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Digital Dividend: Policies to Harness the Productivity Potential of Digital Technologies — Source link

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DIGITAL DIVIDEND: POLICIES TO HARNESS THE PRODUCTIVITY POTENTIAL OF DIGITAL TECHNOLOGIES

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On 3 May 2018, the OECD Council invited Lithuania to become a Member. At the time of preparation, the deposit of Lithuania's instrument of accession to the OECD Convention was pending and therefore Lithuania does not appear in the list of OECD Members and is not included in the OECD zone aggregates.

On 25 May 2018, the OECD Council invited Colombia to become a Member. At the time of preparation, the deposit of Colombia's instrument of accession to the OECD Convention was pending and therefore Colombia does not appear in the list of OECD Members and is not included in the OECD zone aggregates.

This policy paper is a contribution to the OECD Going Digital project, which aims to provide policymakers with the tools they need to help their economies and societies prosper in an increasingly digital and data-driven world. For more information, visit www.oecd.org/going-digital #GoingDigital

This paper was written by Stéphane Sorbe, Peter Gal, Giuseppe Nicoletti and Christina Timiliotis. It builds on the empirical analysis presented in two OECD Economics Department Working Papers:

Andrews, D., G. Nicoletti and C. Timiliotis (2018), "Digital technology diffusion: A matter of capabilities, incentives or both?", OECD Economics Department Working Papers, No. 1476, OECD Publishing, Paris

Gal, P., G. Nicoletti, T. Renault, S. Sorbe and C. Timiliotis (2019), "Digitalisation and productivity: In search of the holy grail – Firm-level empirical evidence from EU countries", OECD Economics Department Working Papers, No. 1533, OECD Publishing, Paris.

digital

Making the transformation work for growth and well-being

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Abstract/Résumé

Digital dividend: Policies to harness the productivity potential of digital technologies

This paper presents a range of policies to enhance adoption of digital technologies and firm productivity. It quantifies illustratively the effect of policy changes by combining the results of two recent OECD analyses on the drivers of adoption and their productivity benefits. Increasing access to high-speed internet, upgrading technical and managerial skills and implementing product and labour market reforms to facilitate the reallocation of resources in the economy are found to be the main factors supporting the efficient adoption of a selection of digital technologies. The most productive firms have benefitted relatively more from digitalisation in the past, contributing to a widening productivity gap with less productive firms. Policies should create the conditions for efficient adoption by less productive firms, which would help them to catch up, achieving a double dividend in terms of growth and inclusiveness. Enhancing skills has a key role to play in this area since less productive firms suffer relatively more from skill shortages.

JEL classification codes : D24, J24, O33

Keywords: digitalisation, ICT, productivity, dispersion, skills, regulation, competition

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Dividende numérique: politiques pour exploiter le potentiel de productivité des technologies numériques

Ce document présente une série de politiques visant à améliorer l’adoption des technologies numériques et la productivité des entreprises. Il quantifie de manière illustrative l'effet de changements de politique en combinant les résultats de deux analyses récentes de l'OCDE sur les facteurs d'adoption et leurs bénéfices en termes de productivité. L’accroissement de l’accès à Internet haut débit, l’amélioration des compétences techniques et managériales et la mise en œuvre de réformes des produits et du marché du travail facilitant la réaffectation des ressources dans l’économie sont les principaux facteurs favorisant l’adoption efficace d’une sélection de technologies numériques. Les entreprises les plus productives ont bénéficié relativement plus de la numérisation dans le passé, contribuant ainsi à creuser l'écart de productivité avec les entreprises moins productives. Les politiques devraient créer les conditions d'une adoption efficace par les entreprises moins productives, ce qui les aiderait à rattraper les premières, générant un double dividende en termes de croissance et d'inclusion. Le renforcement des compétences a un rôle clé à jouer dans ce domaine car les entreprises moins productives souffrent relativement plus de pénuries de compétences.

Classification JEL: D24, J24, O33

Mots-clés : digitalisation, TIC, productivité, dispersion, compétences, régulation, concurrence

Digital dividend: Policies to harness the productivity potential of digital technologies

Main findings

Digital technologies can boost firm productivity. However, despite ongoing digitalisation, productivity has slowed sharply in most OECD countries over the past two decades.

This is because digital technology diffusion has been slow and unequally effective across firms, failing to offset other headwinds on productivity. The gains from digital technologies have been concentrated among the most productive firms, which benefit from the human and organisational capital that is key to harnessing their full potential.

As less productive firms have failed to adopt or make the best use of digital technologies, their productivity performance has been weak, weighing on aggregate productivity growth.

The resulting increase in the productivity gap between leading and lagging firms (about half of which may result from digitalisation) has far-reaching implications, as it contributes to widening wage dispersion and income inequalities.

Policies have a role to play to revert these trends. A range of policies can support the diffusion and efficient use of digital technologies:

- Implementing regulatory frameworks that support investment in broadband and pro-competition reforms in telecommunication sectors to enable broader and cheaper access to high-speed internet;
- Increasing participation in training – especially of low-skilled workers – and its quality, as well as promoting good cognitive, organisational and managerial skills;
- Enabling the efficient reallocation of labour and capital across firms and industries by reducing administrative burdens on start-ups, facilitating job transitions and improving the efficiency of insolvency regimes;
- Reducing financial constraints for young innovative firms, including by encouraging the development of venture capital markets;
- Enhancing competition in digital markets, including by reducing barriers to cross-border digital trade and taking into account the strong network effects and central importance of data characterising certain digital activities;
- Further developing e-government to exploit the synergies between digitalisation of the public and private sectors.

A whole-of-government approach to reforms can be useful as these policies have strong complementarities between themselves.

In addition to stimulating productivity, some of these policies can support inclusiveness to the extent that they help lagging firms to catch up, displaced workers to find other jobs and support wage growth. Upgrading skills is particularly important in this respect.

This paper summarises the findings of two recent OECD empirical studies on the drivers of digital adoption and its effect on productivity. These papers cover a selection of technologies including high-speed internet, back and front office integration, and cloud computing. They focus on European countries due to data limitations, but their policy implications are presumably relevant for other OECD countries as well.

1. Introduction

More than thirty years after Robert Solow first formulated it, the so-called "productivity paradox" is still at the centre of economic debates.[1] While new digital technologies are ubiquitous in our daily lives and seem to offer vast potential to boost firm productivity, the overall productivity growth of OECD economies has slowed considerably over the past decades and especially since the mid-2000s. Even early digital adopters (e.g. Nordic countries) have been affected by the productivity slowdown in the same way as other countries (Figure 1).

Figure 1. The productivity slowdown has affected almost all OECD countries

Note: Labour productivity is defined as real GDP divided by total employment in the economy. The overall picture is robust to using hours worked instead of employment, although hours worked are available for fewer countries.
Source: OECD calculations based on OECD Economic Outlook No 103 database (May 2018).

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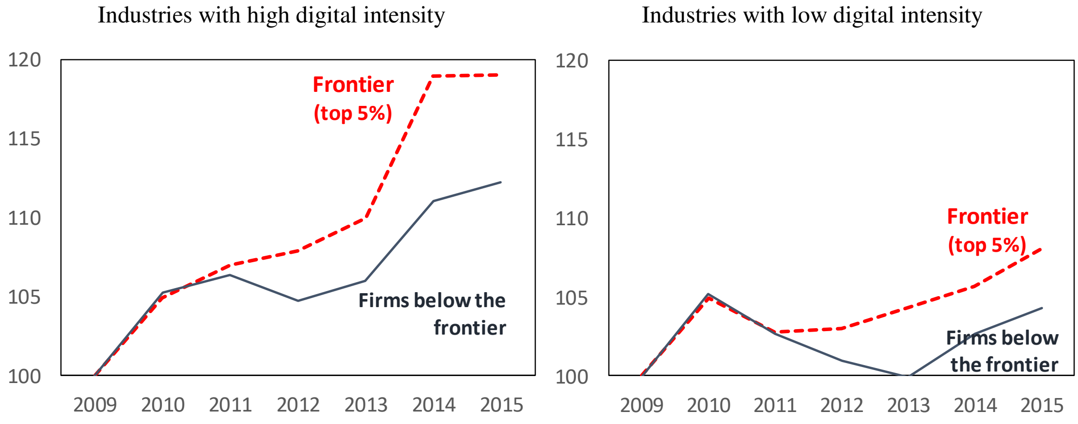
Looking closer, this aggregate picture masks an increasing divide between a small share of highly productive "superstar" firms, which enjoy relatively strong productivity growth, and the mass of laggard firms where productivity growth has been sluggish (Andrews, Criscuolo and Gal, 2016[1]; Berlingieri et al., 2017[2]; Berlingieri et al., 2018[3]). The reasons for this divergence (which is observed at the OECD level but not necessarily in each country) are not fully understood yet, but digitalisation is a likely contributor since this trend is more pronounced in digital intensive industries (Figure 2). This is because the most productive firms are more likely to adopt new technologies than less productive ones and stand to gain more from adoption. Indeed, benefitting from digitalisation requires firms to reorganise production processes, which requires good management and digital skills that are more likely to be found in highly productive firms.

[1] Robert Solow wrote in 1987 in a New York Times article that "you can see the computer age everywhere but in the productivity statistics." For a recent discussion of the "modern productivity paradox", see Brynjolfsson et al. (2017[36]).

Figure 2. Productivity dispersion has widened, especially in digital intensive industries

Multifactor productivity (MFP) at the productivity frontier and for the average non-frontier firm (2009=100)



Note: The "frontier" is measured by the average of log multi-factor productivity, based on the Wooldridge (2009) methodology, for the top 5% of companies with the highest productivity levels in each 2-digit industry and year, across 24 countries. The "firms below the frontier" corresponds to the average of the log-productivity distribution of non-frontier firms in each industry and year. The values obtained for the detailed 2-digit industries are averaged to industry groups that are classified either as having "high" or "low" digital intensities according to the methodology in Calvino et al. (2018[4]). The series are normalised to 100 in the starting year (2009=100).

Source: Gal et al. (2019[5])

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These trends have far-reaching implications for growth and inclusiveness. Slower productivity growth implies slower wage growth overall, and the increasing dispersion in productivity performance across firms is mirrored by an increasing dispersion in wages, which contributes to rising income inequalities between workers (Berlingieri, Blanchenay and Criscuolo, 2017[6]). This is compounded by real wages growing more slowly than productivity in some OECD countries, resulting in a decline in labour shares that may itself at least partly reflect digitalisation and the emergence of "superstar" firms with low labour shares (Autor et al., 2017[7]; Schwellnus et al., 2018[8]).

Looking ahead, less productive firms may lack the ability to adopt increasingly sophisticated technologies (e.g. artificial intelligence). In turn, the most productive firms may become more difficult to challenge, especially in a digital environment where intangible firm-specific assets (such as tacit knowledge, data and algorithms) are an increasingly central source of value. This risks undermining business dynamism and competition and could ultimately affect productivity. Mounting signs of increasing mark-ups and industry concentration and declining firm entry and exit rates, especially in digital intensive sectors, are worrying in this respect (Calligaris, Criscuolo and Marcolin, 2018[9]; Calvino and Criscuolo, 2018[10]; Bajgar et al., 2019[11]).

Future productivity growth at the technological frontier remains largely uncertain and debates between techno-optimists and pessimists are not settled. What seems clearer, as the empirical work supporting this policy paper suggests, is that there is a vast underexploited potential for a greater diffusion of existing technologies among firms (as well as households and governments) and for a better use of them to maximise their productivity benefits. Adoption and efficient use of technology by less productive firms – if coupled with the necessary complementary investments in skills and business organisation – offers hope that they catch up towards more productive firms.[2]

Against this background, this policy paper addresses two questions: (i) Is there evidence that the adoption of digital technologies significantly boosts productivity? (ii) What are the main (policy and non-policy) factors driving the adoption? In addressing these questions, the paper summarises and combines the results of two recent OECD studies on the drivers of digital adoption and its effect on productivity across different industries and firm types (Andrews, Nicoletti and Timiliotis, 2018[12]; Gal et al., 2019[5]). Using firm- and industry-level data, these studies focus on European countries and on a selection of digital technologies (e.g. high-speed internet, cloud computing) that have the potential to lead to efficiency improvements.

Digitalisation poses policy challenges in many areas that are beyond the scope of this paper, such as taxation, data privacy, cybersecurity. These issues are discussed in OECD (2019[13]).

2. Digital technologies support productivity but not uniformly across firms

2.1. Digital adoption can yield productivity gains

Based on previous studies, there is broad consensus that digital technologies can yield positive effects on productivity at the firm and industry level.[3] However, productivity gains from digital adoption are not automatic. They depend crucially on firms' organisational capital and management skills, as well as on their ability to deploy complementary investments and innovations to improve business processes and automate certain routine tasks. In addition, productivity gains can take time to materialise.

The analysis reported in this policy paper sheds new light on this question using European data and focusing on a selection of digital technologies (Box 1). Its results suggest that productivity gains from digital adoption can be substantial. For example, a 10-percentage point increase in the use of high-speed broadband internet (cloud computing) at the industry level is associated with a 1.4% (0.9%) increase in multi-factor productivity for the average firm in the industry after 1 year, and 3.9% (2.3%) after 3 years. This can reflect both productivity increases by the firm adopting these new technologies (including the benefits of concomitant investments in human and organisational capital) and positive spillovers to other firms in the same industry (e.g. suppliers benefitting from more fluid interactions, or competitors enticed to increase their productivity).

The productivity benefits from digital adoption appear greater in manufacturing than in services, and more generally tend to be higher in industries that are intensive in routine tasks. This confirms that streamlining or automating routine tasks is one of the channels through which digital adoption increases productivity. While this could pose challenges for policy in terms of job losses, digitalisation is also prone to generating new jobs due to their complementarity with skilled labour (OECD, 2019[13]).

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[2] Indeed, much of the increase in productivity dispersion is due to the increasing gap between the median and the bottom of the firm-level productivity distribution (Berlingieri et al., 2018[4]).

[3] See for example the reviews in Draca et al., (2009[38]), Syverson (2011[39]) and Gal et al. (2019[6]). While recent evidence has been more nuanced (Acemoglu et al., 2014[40]), there are still good reasons to believe in the productivity potential of digital technologies (Brynjolfsson and McAfee, 2014[37]).

Box 1. Overview of the underlying empirical analysis

This policy paper is underpinned by two analytical papers assessing the drivers and productivity implications of the adoption of a selection of digital technologies across European countries over 2010-16. These technologies include access to high-speed broadband internet, simple and complex cloud computing (i.e. e-mail services vs. online renting of data or computing capacities), as well as back and front office integration systems such as customer relationship management (CRM) and enterprise resource planning (ERP) software.

The first paper (Andrews, Nicoletti and Timiliotis, 2018[12]) identifies the main structural and policy drivers of digital adoption. It relies on industry-level data on digital adoption from a Eurostat survey, and uses a difference-in-difference approach exploiting the fact that some industries are naturally more exposed to certain drivers of adoption. For example, knowledge-intensive industries are expected to be more sensitive to an improvement in skills than less knowledge-intensive ones. The main finding is that both capabilities (e.g. managerial and technical skills) and incentives (e.g. a competitive business environment) support digital adoption, with strong complementarities between the two.

The second paper (Gal et al., 2019[5]) assesses the productivity gains from digital adoption across industries and firms. It combines industry-level data on adoption (from the same Eurostat survey) and firm-level data on productivity (from the ORBIS database) in a neo-Schumpeterian productivity growth model. The combination of firm and industry-level data mitigates potential endogeneity concerns (e.g. the possibility that firms adopting new technologies have intrinsically higher productivity growth than other firms), while also allowing to account for firm heterogeneity. The main finding is that digital adoption at the industry level supports firm productivity, especially among firms that already had high productivity. Results are robust to a number of variants, including using lagged adoption rates to further address endogeneity concerns.

As both papers focus on the same technologies, countries and years, it is possible to combine their results to link drivers of adoption to productivity outcomes. The results are presented in different figures in this paper and the methodology described in Annex A. The exercise inevitably relies on a number of assumptions and the results should therefore be considered as illustrative orders of magnitude rather than precise estimates.

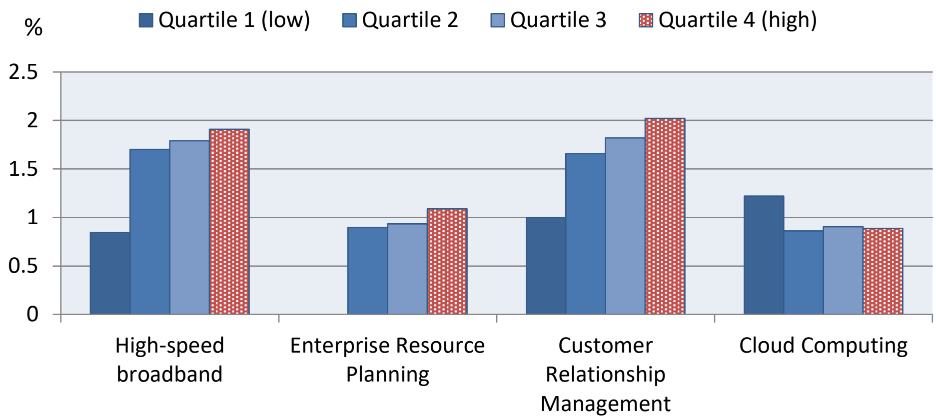
The three main assumptions are as follows: (i) results of both papers can be interpreted as causal; (ii) in industries least exposed to the structural and policy factors considered, changes in these factors have no effect on adoption. For example, it is assumed that in the least knowledge intensive industries (proxied as those with least tertiary educated workers), the lack of skills is only inhibiting adoption to an insignificant extent. This assumption would tend to underestimate the overall effect of policy factors on adoption and productivity to the extent that the least exposed industries might also benefit from adoption; (iii) potential cross-industry adjustments (e.g. workers shifting to another industry) implied by changes in structural and policy factors are ignored. See Annex A for more details.

2.2. Digitalisation contributes to a growing productivity divergence

When digital technologies are adopted in an industry, more productive firms tend to benefit more than less productive ones (Figure 3). Indeed, these firms have better technical and organisational skills that make them more likely (i) to be among the firms adopting these technologies, (ii) to enjoy relatively high productivity benefits when adopting a given technology, for example thanks to complementary reorganisation of production processes, and (iii) to benefit more from positive spillovers from digitalised peers in the same industry. Further research would be needed to assess the relative contribution of these three factors, which could not be disentangled with the available data.

Figure 3. More productive firms benefit more from a digitalised environment

Firm-level increase in multifactor productivity (MFP) from a 10 percentage point increase in digital adoption at the industry level, after one year, by productivity quartile



Note: This figure presents the estimated increase in multifactor productivity growth (after one year) associated to an increase in the industry-level diffusion of digital technologies by ten percentage points across different productivity quartiles. Quartile 1 refers to the bottom of the distribution (i.e. low productive firms), quartile 4 to the top of the distribution (i.e. high productive firms), in each industry-country-year cell. The fact that more productive firms tend to benefit more from industry-level adoption may reflect (i) their higher propensity to adopt, (ii) relatively higher gains when they adopt; (iii) more positive spillovers from adoption in other firms. These three explanations could not be disentangled with available data. Less productive firms benefit more only for cloud computing, which may reflect that cloud computing requires less complementary investments in organisation and skills. Results for Enterprise Resource Planning for the least productive firms are omitted since they are not statistically significant.
Source: Gal et al. (2019[5])

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Skill shortages in an industry, for example of managerial or digital-related technical skills, tend to reduce the productivity benefits from digital adoption. This is especially the case among less productive firms, reflecting that they are more likely to suffer from these shortages, which prevent them from adopting digital technologies or using them to their full potential.[4] Indeed, less productive firms, which tend to be less profitable, may lack the financial resources to attract scarce skilled workers.

Overall, digitalisation, while supporting productivity for the average firm, has also played a role in the widening productivity divergence between firms (Andrews, Criscuolo and Gal, 2016[1]; Berlingieri et al., 2017[2]). About half of the productivity divergence between the top and bottom quartiles of firms in each industry may result from digitalisation (Gal et al.,

[4] Consistent with these findings, Berlingieri et al. (2018[4]) find that catch-up by less productive firms has been slower than average in industries characterised by a high share of ICT specialists.

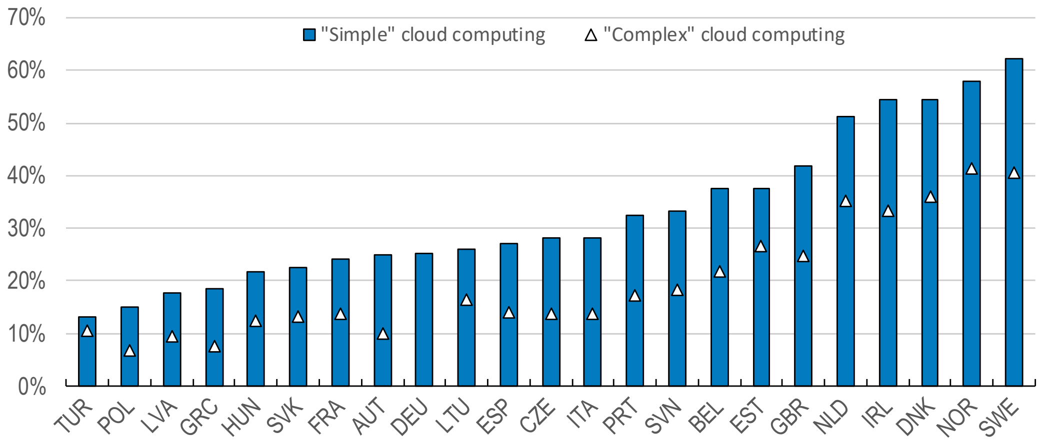
2019[5]). In turn, this points to a crucial need to implement policies aimed at bridging the digital gap by creating the conditions for efficient adoption of digital technologies by less productive firms.

3. A range of policies are needed to harness the full benefits of digitalisation

Despite their important productivity potential, the take-up of digital technologies remains uneven across countries (Figure 4), industries and firms, indicating room for higher adoption, especially among SMEs (OECD, 2017[14]). Adoption of digital technologies depends on both capabilities (e.g. managerial and technical skills) and incentives (e.g. a competitive business environment), with strong complementarities between the two (Andrews, Nicoletti and Timiliotis, 2018[12]). It also depends on the availability of the underlying infrastructure since high-speed internet access is a key enabler for other digital technologies, such as those mentioned above.

Figure 4. The adoption of cloud computing has been uneven

Average adoption rate of cloud computing,
% of total number of firms (10+ employees), 2017 (or latest available year)



Note: Adoption rate of "simple" (e.g. e-mail services) and "complex" (e.g. online renting of data or computing capacities) cloud computing services among firms with at least 10 employees. The figure presents the average adoption rate across industries in each country, using the industry structure of the United States as a benchmark to weight industries in order to avoid that differences in industry structure affect the results. Data are missing for a number of country-industry cells across the sample (reflecting too low a number of responding firms in these cells). Countries with missing data for more than half of industries are excluded. Otherwise, the missing data are imputed using 2016 or 2015 values if available, or otherwise based on a simple model estimated by regressing 2017 adoption rates on sector and country fixed-effects.
Source: OECD calculations based on Eurostat Digital Economy and Society Statistics

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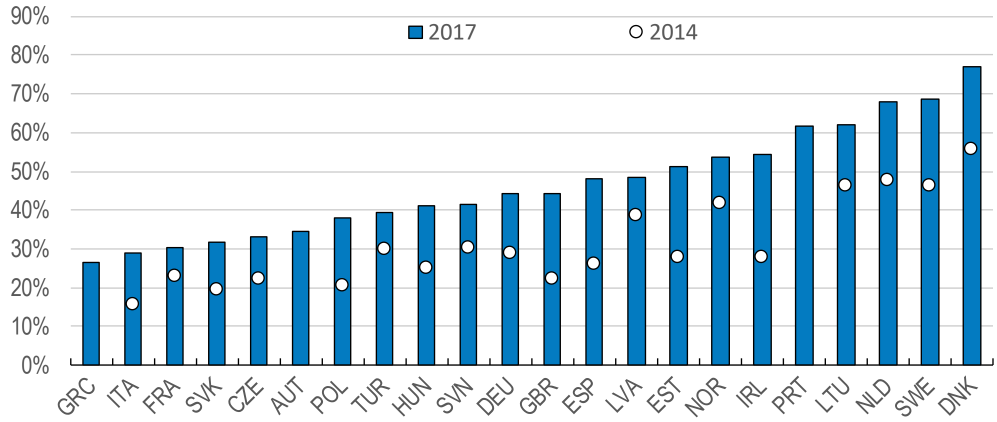
3.1. Enhancing access to high-speed internet

Access to high-speed internet supports firm productivity directly and also by encouraging adoption of productivity-enhancing digital technologies, such as cloud computing. There is wide cross-country dispersion and fast increases in firms' use of high-speed internet (Figure 5). Catching up with the best performing countries – as certain countries are currently in the process of doing (OECD, 2019[13]) – could substantially increase productivity (Figure 6).

Figure 5. Access to high-speed broadband varies across countries

Share of firms (10+ employees) accessing to high-speed broadband



Note: Eurostat definition of high-speed broadband, i.e. least 30 Mbit/sec data transfer speed. Only firms with at least 10 employees. Average across industries in each country, using the industry structure of the United States as a benchmark to weigh industries in order to avoid that differences in industry structure affect the results. Data are missing for a number of country-industry cells across the sample (reflecting too low a number of responding firms in these cells). Countries with missing data for more than half of industries are excluded. Otherwise, the missing data are imputed based on a simple model estimated by adoption rates (either in 2017 or 2014) on sector and country fixed-effects.
Source: OECD calculations based on Eurostat Digital Economy and Society Statistics

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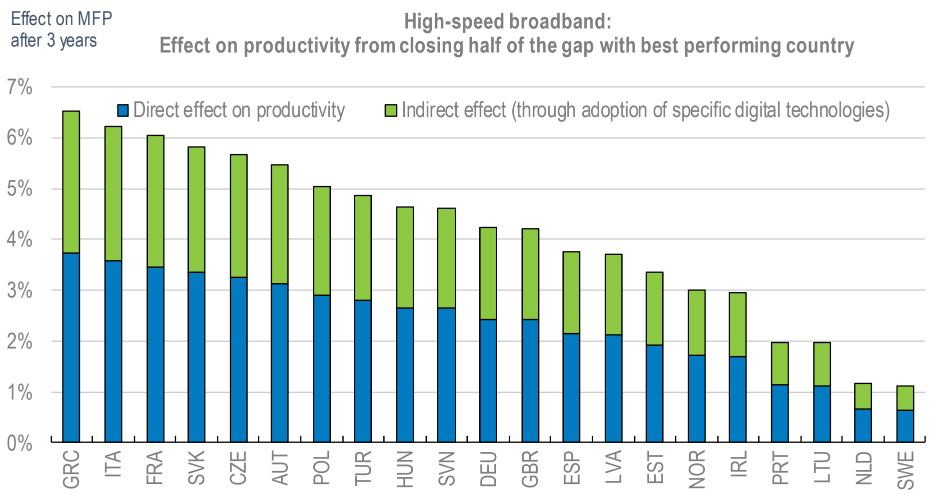
Figure 6. Increasing access to high-speed broadband is associated with higher productivity



Note: Estimated effect on multi-factor productivity (MFP) of the average firm after three years from increasing high-speed broadband access to close half of the gap with the best performing country in the sample (Denmark). The indirect effect captures the productivity benefits from increased adoption of cloud computing, Enterprise Resource Planning (ERP) and Customer Relationship Management (CRM) software resulting from faster internet access. The direct effect corresponds to other sources of productivity gains, either directly related to faster internet access or resulting from adoption of other digital technologies not covered in this paper.
Source: OECD calculations based on Andrews et al. (2018[12]) and Gal et al. (2019[5]). See Annex A for details on the methodology and assumptions underlying these estimates.

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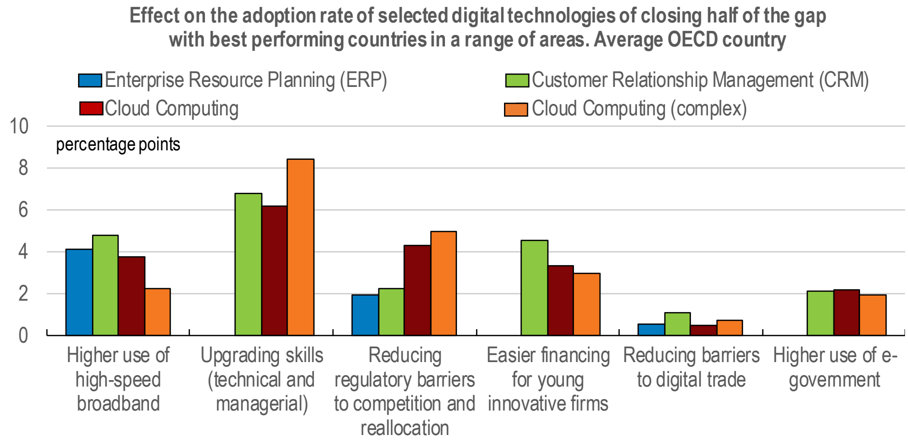
A number of policies are relevant to increase the availability of high-speed internet and make it more affordable, which in turn should enhance take-up by firms (OECD, 2019[13]). Governments may invest directly in high-speed networks or incentivise private investment, with the aim to improve coverage including in rural and remote places, based on socio-economic cost-benefit analyses. Governments should also ensure that technical enablers are in place (e.g. spectrum, internet protocol and exchange points). In addition, pro-competitive reforms in telecommunication sectors (e.g. encouraging the emergence of new entrants or enabling infrastructure sharing) can reduce prices and in many cases also spur investment (OECD, 2019[13]).

3.2. Enhancing capabilities to adopt by upgrading the skill pool

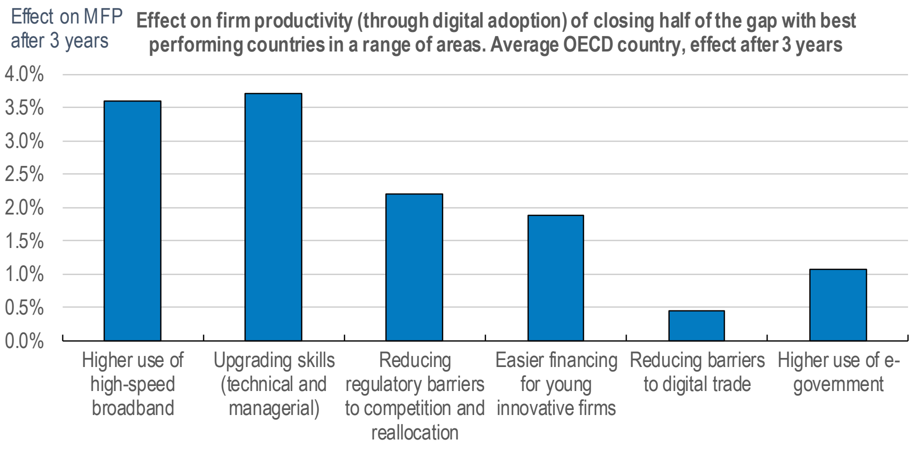
Skills are a key factor to enable the diffusion of digital technologies and maximise their productivity impact (Figure 7). Many skills are relevant to support the adoption and efficient use of digital technologies. They mainly fall in three categories: (i) specialist skills for ICT professionals, (ii) generic ICT skills for other workers, (iii) complementary skills to work in a digitalised environment (OECD, 2016[15]). The latter include general cognitive skills, interpersonal skills (which tend to be complementary to the tasks performed by machines) as well as managerial and organisational skills (Grundke et al., 2018[16]).

Figure 7. A range of policies can support digital adoption and productivity

Panel A: Effect of structural and policy factors on digital adoption



Panel B: Subsequent effect on productivity



Note: Estimated effect on the average digital adoption rate (Panel A) and the multi-factor productivity (MFP) of the average firm (Panel B) of a range of policy and structural factors (see Box 1). The effect of "Higher use of high-speed broadband" on productivity combines the direct and indirect effects presented in Figure 6. "Upgrading skills" covers participation in training (for both high and low-skilled), quality of management schools and adoption of High Performance Work Practices (HPWP). "Reducing regulatory barriers to competition and reallocation" includes lowering administrative barriers to start-ups, relaxing labour protection on regular contracts and enhancing insolvency regimes. "Easier financing for young innovative firms" covers the development of venture capital markets and the generosity of R&D tax subsidies. For each of the underlying indicators, it is assumed that half of the gap to the best performing country in the sample is closed. It is also assumed that policy factors in each group are largely independent from each other. Results are presented for the average OECD country. Results for ERP are sometimes not statistically significant, in which case they are omitted. Country-by-country effects on MFP for each group of structural and policy factors are presented in Annex B.
Source: OECD calculations based on Andrews et al. (2018[12]) and Gal et al. (2019[5]). See Annex A for details on the methodology and assumptions underlying these estimates.

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Good managerial skills are associated with higher digital adoption and shortage of managerial skills reduce the productivity gains from adoption (Andrews, Nicoletti and Timiliotis, 2018[12]; Gal et al., 2019[5]). This probably reflects the fact that reaping the benefits of digitalisation generally requires changing business processes, for which good management is crucial. In particular, High-Performance Work Practices (HPWP) can support digital adoption as they can increase firms' internal flexibility to adapt to technological change (OECD, 2016[17]; Andrews, Nicoletti and Timiliotis, 2018[12]).[5]

While policies cannot directly affect the managerial and organisational performance of firms, good management practices can be promoted indirectly, for example by encouraging their adoption in public administrations and government-owned enterprises or by facilitating students' access to apprenticeship or internship programs. In addition, enhancing product market competition can encourage firms to improve their management practices and contribute to the exit of certain firms that are very poorly managed, while openness to trade and foreign investment can also be beneficial for management practices

[5] HPWP include an emphasis on teamwork, autonomy, task discretion, mentoring, job rotation and applying new learning. They also encompass management practices – bonus pay, training provision and flexibility in working hours – that provide incentives for workers to deploy their skills at work more fully (OECD, 2016[14]).

since multinationals are on average better managed than other firms (Bloom and Van Reenen, 2010[18]).

At the same time, shortages in ICT-related technical skills also reduce the productivity benefits from digital adoption, especially for less productive firms (Gal et al., 2019[5]). Both initial education and subsequent training have a role to play to enhance ICT skills. In addition, "foundation skills", such as literacy and numeracy are important prerequisites for the development of the skills demanded in the digital economy (OECD, 2016[15]).

A higher participation of workers in training facilitates adoption of digital technologies, and also seems to go hand in hand with the hiring of ICT specialists (Andrews, Nicoletti and Timiliotis, 2018[12]). The quality of training is difficult to measure but also likely to matter greatly. In addition, the impact of training appears relatively greater for low-skilled workers than for higher-skilled ones. While increasing participation of low-skilled workers can be challenging since their propensity to participate is low compared to higher-skilled workers (Nedelkoska and Quintini, 2018[19]), can offer the double dividend of increasing productivity (through digital adoption) while reducing inequalities.

Overall, enhancing skills should feature high on the agenda of policy makers aiming to promote digital adoption. This is because enhancing skills has a strong potential to support productivity (as shown in Figure 7), but also (i) to help lagging firms catch up with best performers,[6] and (ii) to reduce income inequalities among workers (since education and training can help lower-skilled workers to upgrade their skills).

3.3. Improving incentives to adopt by tackling barriers to competition and the efficient reallocation of resources

Digitalisation can profoundly change production structures as new activities emerge and grow while others disappear or become less labour-intensive. Reaping its full benefits therefore requires enabling the efficient reallocation of labour and capital across firms, industries and regions. This is especially important since business dynamism appears to have declined over the past decades across OECD countries (Decker et al., 2018[20]; Bijnens and Konings, 2018[21]; Calvino, Criscuolo and Menon, 2015[22]). Even though business dynamism is generally higher in digital intensive sectors, it has declined more in these sectors than in the rest of the economy (Calvino and Criscuolo, 2018[10]).

Enhancing business dynamism requires reducing barriers to entry and growth of young innovative firms, facilitating a smooth exit of the least productive firms, and enabling fluid movements of labour and capital from declining to growing firms and industries, and also within firms. This involves a range of policies in labour and product markets. For example, the results presented in Figure 7 suggest substantial productivity benefits from lowering administrative barriers to start-ups, relaxing labour protection on regular contracts and enhancing insolvency regimes (see also Figure B.2). Going further, other policies are relevant to enhance business dynamism and efficient reallocation, such as promoting residential mobility or reducing barriers to labour mobility that can result from the lack of

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[6] It is not possible to infer directly from the empirical results underlying this paper if policies to enhance skills support digital adoption and productivity relatively more among low (as opposed to high) productivity firms. Still, one can presume that it may be the case since skill shortages undermine the productivity gains from digitalisation relatively more among less productive firms (Gal et al., 2019[6]). Moreover, related evidence by Berlingieri et al. (2018[4]) shows that training enhances the ability of low productive firms to catch up.

recognition of skills and qualifications across jurisdictions (Andrews, Caldera Sánchez and Johansson, 2011[23]; Sorbe, Gal and Millot, 2018[24]).

3.4. *Addressing financing constraints to the growth of innovative firms*

Financial constraints can hinder the growth of young and innovative SMEs, especially since intangible capital is more difficult to collateralise than physical capital. Easier access to financing can therefore support the emergence of innovative and digitally intensive firms, which have a high productivity potential and whose innovations can have positive spillovers on other firms. Reflecting this, greater development of venture capital markets and more generous support to R&D in certain countries may enhance productivity in the average firm via increased industry-level digital adoption (Figure 7, Figure B.3) and catch-up of less productive firms (Berlingieri et al., 2018[3]). Further encouraging equity financing, which in many countries remains less favourable for tax purposes than debt financing, would also help firms relying on hard-to-collateralise intangible assets. More broadly, policies should aim at addressing market failures in the financing of young innovative firms.

3.5. *Reducing barriers to digital trade*

Digital technologies can facilitate trade in goods and services and also enable "digital trade", i.e. trade that entirely takes place through digital means (e.g. digitally delivered cloud-computing services). As in traditional trade, digital trade can be expected to bring productivity benefits by enhancing specialisation and competition, and also providing cheaper and better quality inputs for firms. Indeed, reducing barriers to digital trade can support digital adoption and firm productivity (Figure 7, Figure B.4). As most international agreements on trade pre-date the emergence of digital trade, supporting its development requires international dialogue to improve the consistency of differing regulatory regimes, for example regarding data privacy and security, competition and taxation (OECD, 2019[13]; López González and Ferencz, 2018[25]).

3.6. *Leading by example: digital government*

Countries across the OECD are increasingly relying on digital government. Digital government entails the use of digital technologies in the provision of government services (so-called e-government) but also more broadly the promotion of innovation in the public sector and expanded civic engagement including through open government data initiatives (OECD, 2019[13]). Similarly to digitalisation in businesses, experience suggests that successful shifts to digital government involve complementary investment in rethinking and reorganising government processes and services (OECD, 2018[26]). Another benefit is that it tends to stimulate digital adoption by firms, which in turn can increase their productivity (Figure 7, Figure B.5). Indeed, digital government can foster the development of digital skills among the population and encourage firms to adopt digital technologies to facilitate their interactions with public authorities.

4. Policy complementarities and challenges

These general recommendations have to be adapted to countries' characteristics to take into account their digital adoption rates and main structural and policy bottlenecks to efficient adoption. For example, certain countries may need to prioritise physical infrastructure and others should focus primarily on skills, although the existence of positive complementarities between policies should not be overlooked. Policymakers should also factor in the fact that certain technologies may benefit more to certain firms (e.g. small firms for cloud computing) or industries (e.g. routine intensive industries).

4.1. There are strong complementarities between policies to stimulate adoption

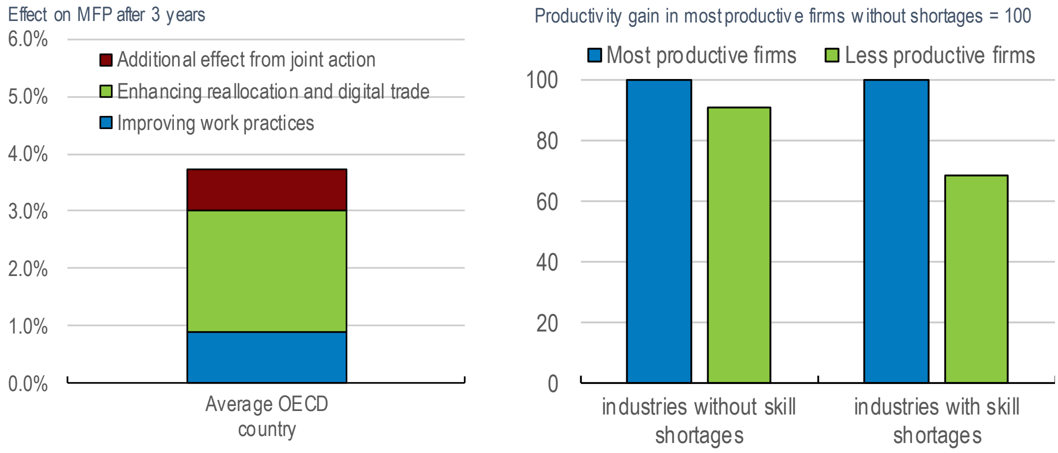
The policies outlined in section 3 have strong complementarities. For example, the positive effects of upskilling can be magnified by a business environment encouraging firms to put these skills to their best use. Acting on several policy fronts to support both capabilities and incentives to adopt can therefore yield additional benefits in terms of digital adoption – and therefore productivity – beyond the cumulated impact of the same policies if they were implemented in isolation (Andrews, Nicoletti and Timiliotis, 2018[12]).

Joint action can indeed increase the benefits of reforms by 20% in the average OECD country (Figure 8, Panel A). Consistent with this, productivity gains from digital adoption can be undermined by skill shortages, especially among less productive firms, suggesting that policies to promote adoption should be complemented by actions to address skill shortages (Panel B). Overall, these complementarities highlight the importance of having a consistent policy agenda and a whole-of-government approach when it comes to policies to harness the benefits of digital technologies.

Figure 8. Policies to support digital adoption offer complementarities

Panel A: Joint action in several areas can offer additional effect

Panel B: Skill shortages reduce gains from digitalisation in less productive firms



Note: **Panel A** presents the estimated effect on multi-factor productivity (MFP) of the average firm (through digital adoption) from improving work practices (measured by the prevalence of High Performance Work Practices) and reduced regulation strictness in three areas (employment protection legislation, administrative burdens on start-ups and barriers to digital trade). For each indicator, it is assumed that half of the gap to the country with the best performance/practice in the sample is closed. The dark red bars show the additional productivity gains from joint action in both areas. Results are presented for the average OECD country after three years. Country-by-country results are presented in Figure B.6. **Panel B** presents the estimated effect on multi-factor productivity (MFP) of digital adoption of a mix of selected technologies (high-speed broadband, cloud computing, ERP and CRM software) for two categories of firms. "Most productive firms" are the 25% most productive firms in each industry (after exclusion of the 5% most productive ones). "Less productive firms" are those between the 50th and the 75th percentile of the productivity distribution in each industry (i.e. firms with below-median productivity but not the least productive ones). The situation without skill shortages is defined as the 25th percentile of the distribution of skill shortages across industries in a range of areas including both managerial and technical skills (source: OECD Skills for Jobs database). The situation with skill shortages corresponds to the 75th percentile of this distribution.
Source: OECD calculations based on Andrews et al. (2018[12]) and Gal et al. (2019[5]). See Annex A for details on the methodology and assumptions underlying these estimates.

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4.2. Meeting the challenges of increasingly digital economies

While a more digitalised environment can boost firms' productivity, it also poses a number of challenges to policy-makers. First, digitalisation creates new job opportunities but it can also lead to the loss of certain jobs. This is because the productivity benefits of digitalisation are higher in routine intensive industries, suggesting that they reflect at least to some extent the automation of routine tasks (Gal et al., 2019[5]). More broadly, new technologies make it possible to automate an increasing share of tasks, and a key challenge is to enable the transition of displaced workers to new tasks, jobs, firms and sometimes industries. Education, training and active labour market policies have a crucial role to play in this area (Andrews and Saia, 2017[27]; Nedelkoska and Quintini, 2018[19]).

A second challenge is to create conditions that enable less productive firms to catch up and compete with the most productive ones. In addition to stimulating efficient digital adoption by these firms, as discussed above, policies should aim at increasing the diffusion of knowledge to less productive firms, which relates among other topics to intellectual property rights and the mobility of workers. A number of policies can help in this respect (Berlingieri et al., 2018[3]). For instance, questions around the ownership of data are becoming more important as data are increasingly used as a source of value for firms (OECD, 2019[13]). Regarding the mobility of workers, an emerging issue is the increasing use of non-compete clauses in labour contracts, which may be detrimental to the diffusion of innovation (US Treasury, 2016[28]).

More broadly, there is a mounting risk that certain high-productivity firms escape competition thanks to firm-specific intangible assets (including data and algorithms), especially in activities that are inherently characterised by strong network effects (e.g. digital platforms). While a certain degree of market power can reflect a legitimate rent for past innovation and even be the sign of healthy competition (OECD, 2018[29]), market power can – if too entrenched – allow these firms to use strategic patenting or buy smaller innovative firms to stifle competition (OECD, 2018[30]). The number of global mergers and acquisitions (M&A) has indeed more than doubled since 2003, which contributed to increasing concentration at the industry level both in North America and in Europe (Bajgar, Criscuolo and Timmis, 2018[31]). There is also growing evidence of rising mark-ups – especially in digital intensive industries – which may be a sign of increasing market power (Calligaris, Criscuolo and Marcolin, 2018[9]).

Moreover, a number of trends related to digitalisation can have the adverse effect of widening income inequalities. Indeed, the automation of routine tasks can affect employment and wages of low- and middle-skilled workers (if they fail to retrain to perform other tasks), increasing productivity dispersion across firms tends to increase wage dispersion (Berlingieri, Blanchenay and Criscuolo, 2017[6]) and the propensity of large digital firms to have relatively low labour shares contributes to a decline in labour shares in a number of OECD countries (Autor et al., 2017[7]; OECD, 2018[32]). While these trends may be addressed at least to some extent by the policies discussed above,[7] complementary policies to enhance redistribution and inclusiveness may also be warranted.

[7] One cannot directly infer from the empirical analysis underlying this paper what would be the effect of policies proposed in section 3 on productivity dispersion across firms. While digitalisation has tended to increase dispersion in the past, policies to enhance skills may benefit more to laggard firms, which suffer more from skill shortages, and therefore reduce dispersion (Gal et al., 2019[6]; Berlingieri et al., 2018[4]). More granular (e.g. firm-level) data on adoption would be needed to assess the effect of other policies on dispersion.

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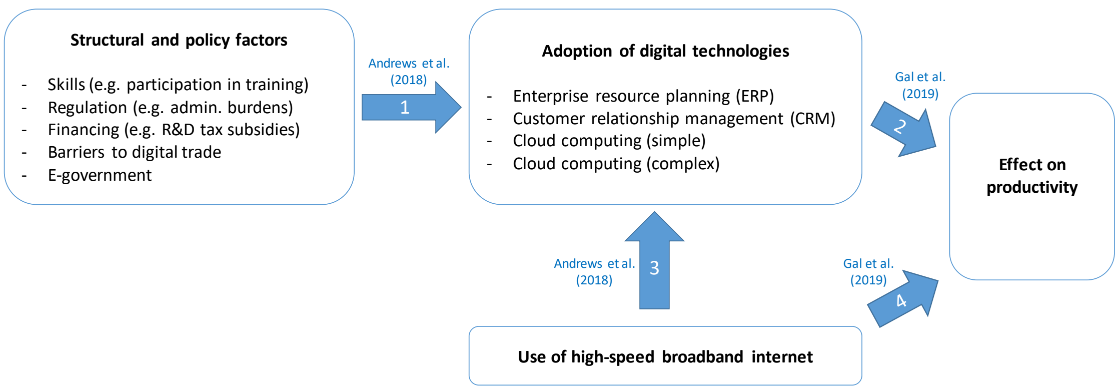
Annex A. Methodology underlying productivity estimates

This Annex describes the methodology and assumptions underlying the estimates presented in this paper (Figure 6 to Figure 8, and Annex B).

The estimates combine the results of Andrews et al. (2018[12]) on the structural and policy drivers of digital adoption and Gal et al. (2019[5]) on the productivity gains from adoption, in order to link policy factors to productivity, assuming in both cases that results are causal. The general approach is summarised in Figure A.1. For a typical policy change, it relies on two steps (arrows 1 and 2) as described below. For the use of high-speed internet, which reflects both policy and demand factors, the approach is slightly different (arrows 2, 3 and 4), reflecting that access to high-speed internet has a direct effect on productivity as well as an indirect effect through the adoption of other technologies.

Figure A.1. General approach to link policies, adoption and productivity



Source: OECD

Effect of a policy change

Step 1: For a given policy factor (e.g. reducing administrative burdens on start-ups), the first step is to assess the effect of a given policy change (e.g. closing half of the gap to the best country in the sample) on digital adoption of each of the four considered technologies (ERP, CRM, simple and complex cloud computing), using the elasticities estimated in Tables 3 and 4 of Andrews et al. (2018[12]).

A difficulty is that the estimations in Andrews et al. (2018[12]) are based on a difference in difference approach à la Rajan and Zingales. This means that the regression results give us the differential effect of policies for different values of a relevant exposure variable (e.g. knowledge intensity) that varies across industries. To translate this into average effects of policies for the whole economy, we first assume that the effect is null for the industry for which the exposure variable is the lowest in the sample – in line with the approach adopted for example in Guiso et al. (2004[33]), Bassanini et al. (2009[34]) and Andrews and Cingano (2014[35]). This may lead to underestimating the effect of policies, to the extent that they might have a positive effect even in industries that are least exposed to them.

Finally, to obtain the average effect for the economy as a whole, we compute the weighted average of the effect across industries, weighting industries by their total value added. This implicitly assumes a constant industry structure and therefore overlooks potential changes in industry composition resulting from policy-induced changes in digitalisation.

Step 2: The second step is to link the estimated changes in adoption of the four technologies to firm productivity, using the results in Gal et al. (2019[5]). Since there is some correlation between the adoption of the different technologies considered, one cannot directly sum the effects of each technology on productivity as it would probably lead to double counting.

To avoid double counting, we use the regression in Gal et al. (2019[5]) that takes as an explanatory variable the first principal component of the adoption of the four technologies and high-speed broadband internet use (last column of Table 2). We first compute how the changes in the adoption of each technology computed in step 1 affect this first principal component (using the weight of each variable in the principal component). Then, we use the elasticity estimated in Gal et al. (2019[5]) to derive the effect of the change in this principal component on multifactor productivity (MFP) growth of the average firm. Since these elasticities vary relatively little by firm size, the effect on the average firm may be representative of the effect on aggregate productivity, although the approach leaves aside potential gains from reallocation across firms, as well as potential effects on firm entry and exit, which may tend to increase productivity gains at the aggregate level.

Finally, given that the regression in Gal et al. (2019[5]) is based on an error-correction type of model (since one of the explanatory variables is the gap to the productivity frontier), this effect on MFP growth can be used to derive effect on MFP levels at different time horizons. In addition, one can assess the effect of simultaneous changes in various policy factors (as done in Figure 7) by summing the effect of individual factors. This final step entails two additional limitations going in opposite directions. On the one hand, it might lead to some double counting if the policy variables considered are to some extent correlated with each other; on the other hand, it may overlook positive effects from complementarities between policies (which, as discussed below, are taken into account explicitly for a subsample of policy factors).

Effect of an increase in the use of high-speed broadband internet

The approach is slightly different for the effect of a change in the use of high-speed broadband internet, which is a key enabler for the adoption of digital technologies (arrow 3 in Figure A.1.), but also affects productivity by itself (arrow 4). The approach cumulates these indirect and direct effects.

The direct effect is estimated using the results of Gal et al. (2019[5]), in a very similar way to step 2 above. As in step 2, we use the results for the first principal component (i.e. computing the effect of broadband use on the first principal component, and then on productivity) to avoid double counting with the indirect effect.

The indirect effect is estimated by combining the effect of high-speed broadband internet use on the adoption of the four considered digital technologies, as estimated in Andrews et al. (2018[12]), and the effect of these technologies on productivity, as estimated in Gal et al. (2019[5]). The methodology is very similar to the combination of steps 1 and 2 described above, but it is slightly less complex since the estimation of the effect of high-speed broadband in Andrews et al. (2018[12]) is direct (as opposed to a difference-in-difference methodology).

Refinements

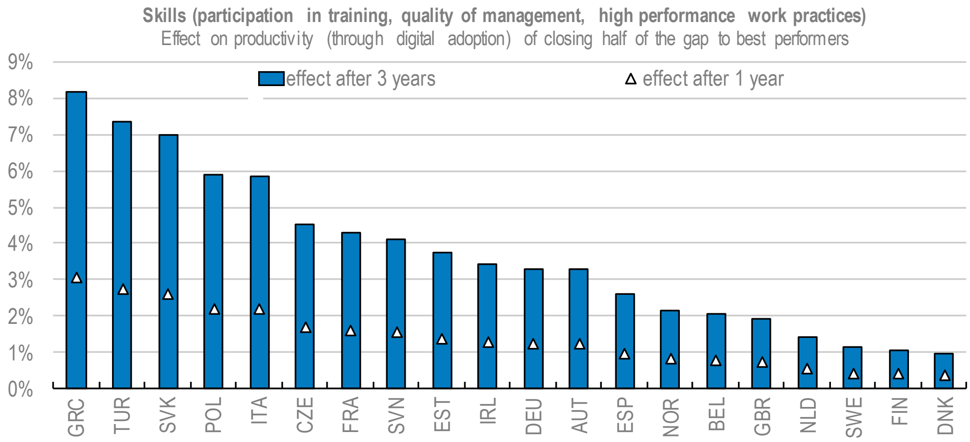
Two refinements are carried out based on the same methodology but using more detailed results from both papers. Complementarities between policies (Figure 8, panel A, and Figure B.6) are illustrated by using results in Table 6 of Andrews et al. (2018[12]). The effect of skill shortages (Figure 8, panel B) is illustrated by using results in Table B.10 (last column) of Gal et al. (2019[5]).

Annex B. Country-by-country estimates of productivity gains from digital adoption induced by a range of structural and policy factors

These figures present the effect of a number of structural and policy factors on productivity through the adoption of selected digital technologies. They combine the results from Andrews et al. (2018[12]) and Gal et al. (2019[5]) using the methodology described in Annex A.

For each factor, the assumption is that half of the gap to the best performing country in the sample is closed.

Figure B.1. Upgrading technical and managerial skills



Note: Estimated effect on multi-factor productivity (MFP) of the average firm from increasing participation in training (for both high-skilled and low-skilled), enhancing the quality of management schools and adopting High Performance Work Practices (HPWP). For each of these indicators, it is assumed that half of the gap to the best performing country in the sample is closed. Best performing countries are respectively Denmark (for the share of high skilled and of low skilled in training and HPWP) and Switzerland (for the quality of management schools). Countries not covered in the PIAAC survey (CHE, HUN, ISL, LTU, LVA, PRT) are excluded due to data limitations.

Source: OECD calculations based on Andrews et al. (2018[12]) and Gal et al. (2019[5]). See Annex A for details on the methodology and assumptions underlying these estimates.

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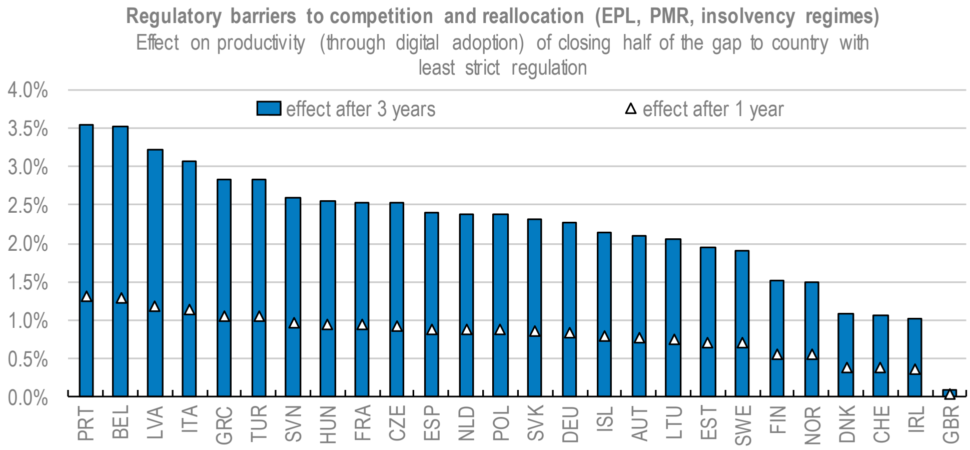
Figure B.2. Reducing regulatory barriers to competition and reallocation



Note: Estimated effect on multi-factor productivity (MFP) of the average firm from reducing employment protection legislation (EPL) on regular contracts, reducing administrative burdens on start-ups (a subcomponent of the OECD PMR indicator) and improving the insolvency regime, as measured by the indicator in Adalet McGowan and Andrews (2018[36]). For each of these indicators, it is assumed that half of the gap to the country with the least strict regulation in the sample is closed.
Source: OECD calculations based on Andrews et al. (2018[12]) and Gal et al. (2019[5]). See Annex A for details on the methodology and assumptions underlying these estimates.

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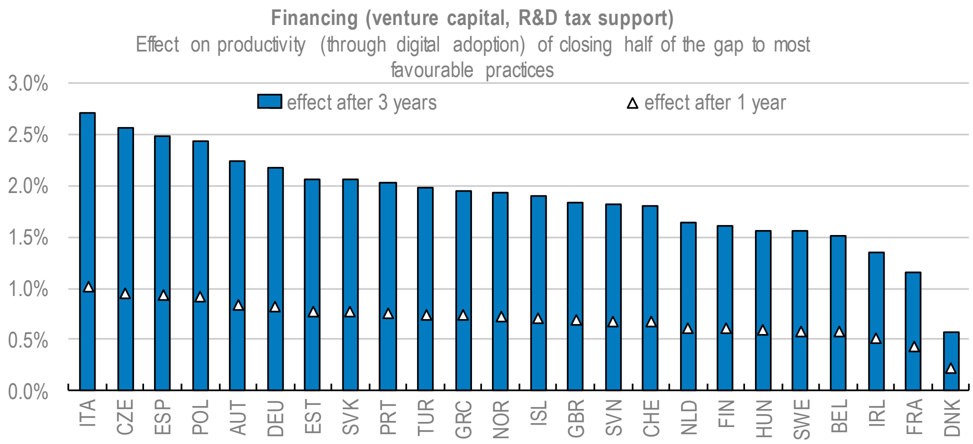
Figure B.3. Easing access to financing for young innovative firms



Note: Estimated effect on multi-factor productivity (MFP) of the average firm from increasing the availability of venture capital (proxied by the ratio of total venture capital to GDP) and increasing R&D tax incentives (as measured in the OECD Science, Technology and Industry Scoreboard). For each of these indicators, it is assumed that half of the gap to the country offering the most favourable conditions in the sample (respectively Denmark and France) is closed.
Source: OECD calculations based on Andrews et al. (2018[12]) and Gal et al. (2019[5]). See Annex A for details on the methodology and assumptions underlying these estimates.

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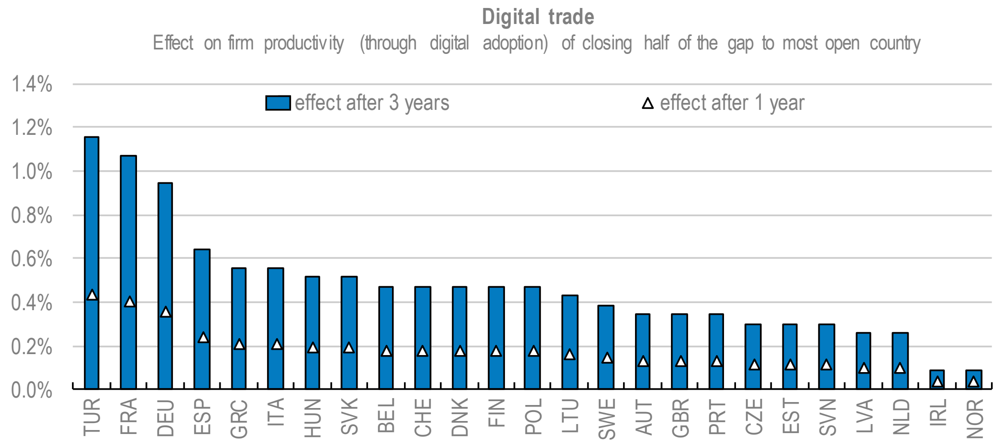
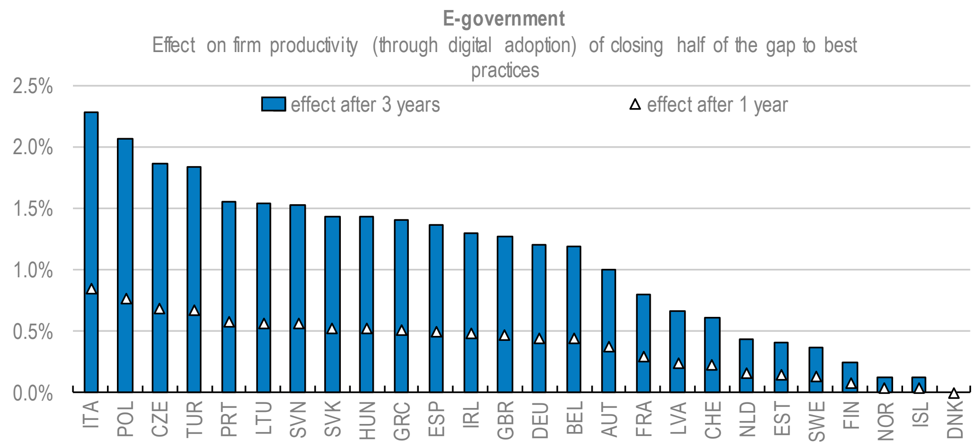
Figure B.4. Reducing barriers to digital trade



Note: Estimated effect on multi-factor productivity (MFP) of the average firm from reducing barriers to digital trade, as measured by the European Centre for International Political Economy. It is assumed that half of the gap to the most open country in the sample (Iceland) is closed.
Source: OECD calculations based on Andrews et al. (2018[12]) and Gal et al. (2019[5]). See Annex A for details on the methodology and assumptions underlying these estimates.

StatLink http://dx.doi.org/10.1787/888933910110

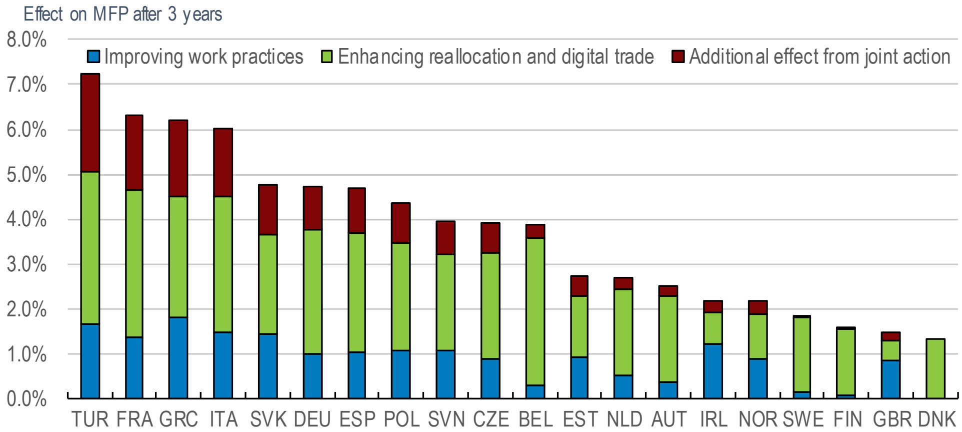
Figure B.5. Increasing e-government use



Note: Estimated effect on multi-factor productivity (MFP) of the average firm from increasing e-government use, as measured by the share of the population that uses the internet to interact with authorities (source: OECD Science, Technology and Industry Scoreboard). It is assumed that half of the gap to the country having the highest prevalence of e-government in the sample (Denmark) is closed.
Source: OECD calculations based on Andrews et al. (2018[12]) and Gal et al. (2019[5]). See Annex A for details on the methodology and assumptions underlying these estimates.

StatLink http://dx.doi.org/10.1787/888933910129

Figure B.6. Illustrating policy complementarities



Note: Estimated effect on multi-factor productivity (MFP) of the average firm (through digital adoption) after three years from increased use of High Performance Work Practices (blue bars) and reduced regulation strictness in three areas (employment protection legislation, administrative burdens on start-ups and restrictions to digital trade) (green bars). For each indicators, it is assumed that half of the gap to the country with the best performance/practice in the sample is closed. The dark red bars show the additional productivity gains from joint action in the different areas.

Source: OECD calculations based on Andrews et al. (2018[12]) and Gal et al. (2019[5]). See Annex A for details on the methodology and assumptions underlying these estimates.

StatLink http://dx.doi.org/10.1787/888933910148