Dirk Pilat and Chiara Criscuolo

THE FUTURE OF PRODUCTIVITY what contribution can digital transformation make?

Abstract

This article summarises emerging evidence on the relationship between productivity and the digital transformation, based on work underway in the OECD's Going Digital project. The article starts by discussing the relationship between the global productivity slowdown and the diffusion of digital technologies and related processes across firms and industries. It then outlines the role of structural factors in digital adoption, before concluding with a brief discussion on policies to strengthen future productivity growth.

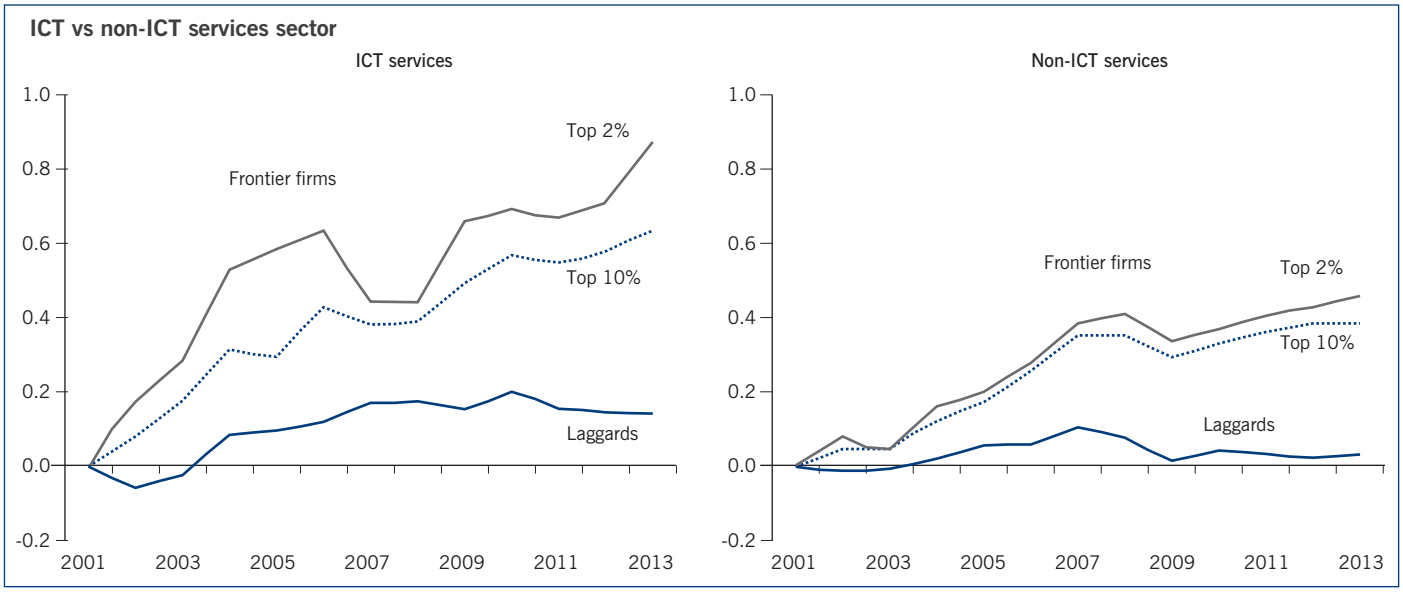
Keywords productivity, technological change, digital transformation

Dirk Pilat is the Deputy Director of the Directorate for Science, Technology and Innovation at the OECD in Paris and **Chiara Criscuolo** is Head of the Productivity and Business Dynamics Division in the Directorate for Science, Technology and Innovation at the OECD in Paris.

The ongoing digital transformation of the economy and society holds many promises to spur innovation, generate efficiencies and improve services, and in doing so boost more inclusive and sustainable growth as well as enhance well-being. But these opportunities will not materialise automatically and require policy action to make digital transformation work for growth and well-being.

One example of such an opportunity concerns productivity. Digital transformation of our economies holds the promise of improving productivity performance by enabling innovation and reducing the costs of a range of business processes (Goldfarb and Tucker, 2017). But, despite the rapid rise of digital technologies starting in the mid-1990s, aggregate productivity growth has slowed over the past decade or so, sparking a lively debate about the potential for digital technologies

Figure 1: The divergence in multi-factor productivity growth



Source: Andrews, Criscuolo and Gal, 2016

to boost productivity. Today, as in the 1980s, when Nobel Prize winner Robert Solow famously quipped, 'You can see the computer age everywhere but in the productivity statistics' (Solow, 1987), there is again a paradox of rapid technological change and slow productivity growth.

This article summarises emerging evidence on the relationship between productivity and the digital transformation, based on work underway in the OECD's Going Digital project, and explores some policies that may help realise its benefits.

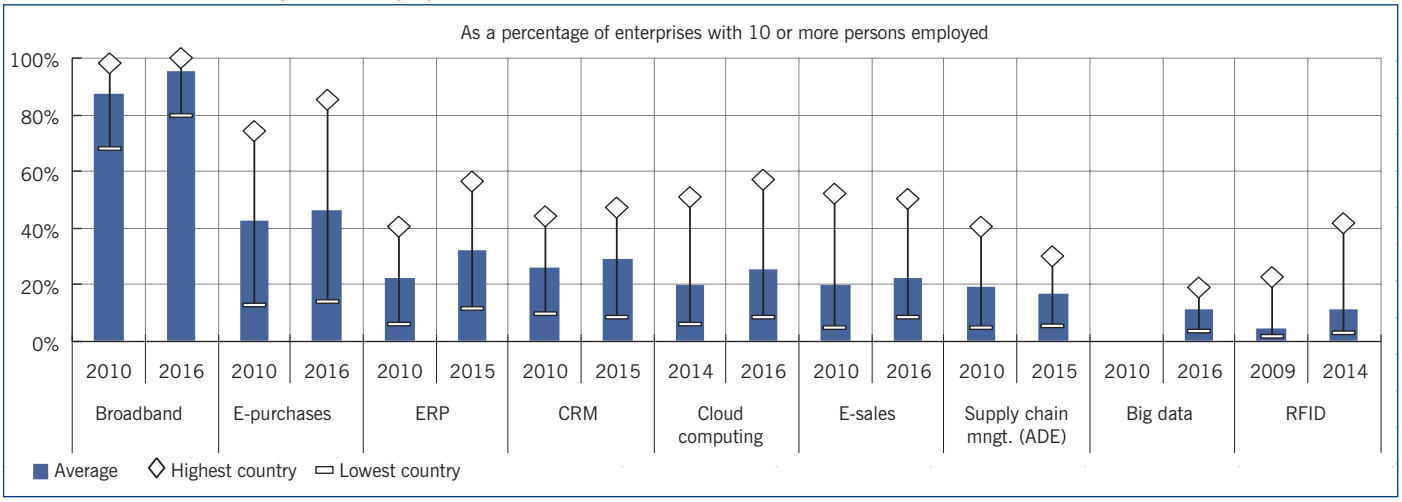
The productivity slowdown: laggard firms and stalling diffusion

The current literature points to several possible factors that may contribute to the new productivity paradox (including inadequate measurement: see, for example, Ahmad, Ribarsky and Reinsdorf, 2017). Together, these provide clues to possible avenues for policy action that could strengthen future productivity growth based on digital transformation.

First, there are still important differences in digital transformation across industries that affect the overall state of digital transformation, and thus its impacts on productivity (see McKinsey Global Institute, 2018). Recent OECD analysis shows that some sectors are less advanced than others in terms of the pace of digital transformation (Calvino et al., 2018; OECD, 2017). For example, even if new technologies are being integrated here too, agriculture, mining and real estate still rank in the bottom part of the distribution on digital intensity across the available indicators. Conversely, telecommunication and IT services rank consistently at the top of the distribution. Other sectors display a large heterogeneity in the adoption of different digital technologies, suggesting that they are engaged in only some aspects of digital transformation.

Looking behind the aggregate and sectoral statistics, micro-level studies reveal that the aggregate productivity slowdown masks a widening performance gap between more productive and less productive firms, especially in ICT services sectors (Andrews, Criscuolo and Gal, 2016; Figure 1). Throughout the economy, this

Figure 2: Diffusion of selected ICT tools and activities in firms, 2010 and 2016, as a percentage of enterprises with ten or more persons employed



Note: The upper and lower bar denote the minimum and maximum average value across countries. ERP refers to enterprise resource planning, CRM to customer relationship management, RFID to radio frequency identification.
Source: OECD, 2017

divergence is driven not just by frontier firms pushing the productivity frontier out, but also by the stagnating productivity of laggard firms, related to the limited capabilities of, or lack of incentives for, such firms to adopt best practices. Together, these signs illustrate that the main source of the productivity slowdown is not so much a slowing of innovation by the most globally advanced firms, but the uneven uptake and diffusion of these innovations throughout the economy (OECD, 2015b).

OECD data also show that the diffusion of digital technologies across OECD countries is far from complete. While most firms now have access to high-speed broadband networks, more advanced, productivity-enhancing digital tools and applications, such as enterprise resource planning systems or big data analytics, have diffused to far fewer firms in OECD countries (Figure 2). Moreover, significant cross-country differences emerge – even among the most advanced economies – raising important questions about why some countries are more successful at adopting digital technologies than others.

Digital transformation of firms involves a process of search and experimentation with new technologies and business models, where some firms succeed and grow and others fail and exit ...

The diffusion of so-called 'general-purpose technologies' (GPT) like digital technologies typically follows an S-shaped curve, where technologies are initially adopted only by some leading firms and later diffuse to all firms, as they become more established, prices fall and markets grow. Moreover, technology development and adoption depend on a host of economic, legal, ethical and social factors, as well as on the availability of the requisite skills and organisational changes. Consequently, there is a significant gap between what can currently be implemented from a technical point of view (and what may be implemented by frontier firms) and what is currently being implemented by firms on average.

The history of technological change also demonstrates that the successful implementation of new technologies involves much trial and error, and that it takes time to reorganise production processes, introduce new business models, and provide workers and management with new skills. Digital transformation is not just about the diffusion of technology, but increasingly about the complementary investments that firms need to make in skills, organisational changes, process innovation, new systems and new business models (Haskel and Westlake, 2017). Some recent research suggests that the scale and complexity of these complementary investments is growing, which may make digital transformation particularly difficult for non-frontier firms, such as traditional small-to-medium enterprises (SMEs) (Brynjolfsson, Rock and Syverson, 2017). During this process of adjustment and experimentation, productivity growth may be low and can even turn negative (ibid.).

On a positive note, the slow diffusion of digital technologies and the related processes across firms and industries in OECD countries suggests that its impacts on productivity are likely to emerge in the years to come, as digital intensity in firms and sectors increases further and the economy adjusts (Van Ark, 2016). This might also be affected by the current business cycle: as firms in several OECD countries are starting to incur labour and skills shortages, they will increasingly look for digital tools to help enhance their productivity performance. Moreover, the recent pickup in global demand may help spur investment and strengthen technology diffusion (McKinsey Global Institute, 2018).

Opportunities and challenges for SMEs

Digital technologies offer new opportunities for SMEs to participate in the global economy, innovate, scale up and enhance productivity. Digital transformation facilitates the emergence of 'born global' small firms, and SMEs' access to customers in local and international markets, with internet platforms increasing the supply of products and services and allowing trades that otherwise would not happen. Big data and data analytics enable SMEs to better understand the processes within the firm, the needs of their clients and partners, and the overall business environment. The use of digital technologies can also ease SMEs' access to skills and talent, such as through better job recruitment sites, and the outsourcing of key business functions, all of which can help improve performance. It can also facilitate access to a range of financing instruments and the development of innovative solutions to address information asymmetries and collateral shortages.

However, SMEs also face particular challenges in the adoption and effective use of ICT, particularly in the case of productivity-enhancing applications. The adoption lag of SMEs is mainly due to a lack of key capabilities, such as human resources and management expertise, and a lack of investment in complementary assets. Furthermore, SMEs face specific challenges in managing digital security and privacy risks, mainly due to lack of awareness, resources and expertise to assess and manage risk effectively. Finally, the slow adoption of digital technology might also be a reflection of the lower incentives for some SMEs which might not be able to reap the same pay-off from the digitalisation of their production processes as larger businesses.

The role of structural factors for digital adoption

A second factor limiting the impacts of digital technologies on productivity is the slow pace of structural change and resource reallocation in OECD economies. Digital

transformation of firms involves a process of search and experimentation with new technologies and business models, where some firms succeed and grow and others fail and exit (OECD, 2004). Countries with a business environment that enables this process may be better able to seize the benefits from digital transformation than countries where such changes are more difficult and slow to occur.

New OECD research shows that the diffusion of selected digital technologies is typically more advanced in sectors where firm turnover (i.e. entry and exit) is higher (Calvino and Criscuolo, 2018). This is consistent with the idea that new entrants: (a) possess a comparative advantage in commercialising new technologies (Henderson, 1993); (b) place indirect pressure on incumbent firms to adopt new technologies; and (c) can more fully reach their potential when they have sufficient space to grow, which is accommodated by the exit of inefficient firms.

Moreover, digital adoption will be facilitated by efficient resource allocation, since a firm's incentives to experiment with uncertain/risky digital technologies will be shaped by its perceived ability to rapidly scale up operations in the event of success, and rapidly scale down operations and potentially exit the market at low cost in the event of failure (Andrews and Criscuolo, 2013). From this perspective, harnessing digital transformation for firms places an added premium on policies that foster business dynamism and efficient resource reallocation. This is a challenge in many OECD countries against the backdrop of declining business dynamism (Criscuolo, Gal and Menon, 2014) and rising resource misallocation (Adalet McGowan, Andrews and Millot, 2017b; Berlingieri, Blanchenay and Criscuolo, 2017) in many OECD countries over the past decade.

A range of policies can incentivise greater digital adoption through experimentation either by increasing competitive pressures or by lowering the costs of reallocation. This includes insolvency regimes that do not inhibit corporate restructuring and do not excessively punish entrepreneurial failure. At the same time, access by entrepreneurs to appropriate forms of finance, such as venture capital financing, together with corporate tax regimes that do not excessively favour debt over equity financing are also associated with higher digital adoption rates.

Importantly, the transition of an economy based on tangibles to one based on intangibles (or ideas) can only succeed if firms have access to the right set of capabilities. For example, qualified firm management that takes the decisions to invest and guides the adoption process has been identified as a key capability (see Bloom, Sadun and Van Reenen, 2012; Pellegrino and Zingales, 2014). Firm-level practices related to workers, including their participation in training, or their flexibility in working hours, are also important in this context.

Second, workers' skills matter, including providing them with the opportunity to continuously develop their skills in order to keep pace with the fast-changing technological landscape, and ensuring that people's skills are allocated to their most productive uses. In addition, evidence gathered within the Going Digital project shows that workers' wages, which can be used as a proxy for their productivity, are positively correlated not only with workers' advanced numeracy skills but also with their management and communication capabilities.

Digital transformation and business dynamism

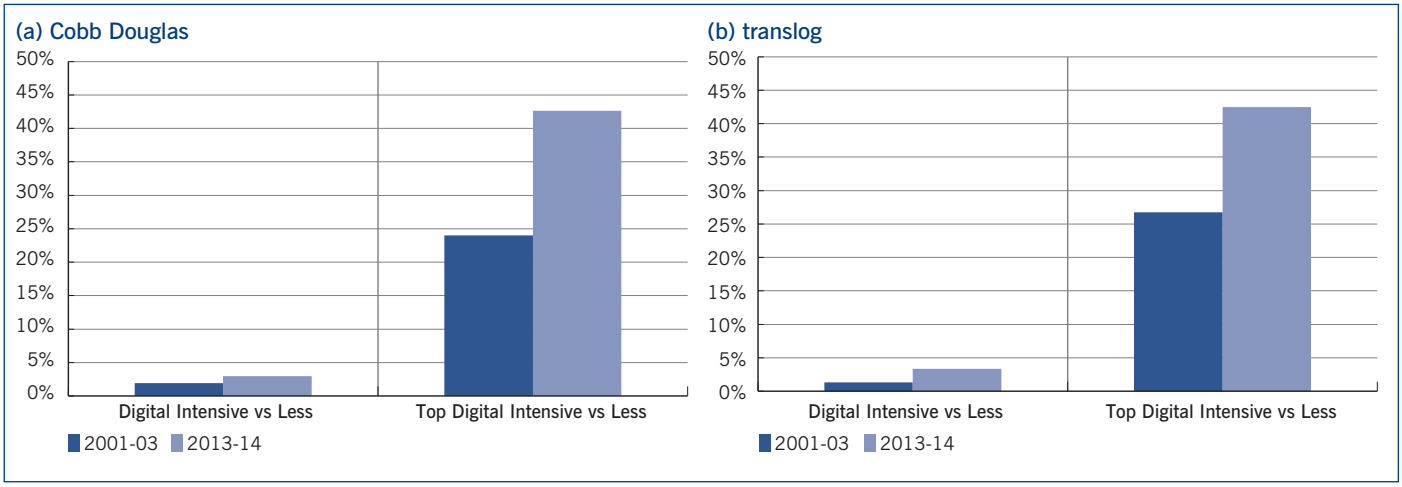
A third, and closely related, factor concerns the link between digital transformation and business dynamism. Recent OECD work has pointed to a slowdown in business dynamism in OECD economies, which has slowed down the necessary reallocation of resources across the economy. For example, the share of non-viable old firms has been increasing in many OECD countries, particularly since the global financial crisis, while the productivity of this group of firms has been falling rapidly relative to 'viable' old firms, as well as younger firms in general (Adalet McGowan, Andrews and Millot, 2017b). The growing amount of resources trapped in unproductive 'zombie' firms and the slowdown in reform efforts to tackle regulations that impede product market competition (Adalet McGowan, Andrews and Millot, 2017a) have also contributed to the slowdown in structural change.

To explore the role of business dynamism for digital transformation in more detail, new evidence from the OECD's Going Digital project investigates two aspects of these issues and how these have been affected by the ongoing digital transformation: business dynamics and mark-ups. First, research examining the association between business dynamism (measured by the churning rate) and selected measures of digital intensity (Calvino and Criscuolo, 2018) points to the existence of a positive role of digital transformation for business dynamics. This is in line with the idea that digital transformation lowers barriers to entry and facilitates reallocation. It also suggests that the more digitally intensive sectors are those that are more dynamic (i.e. with higher rates of entry, higher churning and higher post-entry growth).

On the other hand, sectors where the automation of tasks and the share of turnover from e-commerce are higher are also those where business dynamism is lower. These findings likely reflect the role of high fixed costs, data and networks with customers and suppliers as a barrier for new firms. They might also reflect that

Recent OECD work has pointed to a slowdown in business dynamism in OECD economies, which has slowed down the necessary reallocation of resources across the economy.

Figure 3: Average percentage differences in mark-ups between firms in less digital-intensive and in digital-intensive sectors at the beginning and at the end of the sample period



Note: The graphs report the estimates of a pooled OLS regression explaining firm log mark-ups in the period, on the basis of the company's size, age, and country and year of operation, as well as a dummy variable with value 1 if the sector of operation is digital intensive versus less digital intensive (specifications on the left in the graph), or if the sector of operation is among the top 25% of digital-intensive sectors versus not (specifications on the right in the graph). Panel (a) estimates mark-ups based on a Cobb Douglas production function; panel (b) on a Translog production function. Standard errors are clustered at the company level. All coefficients are significant at the 1% confidence level.

Source: Calligaris, Criscuolo and Marcolin (2018) based on Orbis® data.

growth of firms in highly automated sectors might not always involve the direct creation of new jobs.

Digital technologies are also transforming the way firms produce, scale up and compete. They allow firms to leverage ever larger networks of consumers, access multiple geographical and product markets almost instantaneously, and exploit increasing returns to scale from intangible assets.

In this context, new OECD work (Calligaris, Criscuolo and Marcolin, 2018) explores mark-ups: the difference between the price a firm charges for its output on the market and the cost the firm incurs to produce one extra unit of output. The study estimates mark-ups at the firm level for a large sample of companies across 26 OECD and non-OECD countries, for the period 2001–14. It finds that mark-ups have been increasing over the period, on average across firms and countries, but especially in firms at the top of the mark-up distribution. Furthermore, the results suggest that mark-ups are higher in digital-intensive sectors than in less digitally intensive sectors, other firm characteristics being equal, with the difference increasing over time (see Figure 3).

The results might be reflecting both changes in production as a consequence of the digital transformation – such as stronger reliance on intangibles – and higher fixed costs. They could also be indicative of a shift in the market structure, reflecting lower costs of production, easier penetration of multiple markets and higher intensity in knowledge assets, which allow digital companies to scale up more quickly and more easily, and generate increasing returns to scale, thus potentially making the entry of new players into the market more difficult. Ongoing OECD work investigates the relative importance of these changes in explaining aggregate trends. This analysis helps shed light on the mechanisms underlying increasing trends in market concentration, declining business dynamism, and declining trends in labour share and capital. In addition, providing evidence on the link between these trends and firms' digital intensity expands on existing studies that have uncovered a positive correlation between industry concentration and firms' use of proprietary IT systems (Bessen, 2018).

While the changes in business dynamism and the growth of mark-ups (in particular in digitally intensive sectors) are not necessarily a cause of concern, as they may be inherent to the nature of digital transformation, they do point to important changes in the competitive environment linked to digital transformation that need to be further examined and considered by policymakers.

Policies to strengthen future productivity growth

For policymakers, a number of points emerge from the discussion above. First, digital transformation is already having impacts on productivity in individual firms, and also in specific industries. Second, further and larger impacts are likely to emerge as digital transformation evolves and new technologies, business models and practices diffuse to more firms and industries. Third, ensuring that the largest possible impacts emerge can benefit from proactive policy action. All of this will also support productivity growth more generally. Key actions include:

- *Strengthening national and international technology and knowledge diffusion.* As discussed in detail in OECD (2015a), advanced technology and knowledge often comes from abroad, as it is developed in scientific institutions and global frontier firms. Openness to foreign technology and knowledge is therefore essential to benefit from digital transformation, and requires openness to trade, investment, and international mobility of the highly skilled. Moreover, strengthening knowledge diffusion within the economy is important and can benefit from policy action – for example, as regards the wider use of technology extension services, improvements in science–industry linkages and stronger mobility of human resources within the economy.
- *Fostering investment in tangible and intangible capital, notably skills.* With investment levels remaining low across

most OECD countries, policies that can strengthen investment in tangible and intangible capital are crucial to increase the adoption of digital technologies, strengthen the necessary complementary knowledge and enhance the absorptive capabilities of firms, managers and workers. Training and investment in skills of both workers and managers is particularly important in this context.

- *Enabling SMEs to harness digital transformation.* Enabling SMEs and entrepreneurs to fully harness digital transformation can help ensure that growth is inclusive, as well as boost productivity and competitiveness, as these firms find new niches in global value chains. Comprehensive national digital strategies that take into account SMEs, policies that facilitate access to finance, knowledge networks and skills, including the development of management skills for the digital economy, and SME engagement with competency centres and/or technology extension services can be helpful. National digital security strategies can also help address the specific needs of SMEs by providing them with practical guidance and the appropriate incentives to adopt good practices.
- *Facilitating the necessary structural change in the economy.* Policies in OECD countries often implicitly or explicitly favour incumbents, and do not always enable the experimentation with new ideas, technologies and business models that underpins the success of innovative firms, be they large or small. Policies which (unwittingly) constrain the entry and growth of new firms can also slow down structural change. Moreover, policy should also avoid trapping resources in inefficient firms – e.g., through bankruptcy laws that do not excessively penalise failure.
- *Strengthening structural reform to support digital transformation.* In many sectors of the economy, successful digital transformation will require changes to existing institutions, regulations and markets, as new technologies enable the emergence of new business models, as well as new ways of delivering public and private services. To unlock the potential of digital transformation, further structural reforms will eventually be required in many areas, including financial services, health services and education services, as well as the public sector itself.
- *Ensuring effective competition.* Policymakers will also need to ensure that market competition is effective by providing competition authorities with rules and tools that can address the new challenges posed by the digital economy, where these prove to be necessary; and that co-operation across national competition agencies is enhanced to address competition issues that are increasingly transnational in scope or involve global firms.
- *Investing in innovation to drive the productivity frontier.* Firms and governments will also need to continue investing in innovation to further develop digital and other technologies that can move the global productivity frontier. This includes ensuring sufficient investment in basic research that is key to developing the seeds for future innovation and that has underpinned most of the technologies that drive the current digital transformation (OECD, 2015a, 2015b).

 Contacts: dirk.pilat@oecd.org and chiara.criscuolo@oecd.org.

References

Adalet McGowan, M., D. Andrews and V. Millot (2017a) *Insolvency Regimes, Zombie Firms and Capital Reallocation,* OECD Economics Department working paper 1399, Paris: OECD Publishing, http://dx.doi.org/10.1787/5a16beda-en

Adalet McGowan, M., D. Andrews and V. Millot (2017b) *The Walking Dead? Zombie firms and productivity performance in OECD countries,* OECD Economics Department working paper 1372: Paris: OECD Publishing

Ahmad, N., J. Ribarsky and M. Reinsdorf (2017) *Can Potential Mismeasurement of the Digital Economy Explain the Post-crisis Slowdown in GDP and Productivity Growth?*, OECD statistics working paper 2017/09, Paris: OECD Publishing, http://dx.doi.org/10.1787/a8e751b7-en

Andrews, D. and C. Criscuolo (2013) *Knowledge-Based Capital, Innovation and Resource Allocation,* OECD Economics Department working paper 1046, Paris: OECD Publishing

Andrews, D., C. Criscuolo and P. Gal (2016) *The Best versus the Rest: the global productivity slowdown, divergence across firms and the role of public policy,* OECD productivity working paper 5, Paris: OECD Publishing

Andrews, D., G. Nicoletti and C. Timiliotis (2018) *Going Digital: what determines technology diffusion among firms?*, OECD Economics Department working paper 1466, Paris: OECD Publishing

Berlingieri, G., P. Blanchenay and C. Criscuolo (2017) *The Great Divergence(s),* OECD science, technology and industry policy paper 39, Paris: OECD Publishing, http://dx.doi.org/10.1787/953f3853-en

Bessen, J.E. (2018) *Information Technology and Industry Concentration,* Law and Economics research paper, Boston University School of Law

Bloom, N., R. Sadun and J. Van Reenen (2012) 'Americans do IT better: US multinationals and the productivity miracle', *American Economic Review,* 102 (1), pp.167–201

Brynjolfsson, E., D. Rock and C. Syverson (2017) *Artificial Intelligence and the Modern Productivity Paradox: a clash of expectations and statistics,* NBER working paper 24001, Cambridge: National Bureau of Economic Research

Calligaris, S., C. Criscuolo and L. Marcolin (2018) *Mark-ups in the Digital Era,* OECD STI working paper 2018/10, Paris: OECD Publishing

Calvino, F. and C. Criscuolo (2018) 'Business dynamics and digitalisation: a progress report', DSTI/CIIE(2017)17

Calvino, F., C. Criscuolo, L. Marcolin and M. Squicciarini (2018) *A Taxonomy of Digital Sectors,* STI working paper, Paris: OECD Publishing

Criscuolo, C., P. Gal and C. Menon (2014) *The Dynamics of Employment Growth: new evidence from 17 countries,* OECD STI policy paper 14, Paris: OECD Publishing

Goldfarb, A. and C. Tucker (2017) *Digital Economics,* NBER working paper w23684, Cambridge: National Bureau of Economic Research

Grundke, R., L. Marcolin, T.L.B. Nguyen and M. Squicciarini (2018) *Which Skills for the Digital Era? A return to skills analysis,* OECD STI working paper (forthcoming), Paris: OECD Publishing

Haskel, J. and S. Westlake (2017) *Capitalism Without Capital: the rise of the intangible economy,* Princeton: Princeton University Press

Henderson, R. (1993) 'Underinvestment and incompetence as responses to radical innovation: evidence from the photolithographic alignment equipment industry', *RAND Journal of Economics,* 24 (2), pp.248–70

McKinsey Global Institute (2018) *Solving the Productivity Puzzle: the role of demand and the promise of digitization,* New York: McKinsey & Company

OECD (2004) *The Economic Impacts of ICT: measurement, evidence and implications,* Paris: OECD Publishing, http://dx.doi.org/10.1787/9789264026780-en

OECD (2015a) *Data-Driven Innovation: big data for growth and well-being,* Paris: OECD Publishing, http://dx.doi.org/10.1787/9789264229358-en

OECD (2015b) *The Future of Productivity,* Paris: OECD Publishing

OECD (2017) OECD *Science, Technology and Industry Scoreboard 2017,* Paris: OECD Publishing

Pellegrino, B. and L. Zingales (2014) *Diagnosing the Italian Disease,* NBER working paper 23964, Cambridge: National Bureau of Economic Research

Solow, R.M. (1987) 'We'd better watch out', *New York Review of Books,* 12 July, p.36

Van Ark, B. (2016) 'Navigating the new digital economy: driving digital growth and productivity from installation to deployment', New York: Conference Board