Israel			1.0	0.5
Italy	5.4	2.4	0.5	0.0
Japan	7.0	3.2	1.8	0.9
Korea	3.7	5.6	4.5	3.7
Mexico	3.8	-0.4	1.2	0.9
Netherlands	3.9	2.0	1.5	0.4
New Zealand	2.0	1.0	1.4	0.9
Norway	4.3	3.1	2.2	-0.2
Poland			4.8	2.5
Portugal	5.5	2.4	1.2	1.0
SlovakRepublic			4.4	2.7
Slovenia				2.2
Spain	5.8	3.6	0.3	1.4
Sweden	4.0	1.3	2.5	0.9
Switzerland	3.0	1.1	1.0	0.7
Turkey	6.1	3.1	2.9	1.4
United Kingdom	2.8	2.6	2.4	0.4
United States	2.5	1.3	2.2	1.0

Notes: Growth rates for the period ranges are annual averages.

Source: OECD calculations based on the Conference Board Total Economy Database.

Table A2. Evolution of growth in GDP per hour worked since 1990

Annual average growth within each period

	1990-2000	2000-2007	2007-2013
Australia	1.7	1.3	0.7
Austria	2.5	1.6	0.5
Belgium	1.7	1.0	-0.1
Brazil	1.5	0.6	0.8
Canada	1.7	0.8	0.3
Chile	3.8	2.3	2.1
China*	6.4	9.6	6.5
Czech Republic	0.0	4.3	0.4
Denmark	1.8	1.0	0.2
Estonia	0.0	5.0	1.3
Finland	2.7	2.1	-0.2
France	1.8	1.2	0.2
Germany	1.9	1.5	0.2
Greece	1.5	2.6	-0.8
Hungary	1.6	3.5	0.2
Iceland	0.9	3.1	0.5
India*	4.1	4.9	4.6
Ireland	4.5	1.8	1.5
Israel	0.4	1.3	-0.1
Italy	1.4	0.2	-0.2
Japan	1.9	1.4	0.7
Korea	5.0	3.9	2.8
Luxembourg	2.0	1.2	-1.5
Mexico	0.5	1.0	0.3
Netherlands	1.2	1.4	-0.2
New Zealand	1.2	1.1	0.5
Norway	2.5	1.1	-0.1
Poland	0.0	3.0	2.3
Portugal	1.9	0.9	0.8
Slovak Republic	3.3	4.6	1.3
Slovenia	0.0	3.4	0.7
Spain	1.0	0.6	1.4
Sweden	2.0	2.2	0.4
Switzerland	0.7	1.2	0.0
Turkey	1.7	3.6	-0.1
United Kingdom	2.9	2.0	-0.4
United States	1.8	1.5	0.9

Notes: * refers to GDP per worker

Source: OECD calculations based on the Conference Board Total Economy Database.

Table A3. Contributions to GDP growth; 1990-2013

Percentage point contribution to annual average growth within each period

		Lab. Comp.	Lab. Quant.	K-ICT	K-nonICT	MFP
Australia	1990-2000	0.2	0.8	0.5	0.6	0.8
	2000-2007	0.2	1.0	0.8	1.2	-0.3
	2007-2013	0.2	0.8	0.7	1.6	-1.0
Austria	1990-2000	0.3	-0.1	0.4	0.6	1.1
	2000-2007	0.2	0.2	0.3	0.4	0.8
	2007-2013	0.1	-0.1	0.3	0.2	0.0
Belgium	1990-2000	0.4	0.2	0.4	0.7	0.3
	2000-2007	0.2	0.4	0.5	0.6	0.0
	2007-2013	0.2	0.3	0.5	0.3	-0.9
Brazil	1990-2000	0.0	0.4	0.5	0.8	0.7
	2000-2007	0.2	1.2	0.5	0.7	-0.1
	2007-2013	0.2	0.8	0.4	1.7	-0.7
Canada	1990-2000	0.4	0.5	0.6	0.8	0.3
	2000-2007	0.2	0.8	0.7	0.9	-0.3
	2007-2013	0.1	0.3	0.6	0.7	-0.8
Chile	1990-2000	0.1	1.0	0.4	2.9	1.2
	2000-2007	0.3	0.7	0.4	2.3	-0.1
	2007-2013					
China	1990-2000	0.1	0.5	1.0	3.9	1.4
	2000-2007	0.1	0.3	0.8	4.1	4.5
	2007-2013	0.1	0.1	0.6	4.4	1.4
Czech Republic	1990-2000					
	2000-2007	0.3	-0.1	0.3	1.8	1.9
	2007-2013	0.1	-0.2	0.4	1.2	-1.1
Denmark	1990-2000	0.3	0.4	0.8	0.4	0.4
	2000-2007	0.1	0.3	0.7	0.4	0.1
	2007-2013	0.0	-0.6	0.6	0.0	-0.7
Estonia	1990-2000					
	2000-2007	0.1	0.9		2.4	2.8
	2007-2013	0.1	-1.3		0.8	-0.2
Finland	1990-2000	0.4	-0.6	0.7	0.0	1.7
	2000-2007	0.2	0.5	0.6	0.3	1.2
	2007-2013	0.2	-0.2	0.5	0.2	-1.5
France	1990-2000	0.4	0.0	0.3	0.7	0.3
	2000-2007	0.2	0.2	0.2	0.7	0.3
	2007-2013	0.1	-0.1	0.2	0.5	-0.6
Germany	1990-2000	0.0	-0.1	0.3	0.5	1.1
	2000-2007	0.1	-0.2	0.3	0.2	0.9
	2007-2013	0.1	0.2	0.5	0.1	-0.2
Greece	1990-2000	0.6	0.4	0.6	0.9	-0.3
	2000-2007	0.6	0.6	0.5	1.6	0.3
	2007-2013	0.3	-1.6	0.5	0.3	-3.5
Hungary	1990-2000	0.2	-0.9	1.1	0.6	0.0
	2000-2007	0.5	-0.2	1.1	0.8	0.5
	2007-2013	0.2	-0.6	0.7	0.1	-1.8
Iceland	1990-2000	0.2	0.9		0.8	0.3
	2000-2007		0.5		1.5	1.9
	2007-2013					
India	1990-2000	0.2	1.2	0.5	2.1	1.3
	2000-2007	0.1	1.3	0.6	2.4	1.8
	2007-2013	0.1	0.5	0.5	2.7	1.2
Ireland	1990-2000	0.3	1.2	0.8	1.3	2.9
	2000-2007	0.4	1.4	0.7	1.8	-0.2
	2007-2013	0.1	-1.6	0.5	0.8	-0.8
Israel	1990-2000	0.1	2.7	0.6	2.3	-0.6
	2000-2007		0.9	0.5	0.9	0.5
	2007-2013		1.8	0.6	1.0	-0.3
Italy	1990-2000	0.2	0.1	0.2	0.5	0.5
	2000-2007	0.2	0.6	0.2	0.6	-0.5
	2007-2013	0.0	-0.6	0.2	0.0	-0.7
Japan	1990-2000	0.3	-0.5	0.3	1.1	-0.1
	2000-2007	0.3	-0.1	0.2	0.3	0.6
	2007-2013	0.1	-0.4	0.3	0.0	0.1
Luxembourg	1990-2000		1.4		2.1	0.6
	2000-2007		1.3		2.2	0.0
	2007-2013		0.9		1.7	-3.0
Mexico	1990-2000	0.2	0.9	0.2	1.8	0.0
	2000-2007	0.1	0.4	0.5	1.9	-0.6
	2007-2013	0.1	0.3	0.5	1.8	-1.6
Netherlands	1990-2000	0.2	1.1	0.5	0.5	0.5
	2000-2007	0.3	0.2	0.3	0.3	0.6
	2007-2013	0.1	0.1	0.2	0.2	-0.7
NewZealand	1990-2000	0.4	0.9	0.7	0.4	0.2
	2000-2007	0.3	1.2	0.6	1.0	-0.1
	2007-2013	0.2	0.3	0.6	0.5	-0.6
Norway	1990-2000	0.1	0.4	0.4	0.8	1.6
	2000-2007	0.1	0.4	0.4	1.4	-0.4
	2007-2013	0.1	0.4	0.4	1.3	-1.5
Poland	1990-2000	0.0	-0.7	0.7	0.6	3.1
	2000-2007	0.2	0.2	0.5	0.8	1.5
	2007-2013	0.1	0.0	0.4	1.5	0.2
Portugal	1990-2000	0.1	0.5	0.7	1.1	0.4
	2000-2007	0.8	0.0	0.6	0.7	-1.0
	2007-2013	0.5	-1.3	0.4	0.1	-1.1
Slovak Republic	1990-2000	0.1	-0.8	0.9	0.8	0.7
	2000-2007	0.2	0.3	0.8	0.9	2.9
	2007-2013	0.1	0.0	0.7	0.5	-0.4
Slovenia	1990-2000					
	2000-2007	0.6	0.3	0.4	1.1	1.3
	2007-2013	0.2	-1.5	0.5	0.2	-0.9
Korea	1990-2000	0.7	0.5	0.7	2.0	1.8
	2000-2007	0.6	0.1	0.3	1.1	1.8
	2007-2013	0.2	-0.5	0.3	0.9	1.5
Spain	1990-2000	0.5	0.9	0.3	1.2	-0.4
	2000-2007	0.4	1.5	0.4	1.3	-0.7
	2007-2013	0.3	-1.6	0.2	0.5	-0.5
Sweden	1990-2000	0.2	-0.1	0.6	0.4	0.8
	2000-2007	0.2	0.3	0.3	0.6	1.2
	2007-2013	0.1	0.2	0.5	0.5	-0.5
Switzerland	1990-2000	0.1	0.2	0.5	0.4	-0.2
	2000-2007	0.0	0.4	0.6	0.2	0.6
	2007-2013	0.0	0.7	0.5	0.1	-0.3
Turkey	1990-2000	0.1	0.6	0.2	4.0	-1.7
	2000-2007	0.1	0.2	0.3	3.3	-0.1
	2007-2013					
United Kingdom	1990-2000	0.6	-0.1	0.6	0.5	1.0
	2000-2007	0.4	0.4	0.5	0.6	0.7
	2007-2013	0.1	0.1	0.2	0.5	-1.2
United States	1990-2000	0.2	0.8	0.7	0.6	0.6
	2000-2007	0.2	0.4	0.5	0.6	0.5
	2007-2013	0.1	-0.1	0.4	0.2	0.3

Notes: Non-ICT investment refers to construction, machinery and transport equipment, while ICT investment refers to software, hardware and telecommunications.

Source: OECD calculations based on the Conference Board Total Economy Database.

Table A4. Labour productivity growth since 1990

Growth in GDP per hour worked (unless otherwise noted)

	MFP	LP
Australia	-7.7	6.1
Austria	-0.1	4.3
Belgium	-6.5	-0.8
Canada	-5.6	2.7
China	9.4	63.8
Czech Republic	-8.3	3.3
Denmark	-4.7	2.0
Estonia	-1.5	10.5
Finland	-11.5	-1.7
France	-4.6	1.3
Germany	-1.6	1.8
Greece	-27.9	-6.3
Hungary	-13.2	1.7
Iceland*		4.3
India	8.1	38.4
Ireland	-5.5	13.0
Israel	-2.4	-0.6
Italy	-5.2	-1.3
Japan	0.8	5.6
Korea	9.8	25.1
Luxembourg	-23.6	-11.2
Mexico	-12.1	2.4
Netherlands	-5.2	-1.8
New Zealand	-4.1	4.0
Norway	-11.0	-0.5
Poland	1.1	19.5
Portugal	-7.8	6.2
Slovak Republic	-3.0	10.9
Slovenia	-6.2	5.3
Spain	-3.4	12.0
Sweden	-3.7	3.4
Switzerland	-1.9	0.2
Turkey	-11.0	-0.7
United Kingdom	-8.7	-3.0
United States	1.9	7.5
OECD	-1.7	3.7
Emerging	3.0	28.4

Notes: Multi -factor productivity growth measures the growth of GDP over the combined contributions of total hours, workforce skills, machinery and structures and ICT capital.

Table A5. Main features of R&D tax incentives provisions in selected OECD and non OECD countries, 2013

Expenditure-based R&D tax incentives				
Corporate income tax				Social security/payroll withholding tax
R&D tax credit		R&D tax allowance	Accelerated depreciation of capital	
Volume	Incremental/hybrid			
Australia, Austria, Belgium (incompatible with allowance), Canada, Chile, Denmark (deficit only), France, Norway, Hungary	Ireland, Italy, Japan, Korea, Portugal, Spain, United States (credit on fixed, indexed base and incremental for simplified credit)	Belgium, Brazil, China, Czech Republic, Finland, Hungary, Iceland, Netherlands, Russian Federation, Slovenia, Slovak Republic (subsidy recipients only), South Africa, Turkey (hybrid), United Kingdom	Belgium, Brazil, Canada, Chile, Denmark, France, Israel (non R&D specific), Poland, Russian Federation, Turkey, United Kingdom	Belgium, France, Netherlands, Hungary, Russian Federation, Turkey
Treatment of excess claims				
Refund				
Australia (SMEs), Austria, Belgium, Canada (SMEs), Denmark, France (SMEs), Norway	Ireland	United Kingdom	...	*Automatic refund through wage system*
Carry-forward				
Australia, Belgium, Canada, Chile, France	Ireland, Japan, Korea, Portugal, Spain, United States	Belgium, China, Czech Republic, Finland, Netherlands, Russian Federation, Slovenia, Slovak republic, South Africa, Turkey, United Kingdom	*Country-specific loss carry-forward provisions apply*	*Not applicable*
Enhanced tax credit/allowance rates or more favourable terms				
SMEs				
Australia, Canada, France (up to EUR 100K R&D), Norway	Japan, Korea, Portugal (start-ups)	United Kingdom	...	France (young innovative firms), Netherlands (start-ups), Belgium
Collaboration				
France, Norway	Japan	Hungary	...	Belgium
Limitation of benefits				
Ceilings and threshold-dependent rates				
Australia, Austria, Canada, Chile, Denmark, France, Hungary, Norway	Ireland, Italy (budget limit), japan, Portugal, Spain, United States	Finland, Hungary, Iceland, Slovak republic, United Kingdom	...	France, Netherlands, Turkey (5 year limit)
No expenditure-based R&D tax incentives				
Estonia, Germany, Luxembourg, Mexico, Netherlands, New Zealand, Sweden, Switzerland				
Tax incentives linked to corporate income arising from R&D or related activities				
Belgium, China, France, Hungary, Luxembourg, Netherlands, Spain, Turkey, United Kingdom				

Note: R&D tax allowances are tax concessions by which a multiple of the R&D expenditure which can be used to offset taxable income. R&D tax credits reduce the actual amount of tax that must be paid. For additional country details see http://www.oecd.org/sti/rd-tax-stats.htm,

Source: OECD, based on 2013 OECD-NESTI data collection on tax incentives support for R&D expenditures, http://www.oecd.org/sti/rd-tax-stats.htm, and publicly available sources, 30 September 2013.

Table A6. Policy instruments to support the market for early stage financing

Policy setting as at mid-2012; change in the policy setting in the last 5 years

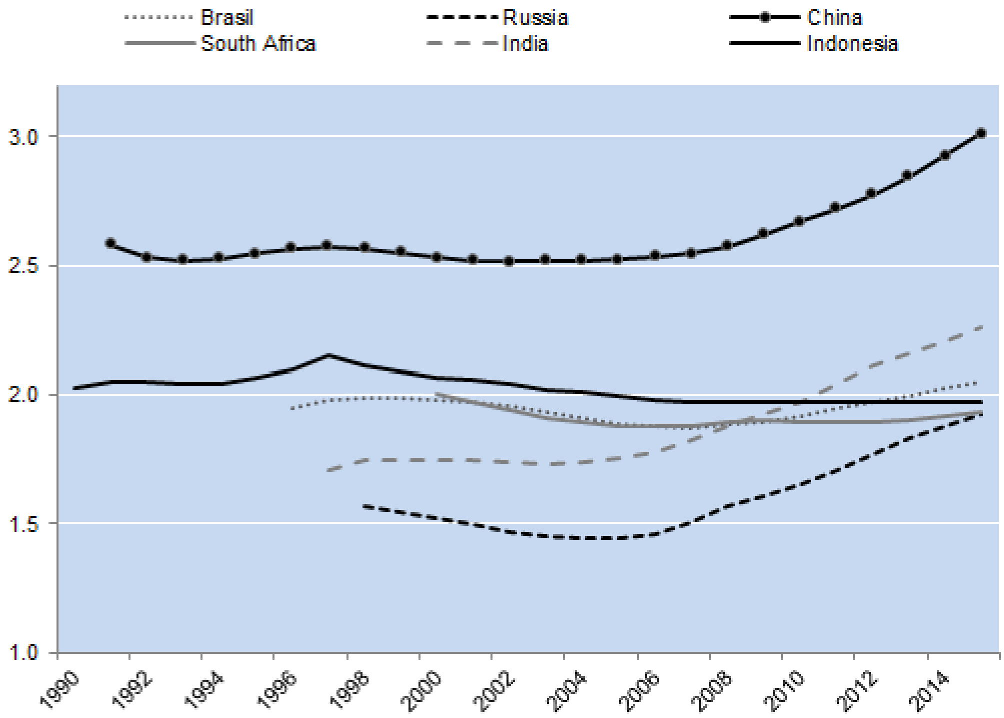
	Fiscal incentives			Government Equity Financing Instruments		
	Young Innovative Company schemes	"Front-end" tax incentives	"Back-end" tax incentives	Public Equity Funds	Fund of Funds	Co-investment Funds
Australia			unchanged			increased
Austria		decreased	decreased		new	
Belgium	increased	increased	decreased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

Notes: * The Slovak Republic has both Young Innovative Company Schemes and Front-end tax incentives but no information is available on the extent to which the generosity of such schemes has changed over time. Most OECD countries have some type of government equity finance programme, such as direct public VC funds, "funds of funds" – an investment strategy consisting of holding a portfolio of other investment funds rather than investing directly in companies – and co-investment funds, whereby public funds are matched to those of private investors who are approved under the scheme. These programmes, especially funds of funds and co-investment funds, have grown in importance over the past five years. While fiscal incentives are less common, some 17 OECD countries still employ either "front-end" tax incentives or tax deductions for investment in seed and early stage VC and "back-end" tax relief on capital gains, including rollover or carry forward of capital gains or losses. Of course, it is important to keep in mind the broader taxation environment – and particularly the existence of capital gains tax – when assessing these specific fiscal incentives.

Source: OECD Financing Questionnaire. See Wilson and Silva (2013).

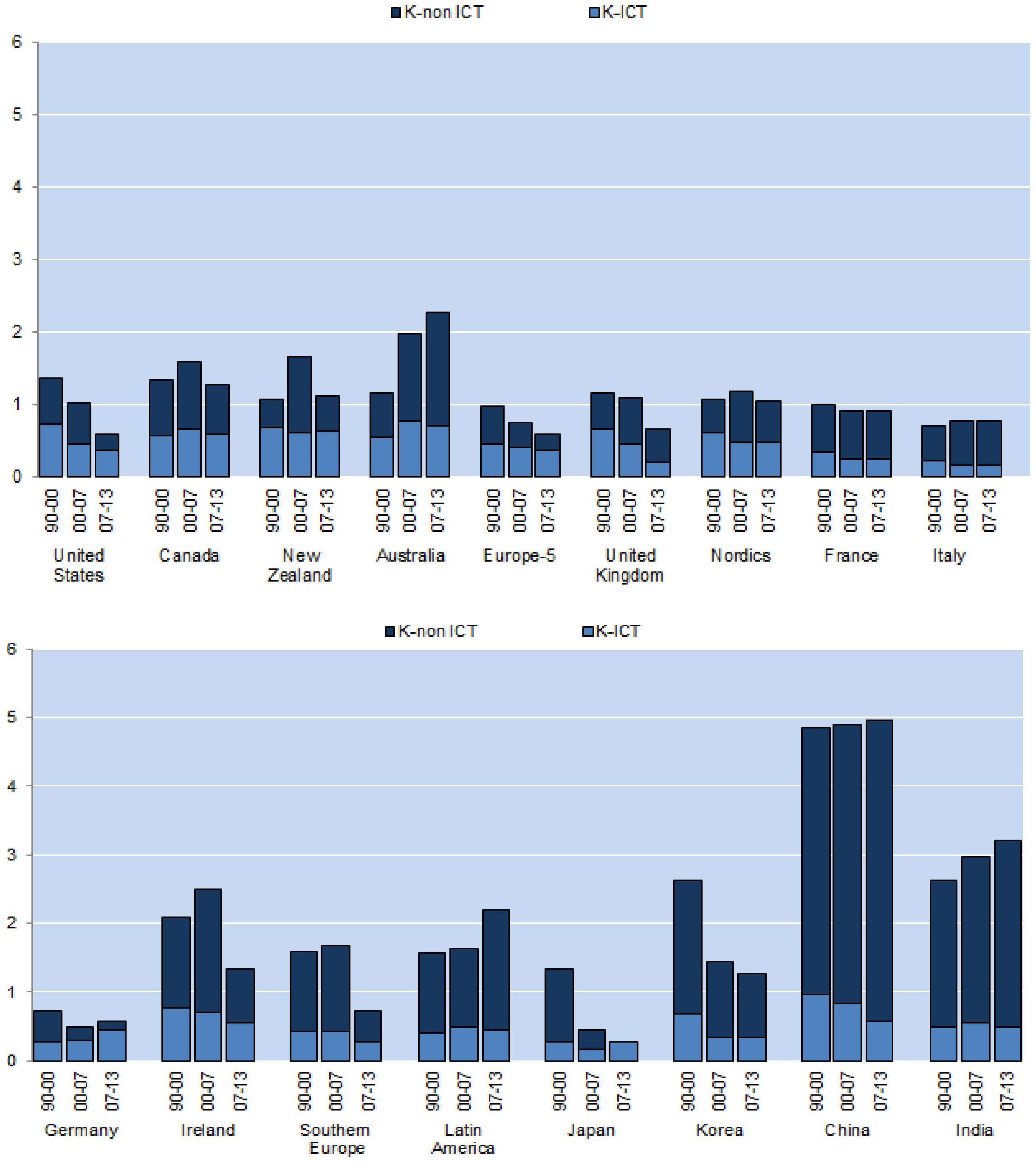
Figure A1. Capital ratios in emerging markets

Capital to potential output



Source: OECD Economic Outlook and Long Term Databases.

Figure A2. Contribution of ICT and non-ICT capital to GDP growth

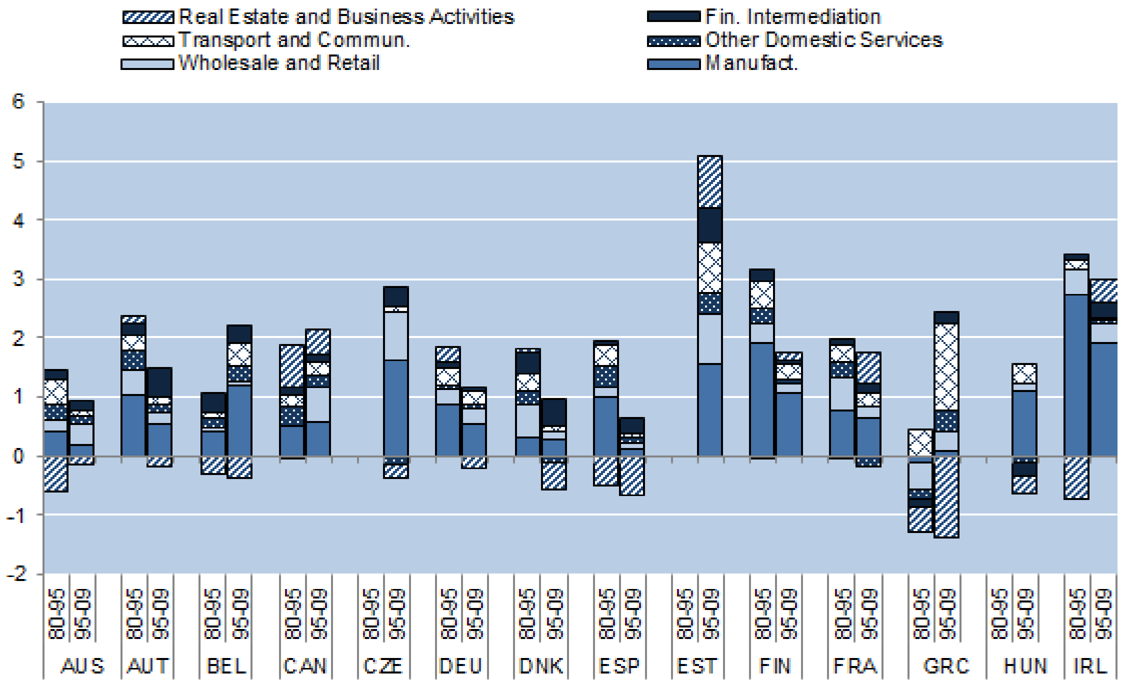


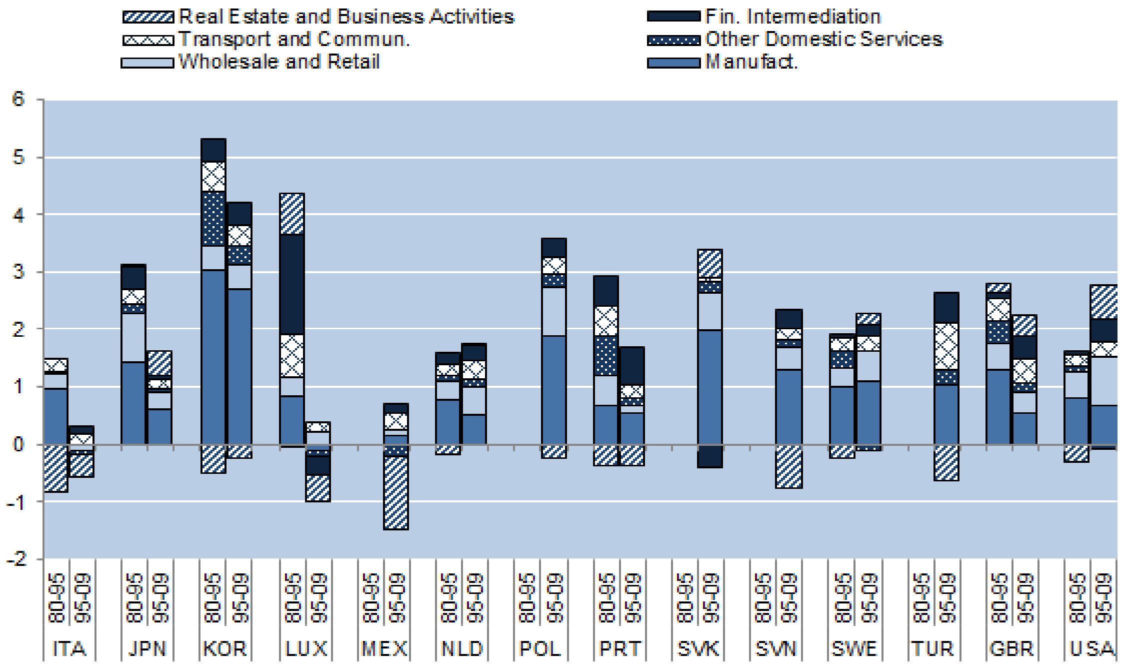
Notes: Country groupings are aggregated using GDP-PPP weights. Europe-5 includes: Austria, Belgium, Luxembourg, the Netherlands and Switzerland; Nordics includes: Denmark, Finland, Iceland, Norway and Sweden; Southern Europe includes: Greece, Portugal and Spain; and Latin America includes: Brazil, Chile and Mexico. Non-ICT investment refers to construction, machinery and transport equipment, while ICT investment refers to software, hardware and telecommunications. The corresponding country-specific data are contained in Table A3.

Source: OECD calculations based on the Conference Board Total Economy Database.

Figure A3. Industry drivers of labour productivity growth

Percentage point contribution to non-farm business sector labour productivity growth, selected OECD countries





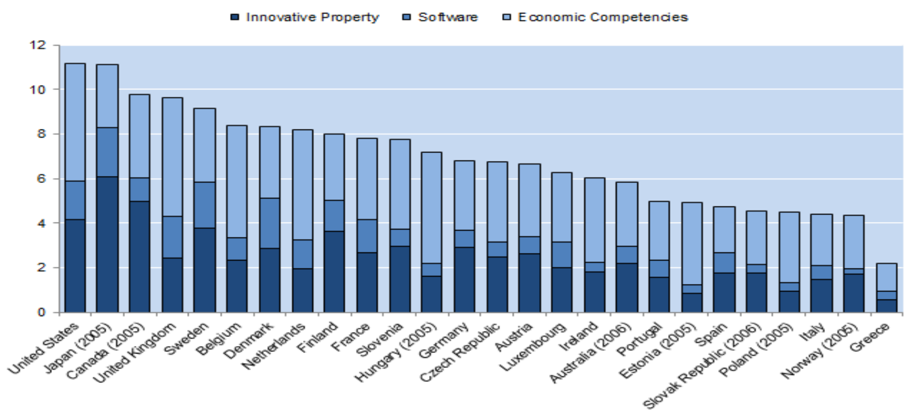
Notes: Other domestic services refer to ISIC Rev. 4 industry classification codes 40-41, 45, 55. Industry groupings are aggregated using value-added weights.

Source: OECD calculations based EU-KLEMS and WIOD databases.

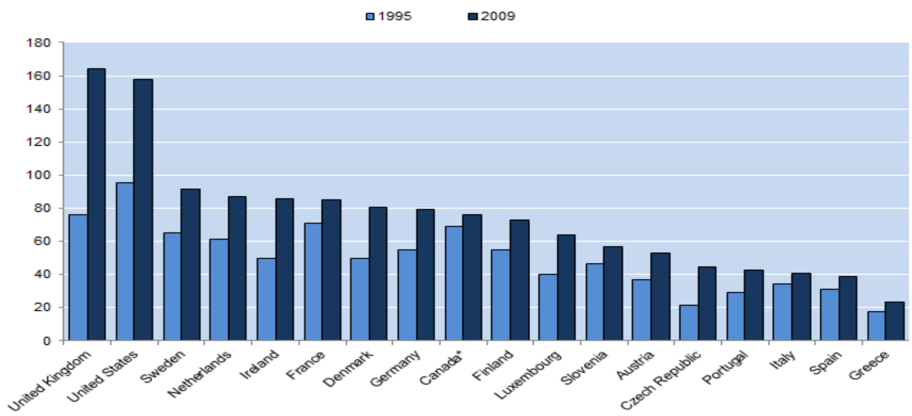
There are important cross-country differences in the level and growth rates of investment in KBC (Figure A4). For example, English-speaking countries – particularly the United States – Japan and Sweden, invest relatively heavily in KBC which translates into a relatively larger contribution of intangible capital deepening to labour productivity growth.[58] By contrast, the resources devoted to KBC and their contribution to productivity growth tend to be smaller in some continental and Southern European economies (van Ark et al., 2008). Beyond their direct effect on capital accumulation, these cross-country differences matter to the extent that KBC is often only partially excludable, which implies that privately-created knowledge diffuses beyond its place of creation, thus providing wider benefits. Indeed, that a positive association between the contribution of capital deepening and MFP growth is clearer for KBC than for tangible capital, provides suggestive evidence of such spillover effects (Figure A5). These cross-country differences in KBC reflect the fact that some countries are more successful at reallocating resources to underpin the growth of firms that invest in KBC (Andrews and Criscuolo, 2013).

Figure A4. Investment in KBC varies significantly across countries and matters for productivity

A: Per cent of GDP; Selected OECD countries; 2009 or latest year available



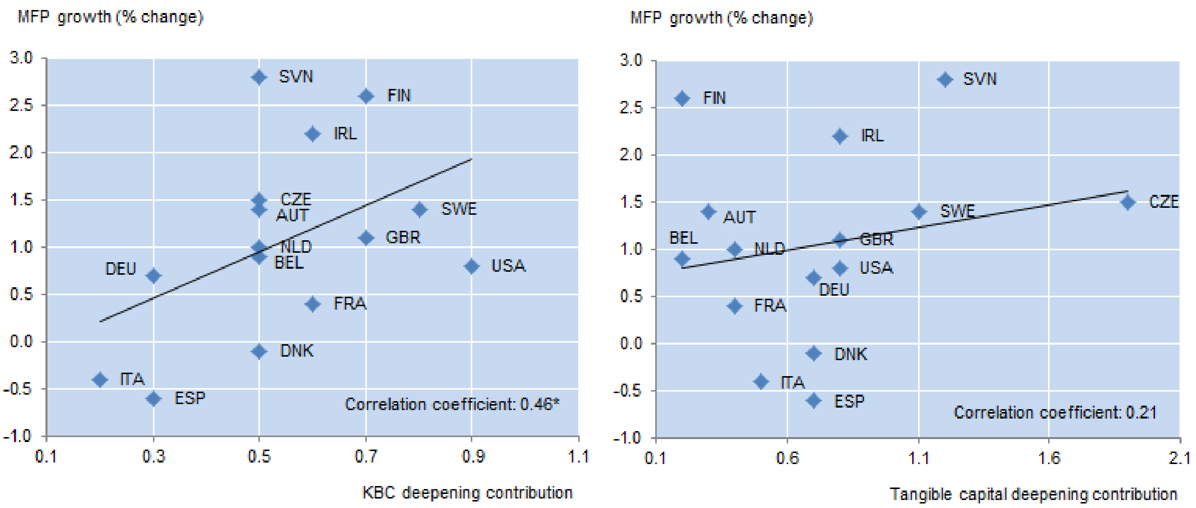
B: The evolution of investment in KBC relative to tangible capital; 1995-2009



Source: Corrado et al., (2012).

58 Over the period 1995-2006, incorporating KBC is estimated to reduce the contribution of MFP by close to one-half in Sweden; one-quarter in the United States and Finland; one-fifth in France, the United Kingdom, Czech Republic and Australia; and by one-tenth or less in Austria, Denmark, Germany and Japan (van Ark et al., 2009; OECD, 2011b).

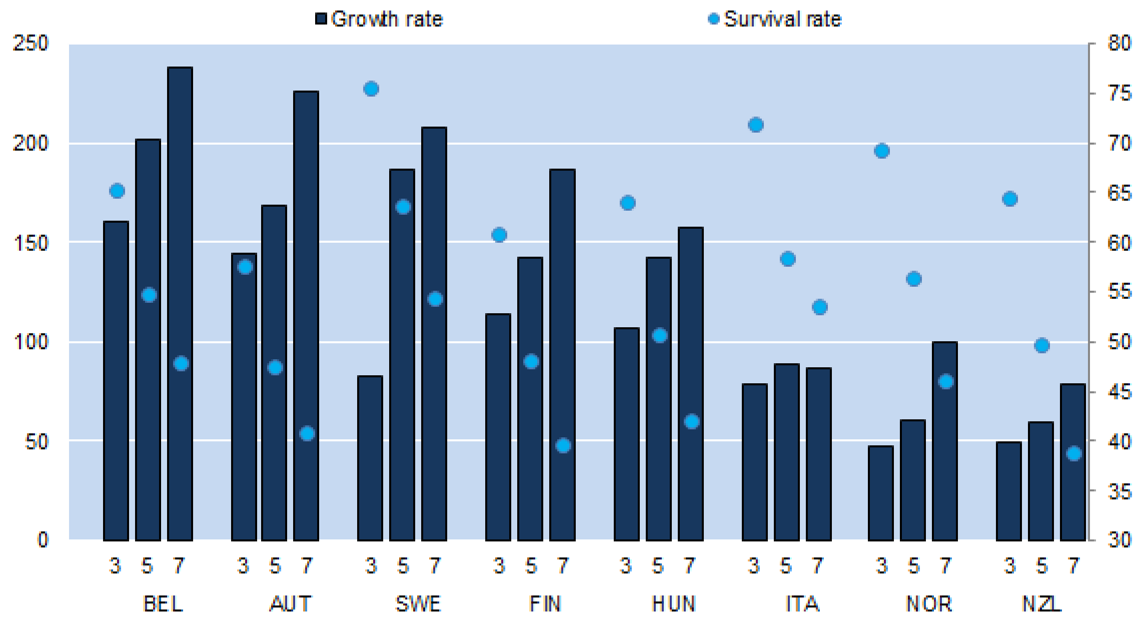
Figure A5. Knowledge-based capital and spillover effects; 1995-2007



Note: Labour productivity growth can be decomposed into the contribution of capital deepening and the contribution of MFP. The chart plots the contribution of KBC/tangible capital deepening to labour productivity growth against the growth rate in MFP. The correlations are robust to individually dropping outliers, such as the Czech Republic, Finland and Slovenia. Unlike in conventional growth accounting exercises, the MFP estimates are based on a value-added series that capitalises the full set of KBC indicators. * denotes statistical significance at the 10% level.

Source: Corrado et al., (2012).

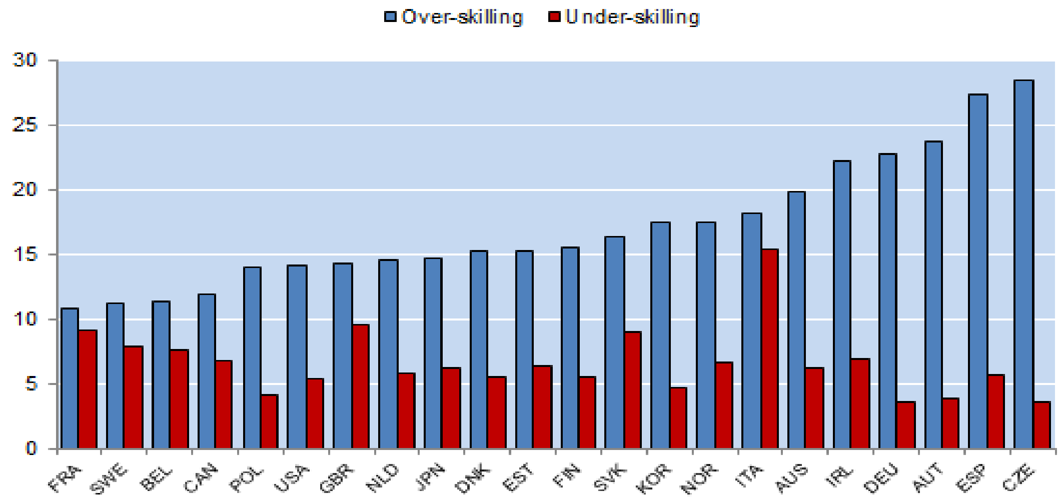
Figure A6. Firm growth and survival rates, by firm age



Notes: The graph uses preliminary data from the Dynemp v.2 project. The light blue dots report the average survival rates (as reported on the right y-axis) after 3, 5 and 7 years for micro (less than 10 employees) startups of the 2001; 2004 and 2007 cohorts. The dark blue bars report average growth rates relative to their initial size. Values are averaged across all available years.

Source: Calvino et al. (2015).

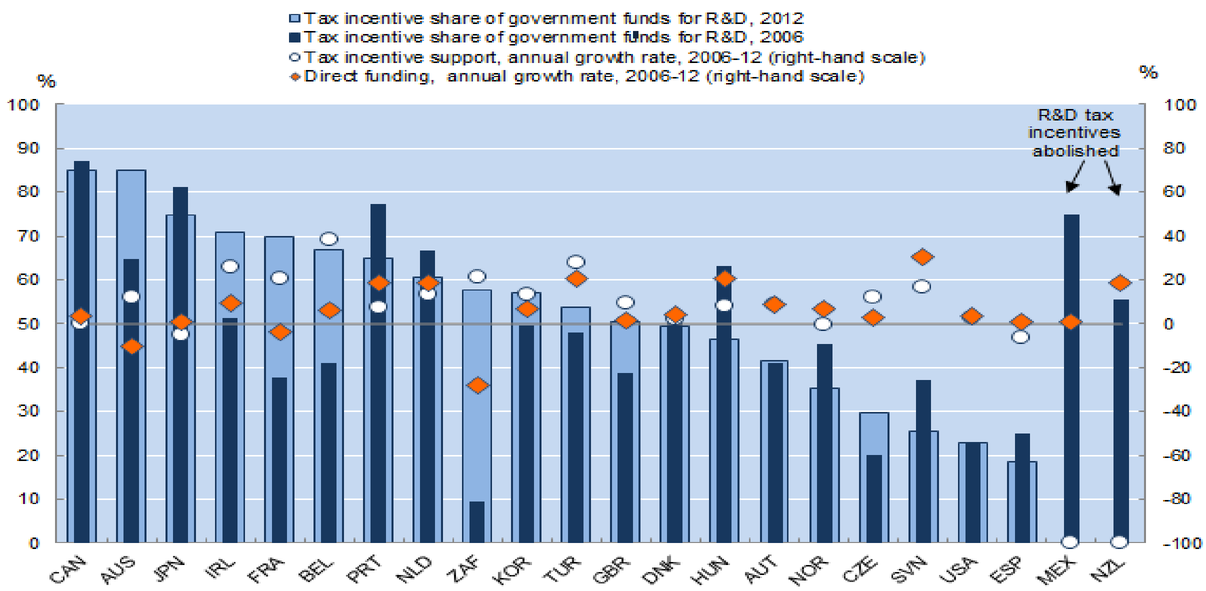
Figure A7. Components of skill mismatch; selected OECD countries, 2011-12



Notes: Under- (over-) skilled workers refer to the percentage of workers whose scores are higher than that of the min (max) skills required to do the job, defined as the 10th (90th) percentile of the scores of the well-matched workers in each occupation and country. In order to abstract from differences in industrial structures across countries, the 1-digit industry level mismatch indicators are aggregated using a common set of weights based on industry employment shares for the United States.

Source: Adalet McGowan and Andrews (2015a) based on the *Survey of Adult Skills* (2012).

Figure A8. Changes in public support for BERD; 2006-2012

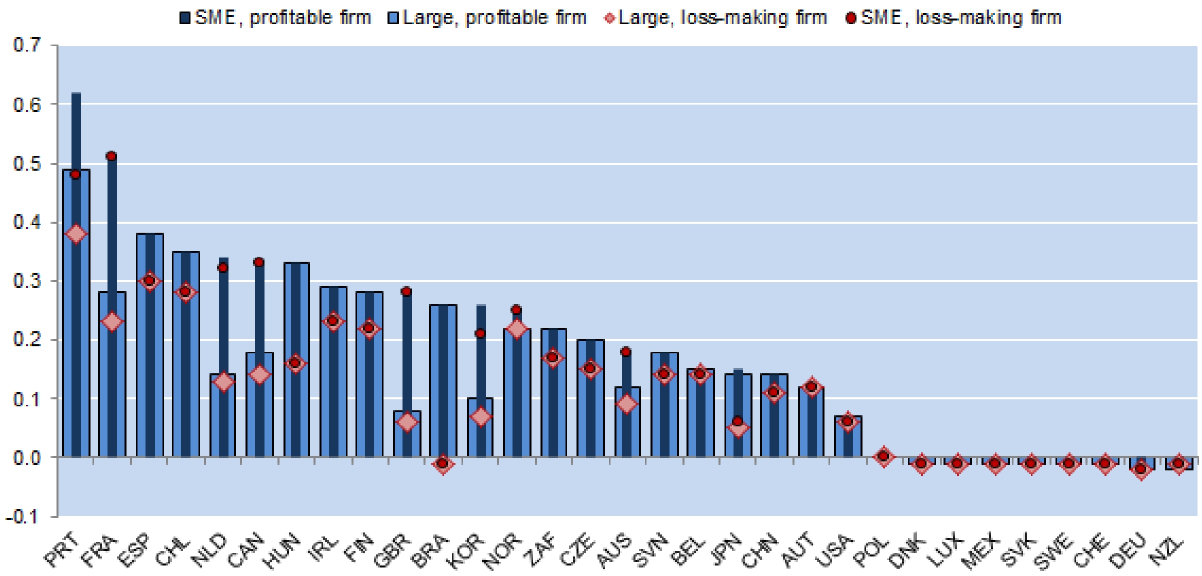


Notes: These are experimental indicators. International comparability may be limited. For more information, and for country specific notes see www.oecd.org/sti/rd-tax-stats.htm. Results restricted to countries providing information on expenditure-based R&D tax incentives for five or more years between 2006 and 2012. A minimum 2% threshold for the tax incentive share of government support for R&D (2012 or latest year) is applied to ensure reliable estimates of growth rates.

Source: OECD R&D Tax Incentives Indicators, based on 2013 OECD-NESTI data collection on tax incentives support for R&D expenditures and OECD, National Accounts and Main Science and Technology Indicators, 15 September 2014. Direct funding estimates for Brazil are based on national sources. For more information see http://www.oecd.org/sti/rd-tax-stats.htm.

Figure A9. Tax subsidy rates on BERD by firm size and profit scenario

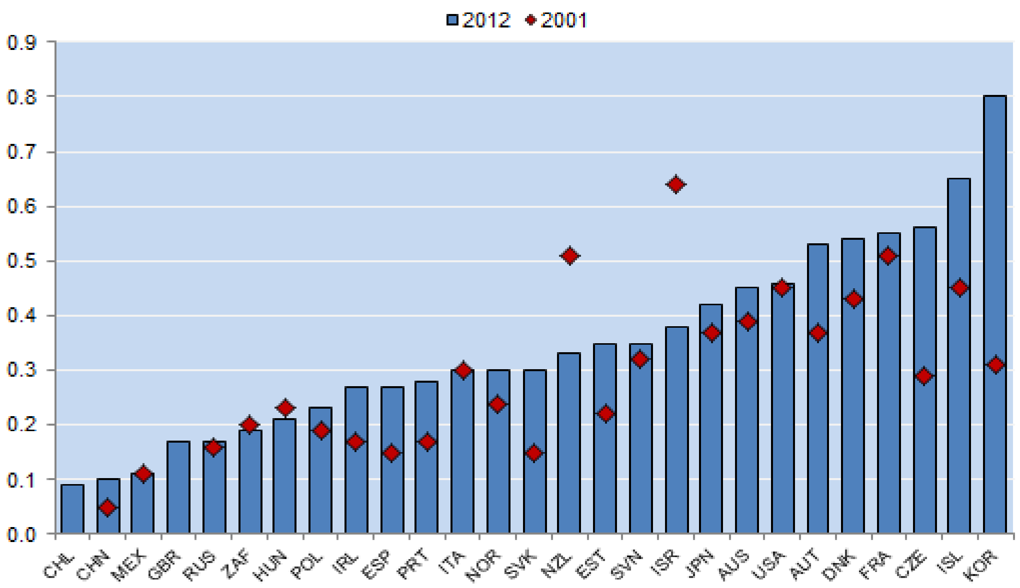
1- *B-Index*; 2013



Notes: The tax subsidy rate is defined as 1 minus the B-index, a measure of the before-tax income needed by a “representative” firm to break even on USD 1 of R&D outlays (Warda, 2011). For more details, see www.oecd.org/sti/rd-tax-stats.htm.

Source: OECD, Science, Technology and Industry Scoreboard (2013).

Figure A10. Basic research as a per cent of GDP

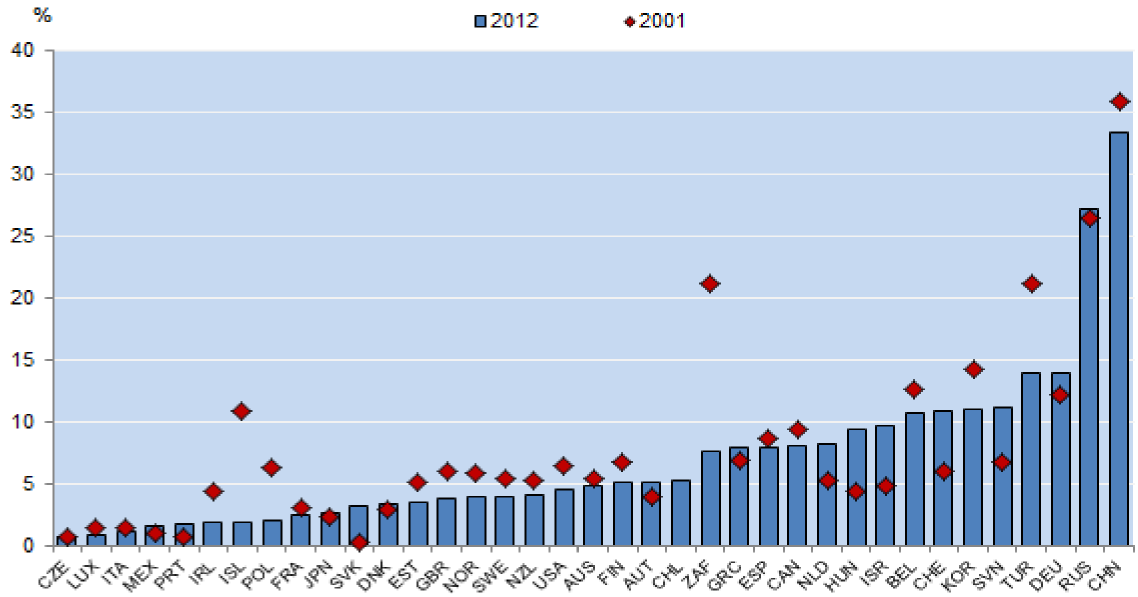


Notes: Data refer to 2002 for Australia, Austria and Ireland, 2003 for Denmark and 2005 for Italy. Data refer to 2011 for Austria, Denmark, France, Ireland, Iceland, Italy, Norway, New Zealand, Portugal, South Africa, Spain and the United Kingdom, 2009 for Mexico and 2008 for Australia.

Source: OECD, Science, Technology and Industry Scoreboard (2013).

Figure A11. Research collaboration between firms and universities

Per cent of higher education R&D financed by industry

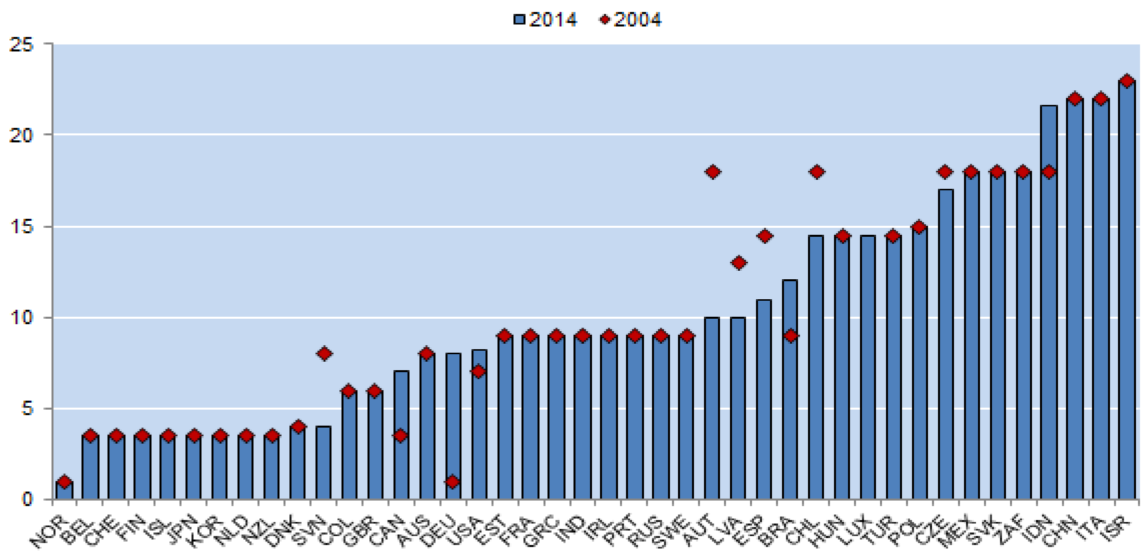


Notes: Data refer to 2002 for Australia, Austria, Switzerland, 2003 for China and 2005 for Italy and Luxembourg, 2011 for Austria, Belgium, France, Germany, Iceland, Mexico, the Netherlands, New Zealand, Norway, Portugal, South Africa, Spain and Sweden, 2010 for Australia and Israel.

Source: OECD, Science, Technology and Industry Scoreboard (2013).

Figure A12. Bankruptcy legislation

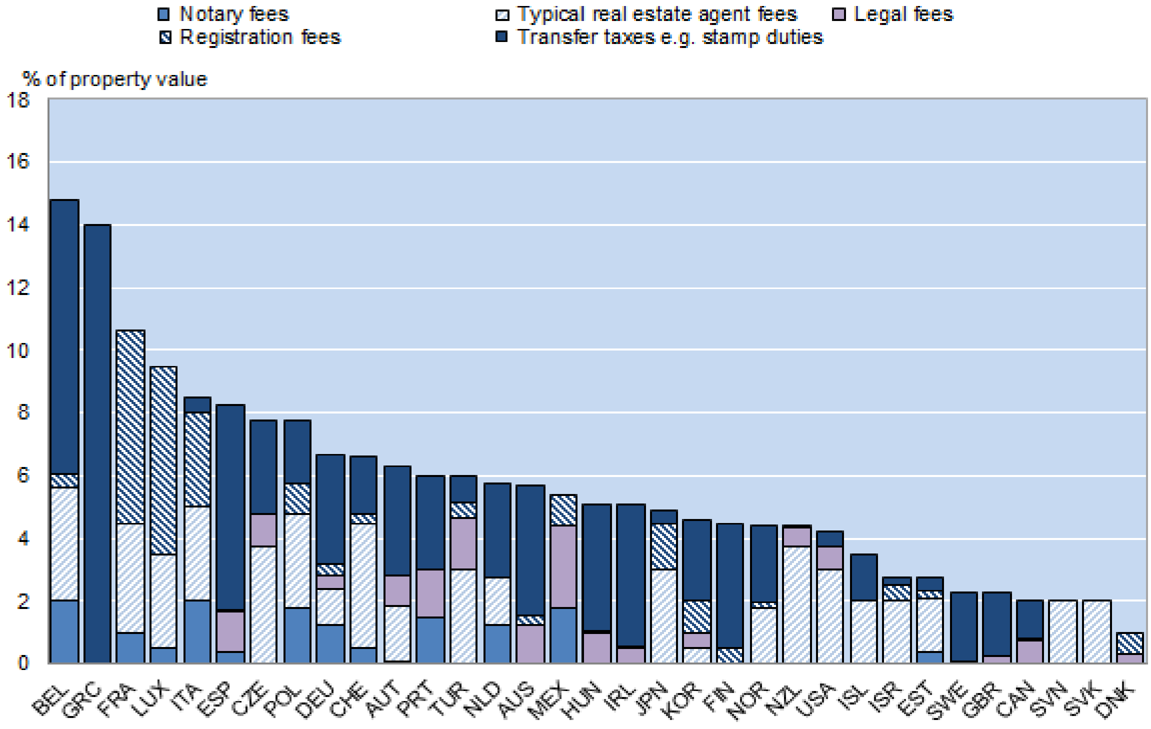
The average cost of bankruptcy proceedings as a percentage of the estate's value



Notes: The cost is calculated on the basis of questionnaire responses and includes court fees and government levies; fees of insolvency administrators, auctioneers, assessors and lawyers; and all other fees and costs. Data refer to 2005 for Iceland. 2004 data refer to São Paulo for Brazil, Shanghai for China, Mumbai for India, Jakarta for Indonesia, Mexico City for Mexico, New York for the United States, Tokyo for Japan and Moscow City for Russia.

Source: World Bank, Doing Business Database.

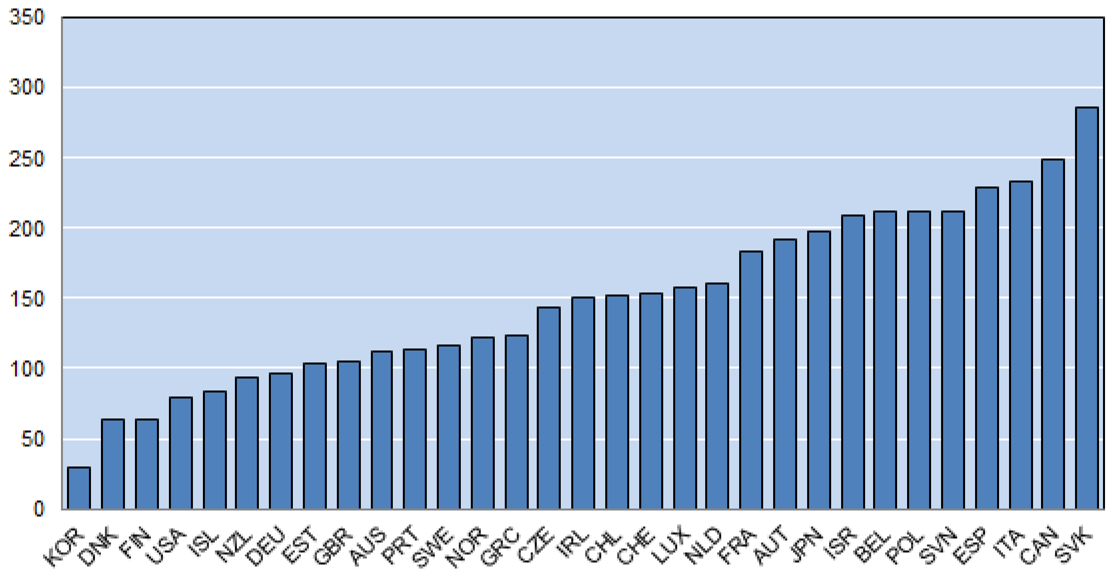
Figure A13. Transaction costs on buyer by type, 2009



Notes: Transaction costs refer to average costs.

Source: Andrews et al. (2011).

Figure A14. Number of days to obtain a building permit, 2014

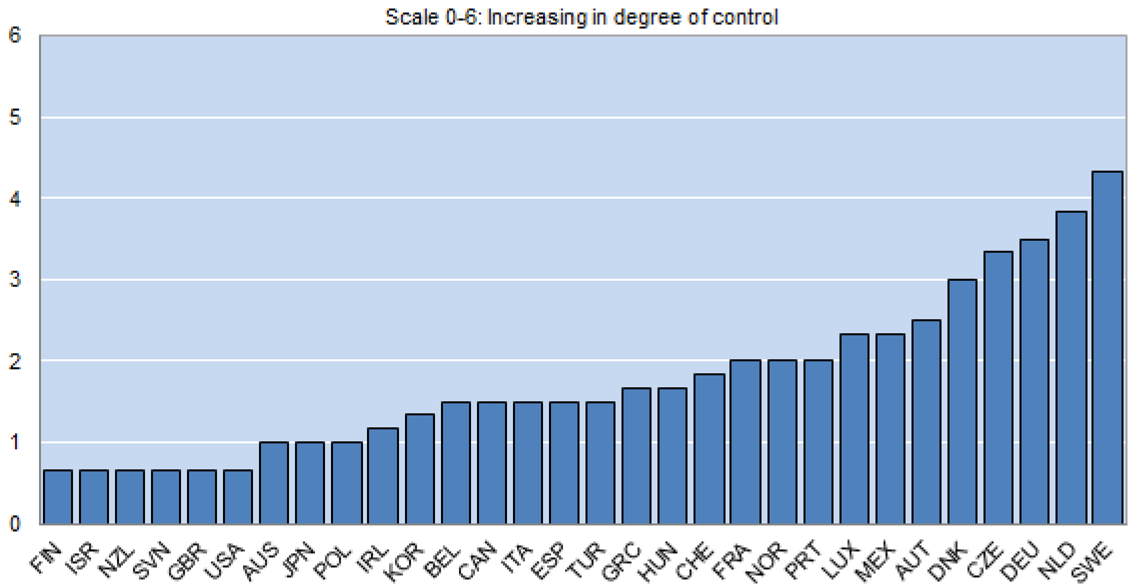


Notes: The number of days to obtain a building permit measured as the median duration that local experts indicate is necessary to complete a procedure in practice.

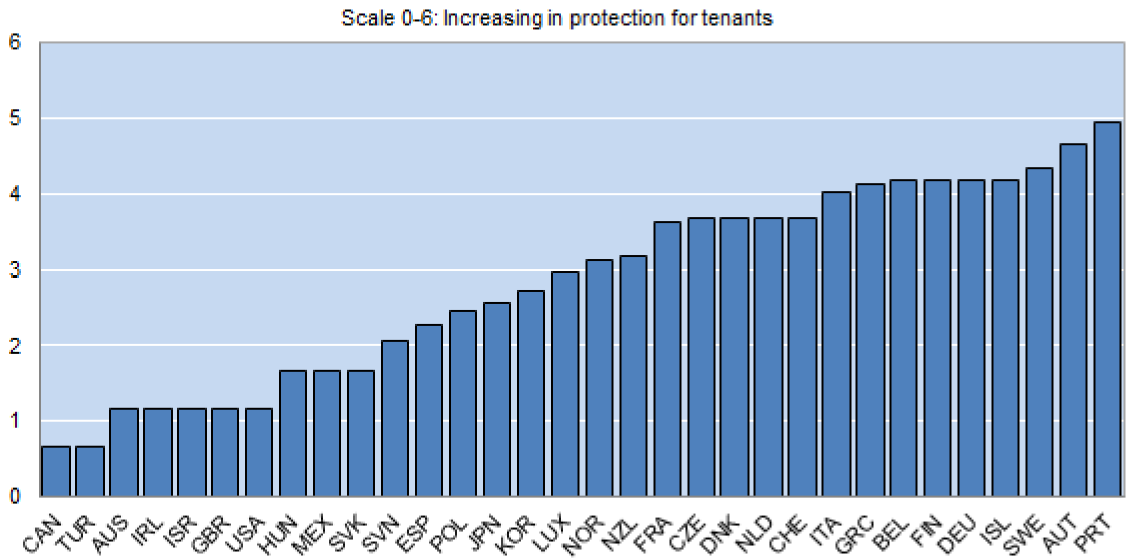
Source: World Bank, Doing Business Database.

Figure A15. Pro-tenant regulations, 2009

A: Rent control in the private rental market, 2009



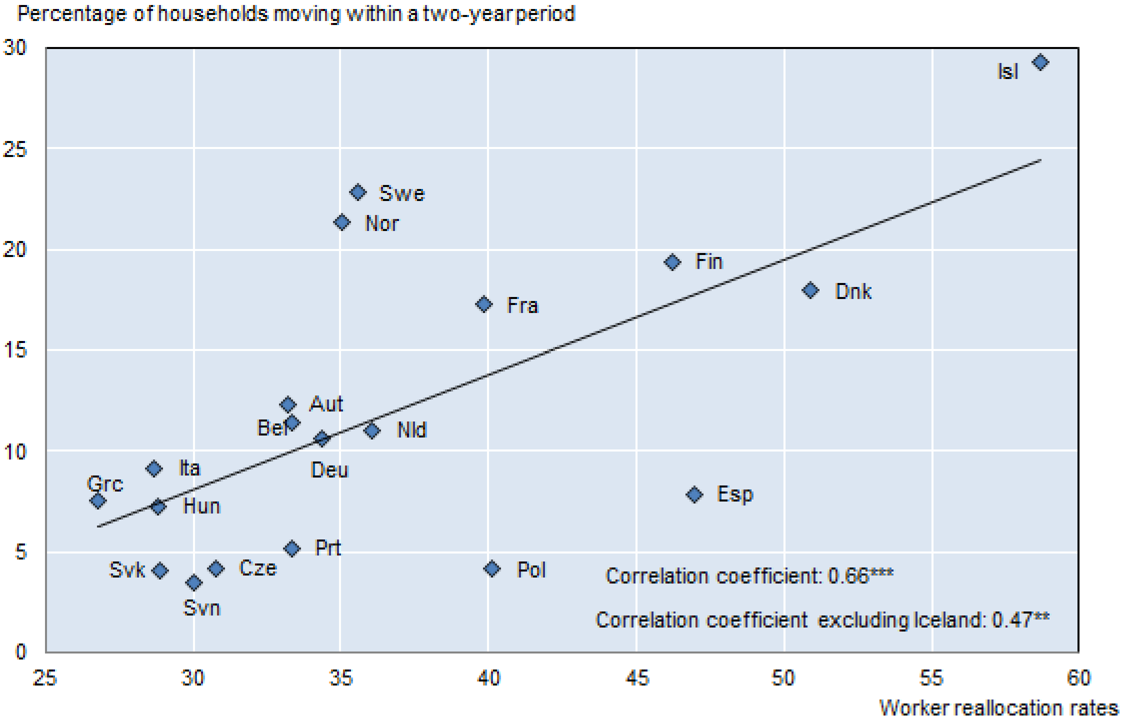
B: Tenant-landlord regulations in private rental market, 2009



Notes: Panel A: This indicator is a composite indicator of the extent of controls of rents, how increases in rents are determined and the permitted cost pass-through onto rents in each country. Panel B: The indicator measures the extent of tenant-landlord regulation within a tenancy. It includes the ease of evicting a tenant, degree of tenure security and deposit requirements.

Source: Andrews et al. (2011).

Figure A16. Residential mobility and worker reallocation rates



Notes: Worker reallocation rates are country averages of reallocation rates (hiring and firing rates) expressed in percentage of total dependent employment (adjusted for industry composition). The data are sourced from OECD (2010) and refer to 2000-07 except for Austria, Iceland, Slovenia: 2002-07; Canada, Denmark, France, Germany, Italy, Portugal, Sweden and the United States: 2000-06; the Czech Republic: 2001-07; Greece, Hungary, Ireland, Spain: 2000-05; Norway: 2000-04; Poland: 2004-05; the Slovak Republic: 2002-06; and Turkey: 2007. Residential mobility data are from Andrews et al. (2011) based on 2007 EU-SILC Database, on HILDA for Australia, AHS for the United States and SHP for Switzerland. *** denotes statistical significant at 1% level; ** denotes statistical significant at 5% level.

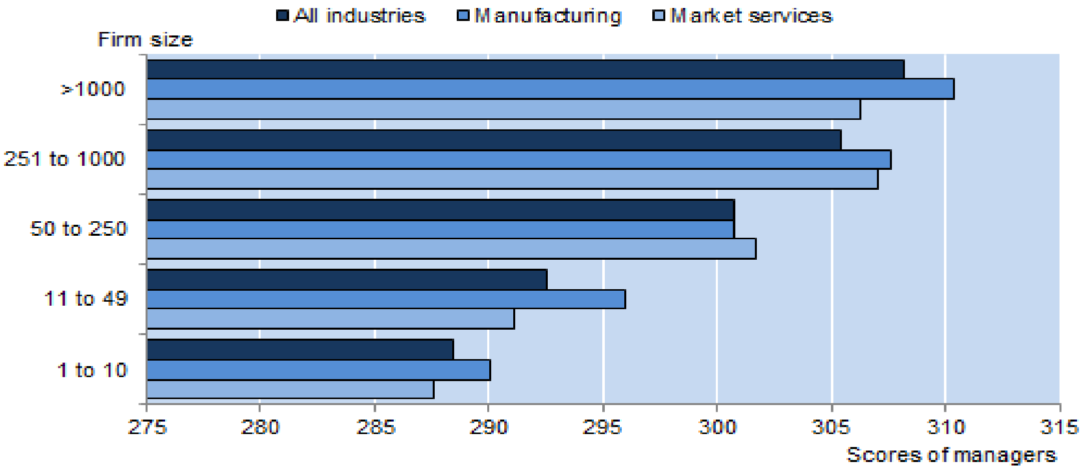
Source: Andrews et al. (2011) and OECD (2010), *Employment Outlook*, Paris.

Larger firms tend to have better managers than smaller firms on average across OECD countries, and these patterns are more pronounced in the manufacturing sector than services, consistent with more efficient resource allocation in the former (Figure A17, Panel A). However, some interesting cross-country differences emerge, with the monotonic pattern particularly pronounced in Sweden, while there is no apparent relationship between managerial quality and firm size in Poland (Figure A17, Panel B). These patterns are symptomatic of differences in the efficiency of resource allocation across the two economies (Andrews and Cingano, 2014) and are broadly consistent with evidence from Bloom et al. (2013), which measure the core managerial practices in the areas of monitoring, targets and incentives.

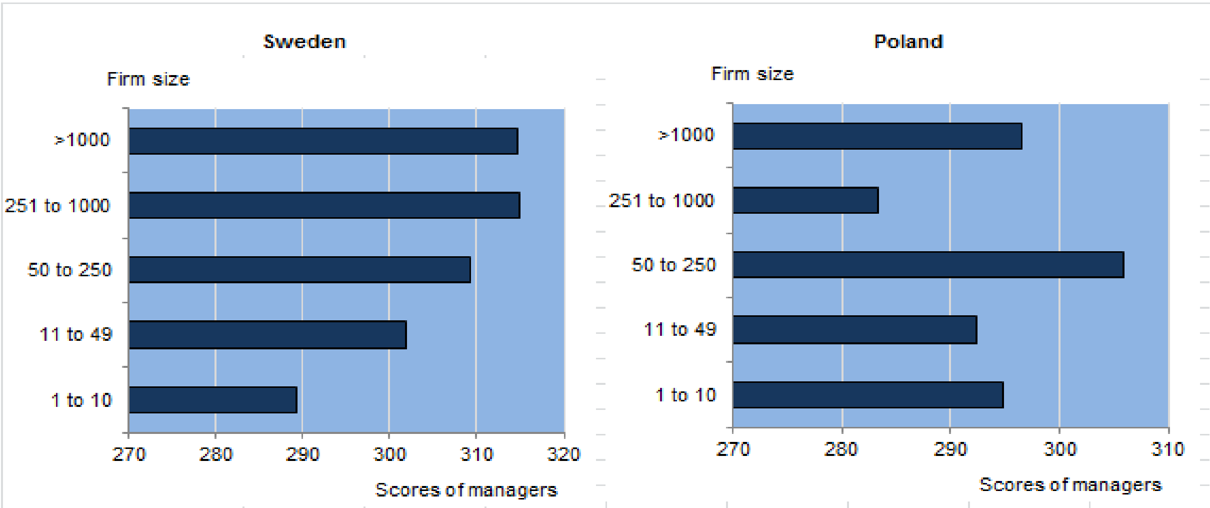
Figure A17. Managerial quality across industries and firm size

Scores increasing in skills

Panel A: Average across selected OECD economies; industry break-down



Panel B: A two country example – Sweden and Poland, all industries



Notes: Firm size is measured as the number of employees at the firm. Skills of managers refer to the average of the proficiency scores (in literacy) of managers in each country. Panel A shows the unweighted average of the scores of managers in the 22 OECD countries in the *Survey of Adult Skills* (2012). Market services include wholesale and retail trade, transportation and storage, accommodation and food service activities, information and communication, real estate activities, professional, scientific and technical activities, and administrative and support service activities.

Source: Adalet McGowan and Andrews (2015a) based on the *Survey of Adult Skills* (2012).

Box A1. R&D Tax Incentives and Productivity Growth

While R&D fiscal incentives unambiguously boost R&D expenditure (Westmore, 2013) and the ultimate goal of such incentives is to raise productivity growth, they also incur compliance and administration costs. R&D fiscal incentives could be expected a priori to have positive effects on productivity growth, since they lead to additional business R&D and business R&D has important effects on productivity growth. However, direct empirical evidence on the impact of R&D fiscal incentives on productivity growth is less clear-cut (Lokshin and Mohnen, 2007; Westmore, 2013).

Besides the design features of such schemes (see below), the failure to find a clear-cut direct positive effect of R&D fiscal incentives on productivity growth could reflect measurement and identification issues, but could also arise if:

- R&D fiscal incentives lead to an increase in the price of R&D (e.g. via higher wages of scientists) as opposed to the volume of R&D. Recent estimates suggest that this wage effect could reduce the effectiveness of R&D tax incentives (in terms of the volume of R&D) by 10% (Lokshin and Mohnen, 2008) to 25% (Haegeland and Møen, 2007). This suggests that the effectiveness of such schemes could be enhanced by education policies that raise the supply of skilled workers.

- Projects financed by R&D tax incentives have lower than average marginal productivity (Hægeland and Moen, 2007). For example, evidence suggests a positive effect of R&D tax incentives on incremental innovations that are new to the firm (e.g. Czarnitzki et al., 2005; de Jong and Verhoeven, 2007) but not on innovations new to the market (Cappelen et al., 2012).

- R&D tax incentives may lead to R&D duplication or a re-labelling of existing non-R&D activities as R&D investment (Lemaire, 1996; Hall and Van Reenen, 2000). However, tentative evidence suggests such policies are unlikely to lead to significant increases in re-labelling of investment (Westmore, 2013).

- Information problems limit governments' ability to channel direct support measures to those projects that have the highest potential.

- The firms that benefit most from R&D fiscal incentives are actually those for which R&D is less likely to generate large spillovers. While smaller – but not necessarily younger – firms tend to be more responsive to R&D tax incentives than larger firms given they are more credit constrained (Lokshin and Mohnen, 2007), such firms might be more likely to focus on niche markets where spillovers are smaller (Bloom et al., 2013b).

The Future of Productivity

Productivity growth of the globally most productive firms remained robust, despite the slowing in aggregate productivity, which was evident even before the crisis. This rising productivity gap between the global frontier and other firms raises questions about why seemingly non-rival technologies and knowledge do not diffuse to all firms and suggests that future growth will depend on re-harnessing the forces of knowledge diffusion, which propelled productivity growth for much of the 20th century. Accordingly, this book identifies a number of structural impediments to future productivity growth, which span the decline in business start-ups, slowing knowledge based capital accumulation and inefficient resource allocation. The latter is reflected in barriers to up-scaling, which undermine entry into international markets and scope for knowledge diffusion from the global frontier, and relatively high rates of skill mismatch, which constrains the growth of innovative firms. Analysis based on micro and industry-level data highlights the importance of reallocation-friendly policies, including well-functioning product, labour and risk capital markets, efficient judicial systems, bankruptcy laws that do not excessively penalize failure and housing policies that do not unduly restrict labour mobility. Improvements in public funding and organisation of basic research will also become increasingly necessary, while other innovation policies – including R&D fiscal incentives, university-industry R&D collaboration and IPR protection – should be designed so that they do not excessively favour applied vs basic research and incumbents vs young firms.