Why is productivity slowing down?

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Abstract

Productivity growth is an essential component of economic growth and development. The recent slowdown in aggregate labour productivity in leading economies has been widely identified as a puzzle, even paradox, leading to extensive research into possible explanations. In this paper, we review the relevant literature and identify the reasons underpinning slowing productivity, which appears orthogonal to recent technological advances. Our review indicates that the slowdown is real, and that while many factors matter, it can be largely explained by a slowdown of investment, an increasing gap between frontier and laggard firms, a slowdown in trade, and technological change. An apparent paradox, which contrasts the slowdown in productivity growth with accelerating technological change, may be explained by mismeasurement, implementation lags for technologies, and creative destruction processes which means that a growing share of investment and business practices are out of date.

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1 Introduction

Productivity measures the rate at which inputs are turned into outputs, and is widely seen as the main long-run determinant of per capita output growth and living standards. As a result, the slowdown in measured productivity growth over the recent decades has raised serious concerns, both in academic circles but also among business and policy decision makers. Here we review the large number of papers that have put forward explanations for the decline in productivity growth. Our main focus is on understanding trends in labour productivity, generally measured as output per hour worked.

Understanding what drives labour productivity growth is not a simple task. Growth accounting – trying to explain the growth in output per hour by the growth in other productive inputs - generally distinguishes between three different sources: labour quality, capital per worker, and total factor productivity (TFP). TFP is mainly associated at the firm level with management practices and the adoption of new technologies. At a more aggregated level, reallocation plays an important role, with market competition gradually replacing inefficient firms with more productive ones in a process that Schumpeter identified as being essential for progress. The functioning of markets is itself constrained by a set of institutions governing factor markets, international trade, and technology diffusion. Country and period specific factors, such as the 2008 financial crisis, also play important roles and make it hard to provide general, one-size-fits-all explanations.

In this paper, we review the key recent contributions attempting to explain the recent slowdown and assess the relative importance of each component of productivity growth. Three decades after Robert Solow's famous quip that 'you can see the computer age everywhere but in the productivity statistics,' this puzzle is as relevant as ever for those who believe technological change to be accelerating (Solow, 1987).

The slowdown in measured labour productivity growth after, and to an extent before, the Great Recession is indisputable. Table 1 demonstrates that productivity growth rates have generally halved since the 1996-2004 period across major OECD economies. Compound labour productivity growth in the USA from 1996 to 2004 averaged 2.64% per year, but recently it has fallen to 0.36%. Similar declines are observed for the largest European countries, from around 2% to around 1%, and in Japan, from 2% to less than 1%. The intervals are the same as in Gordon (2015), but these figures also contextualise the productivity paradox of the 90's: the supposed gains from computerisation were only realized for the United Stated after 1996. Interestingly, this was not the case for the other countries, as they experienced a decline in productivity growth rates after 1996. This is in contrast to the pervasive slowdown after 2004, and is not only confined to the advanced economies: emerging markets have also seen their productivity growth reduced, but this started later and from a higher level.

Table 1: Compound annual growth rate of real GDP per hour worked in selected intervals

	1971-1996	1997-2004	2005-2016	2010-2016
France	3.01	1.83	0.51	0.70
Germany	2.85	1.54	0.88	1.04
Japan	3.69	2.02	0.73	0.85
United Kingdom	2.40	2.33	0.39	0.22
United States	1.43	2.64	0.94	0.36
OECD	-	1.98*	0.87	0.80

Notes: 2010 USD, constant prices and PPP. Source: OECD

*Data on OECD Total Real GDP per Hour Worked available from 2000 only

To illustrate what such a slowdown in productivity growth implies, Goodridge, Haskel, and Wallis (2016a) calculate that 'the level of UK productivity in 2011 was 13 percentage points below what it would have been had value-added per hour continued at a 2.64% p.a. rate.' (2000-2007). For the US, Syverson (2017) determines that 'had the measured productivity slowdown not happened, measured GDP in 2015 would have been, conservatively, $3 trillion (17 percent) higher than it was.'

In part, this phenomenon has created a division in current research between those that consider technological adoption – or the lack of it – as the main source of the slowdown and those that are less optimistic about technological capabilities. Examining the arguments of the latter group, Crafts (2018) offers reasons 'why [a sustained productivity slowdown] has happened despite the apparent potential of exciting new technologies.' Gordon (2015), on the other hand, challenges the usefulness of new technologies and argues that these do not measure up to past industrial revolutions, implying that the reason for the productivity slowdown is slowing technological progress. Brynjolfsson, Rock, and Syverson (2017) are more optimistic, and suggest that Artificial Intelligence (AI) can leverage rapid advances in other sectors in the future. They explain the failure of this to be reflected in current productivity improvements by pointing to time lags involved in the adoption process, and in particular to the development and adoption of complementary innovation and management practices. Technology optimists also argue that we are not yet seeing productivity improvements because output derived from these new technologies is mismeasured.

However, a wide range of economic factors other than technological change affects productivity. Several authors depart from the technological focus to look into these as possible sources of the puzzle. For instance, Haldane (2017) suggests that slowing productivity is linked to the financial crisis, the resulting regulatory forbearance and the process of quantitative easing. These changes further impede the rate of innovation and directly affect the diffusion dynamics. In a similar vein Askenazy, Bellmann, Bryson, and Moreno Galbis (2016) point to the depressed aggregate demand (and lower investment), and weakness in markets and institutions (which for example result in zombie firms or labour hoarding) that magnify the slowdown alongside slower technological change. Goodridge et al. (2016a) attribute the UK slowdown to lower TFP growth, which is in itself due to low productivity growth in core industries (oil, gas and financial services) and changes in factor utilisation, including the hoarding of unproductive labour.

The effects of business dynamism and educational attainment are also often linked to productivity (Fernald & Jones, 2014). Others tie the productivity slowdown to the wider discussion on secular stagnation by either pointing out the divergence in returns on risky capital and safe assets or the low investment and investor confidence levels (Caballero, Farhi, & Gourinchas, 2017; Carlin & Soskice, 2018). The changes in traditional inputs including the contraction in both capital formation and intellectual property investment (Hall, 2017) and the misallocation of resources, especially labour, have also been reported on in this process (Barnett, Batten, Chiu, Franklin, & Sebastia-Barriel, 2014; Pessoa & Van Reenen, 2014).

In this paper, we systematically review these explanations. We first discuss mismeasurement, in Section 2; Section 3 analyses labour markets and human capital while Section 4 delves into the factors related to investment; Section 5 considers the role of misallocation and productivity divergence between firms; Section 6 considers the impact of globalisation; Section 7 reviews innovation related explanations. In Section 8, we conclude by evaluating the many explanations and offer insights to unravel the productivity paradox.

2 Mismeasurement

We examine three aspects of mismeasurement. First, economic statistics are simply not supposed to capture some sectors, but they do matter for welfare – in this sense they may explain a paradoxical perception that technology is improving our welfare while productivity statistics fail to support this view. We review recent estimates of the value of free goods and in particular free digital services. Second, we review the much-debated idea that price indices do not reflect quality changes and the value of new goods adequately, so that inflation is overestimated and real output underestimated. Finally, we discuss the mismeasurement of inputs, and in particular intangible capital.

2.1 Unmeasured sectors

While deriving measures of output from market-exchanged goods and services is relatively straightforward, how to measure output of non-traded goods is less clear. There are three sectors that pose important boundary issues for national accounting, essentially due to the lack of market valuation and/or the conceptual difficulty in defining a unit and constructing price indices (Hulten, 2010): the public sector, the household sector and the service producing sectors. The direct comparability of the measured inputs and outputs over time and across countries can also be problematic. A number of factors including regulations, competition, trade deals or public sector spending may cause changes in productivity that are often overseen in these comparisons. Official output measures may therefore underestimate true output, and any fluctuation in the share of unmeasured output would appear as a change in productivity if measured inputs have not varied.

One significant part of the economy that should normally be included in GDP measurements as a typical market activity, but in practice is not easy to account for in the productivity data, is the shadow economy and illegal exchanges. The level of this oversight can be large even for the rich OECD economies with an average of 17% of GDP involved in these transactions as shown in a sample of 162 countries during the period 1999 – 2007 (F. Schneider, Buehn, & Montenegro, 2010). In Sub-Saharan Africa the shadow economy is estimated at more than a third of economic activity (38%), in Europe and Central Asia it is 37% and in high income OECD countries it averaged 14%. The estimated size of the shadow economy has shown a negative trend between1999 – 2007, but this fluctuates depending on local regulations, taxation or the quality of public and private services in each country. For example, an increase in taxation can affect the volume of market exchanges and shift them towards non-market ones, especially in cases where regulations are inefficiently able to monitor these transitions (F. Schneider &

Buehn, 2016). Cross-country comparisons of trends in the shadow economy after the financial crisis are not available. While the crisis may have led to a growth in the shadow economy in some economies, it is unlikely that given the very different impact of the crisis across countries and the different regulatory and other environments that this disruption could provide a generalisable explanation of the productivity slowdown.

The digital economy has facilitated the launch of platforms for transport and rental services (predominantly through Uber and AirBnB) which further contributed to shifting inputs from the measurable GDP into the unmeasured territory. These platforms have turned households into producers without a change in the underlying assumptions for national accounting. While this practice is not new – as households have been offering informal services for a long time – its scale is unprecedented: in 2017 the capitalization of AirBnB exceeded the combined capitalization of Hilton and Hyatt[1]. These developments have been driven by the opportunities available to households and the adoption of high capacity computing power connected through fixed or mobile internet access services. The level of the GDP oversight depends on the ways that household and corporate incomes are declared. Any additional household income will show up in national statistics if platforms are formally registered.

Similarly, the local revenues for the intermediaries themselves will be properly accounted for unless they declare their turnover, either directly for corporation tax or VAT in more favourable tax environments (Ahmad & Schreyer, 2016). Profit shifting from multinationals is estimated to exceed $500b annually, predominantly for revenues originating from the OECD countries (Cobham & Janský, 2018). Ahmad, Ribarsky, and Reinsdorf (2017) estimate that in the UK, total investment would increase by only 0.04% if Uber drivers' cars were accounted for as investment.

Other parameters that can be linked to productivity growth include the (geo)political and institutional environment in each country. These changes affect the entire ecosystem (firms, households, individuals) which may adapt to the new macroeconomic conditions further shifting inputs toward the measured or unmeasured economic outcomes.

There is a growing conviction in the literature that technology is increasingly affecting consumers directly, and would not appear in GDP by definition. Hulten and Nakamura (2017), introduce a theoretical framework where technology shifts the utility function, such that innovation can be 'output-saving.' In this framework, rather than saving inputs when TFP growth shifts the production function, innovation implies that less – measureable – output is needed to achieve the same utility levels. While the consensus in the literature appears to be that unmeasured consumer surplus from new digital services is not large enough to explain a major part of the productivity slowdown, there is a recognition that measuring the effects of the new wave of digital services on consumer welfare is imperfect. This dimension of the mismeasurement explanation should not be discarded entirely.

A large set of studies has been devoted to evaluating the effects of free or mismeasured digital goods on consumer surplus. A key point to note is that many new digital goods are financed by advertising, which is considered an intermediate input in national accounting, and therefore does not count towards GDP (although Ahmad et al. (2017) note that advertising-financed 'free' goods still appear in GDP through the higher price paid for the advertised products). Byrne, Oliner, and Sichel (2017) evaluate the contributions of internet quality and e-commerce, finding that TFP growth in 2004-2014 would be only five basis points higher. They and Syverson (2017) review recent studies estimating the value of free digital goods, and found generally modest effects even though the numbers vary considerably. One approach is to measure the time consumers spend online. With their valuation of individuals' time, Brynjolfsson and Oh (2012) estimate that the consumer surplus created by these

[1] https://skift.com/2016/09/23/airbnbs-latest-investment-values-it-as-much-as-hilton-and-hyatt-combined/

services is around $100b per year in the US alone, a significant number but one that still represents only 3.3% of Syverson's 'missing' $3 trillion from the economy. Syverson's (2017) update of this number with more generous assumptions leads to $863b, closer to explaining a third of the paradox. More recent estimates by Brynjolfsson, Eggers, and Gannamaneni (2018), using discrete choice experiments, suggests a rather high estimate, with the median consumer requiring $32,000 to be willing to give up all digital services (search, email, etc..) for a year. In contrast, using different valuation methods, for instance based on observed prices for Internet tracking and advertising, Ahmad et al. (2017) found that Wikipedia represents an insignificant value as compared to GDP. They evaluate that adding advertising-funded 'free' media into household expenditures would increase GDP marginally, for instance 0.04pp for 2011-13 in the US.

While the literature on the productivity paradox has focused on semiconductors and digital services, there are other sectors in which mismeasurement is important, chief among them being health (Baily & Gordon, 2016). Certainly, health services and health technologies have improved, and health as a share of the total economy has grown substantially and regularly over the past 70 years, suggesting that this source of mismeasurement may have become more serious on aggregate. To explain the collapse in productivity would however require some step change in the way that health has been mismeasured in many countries.

2.2 Quality adjustment of price indices

Increased efficiency and product quality may lead to lower measured output and productivity if output statistics do not reflect improvements in the quality of goods and services. If, say, a constant number of units is sold but quality increases and price stays constant, we would expect our true measure of real output to increase. This will only be the case if our price index is quality-adjusted, so that price per quality-adjusted unit decreases (Boskin, Dulberger, Gordon, Griliches, & Jorgenson, 1996; Gordon, 1990; Nordhaus, 1996). This issue has become even more relevant today due to the growth of the digital economy and Information and Communication Technology (ICT) services (Abdirahman, Coyle, Heys, & Stewart, 2017).

A typical example that highlights this effect is that the price of a phone bill has remained largely unchanged over the last decade, yet the volume of text messages, minutes, and data provided in new bundles has grown exponentially (OFCOM, 2014). Other examples related to smartphones are digital photos and high accuracy GPS services (Varian, 2018). In both cases, consumption (e.g. number of photos taken) has increased rapidly, but overall measured sales have decreased because the sales of standalone cameras and GPSs have gone down, and the quality-adjustment for smartphones prices has not nearly kept pace.

Several recent studies have attempted to estimate quality-adjustment in key digital products. For instance, Abdirahman et al. (2017) demonstrate that official prices of telecommunication services should have fallen by up to 90%, instead of the 10% reported between 2010 and 2015. Byrne et al. (2017) suggest that the recent observed slowdown in decrease of microprocessor prices is an artefact of the matched model methodology adopted for constructing the PPI, and disappears once a hedonic method accounting for wider dimensions of performance is adopted. Ahmad et al. (2017) found very significant differences between ICT-related price indices in different countries, pointing out an important mismeasurement of the size of the digital economy, but found that this translates into an upper-bound revision to GDP growth rates of only 0.2% per year.

Another well-known issue relates to the measurement of new goods: precisely because they are new, they cannot be compared ('matched') with existing goods to construct price indices. More subtly, if new goods replace existing goods, the procedure followed by statistical agencies to impute price changes from the average of surviving product will overestimate inflation. This is compelling as an explanation of the productivity paradox, because this implies that it is precisely when creative destruction is accelerating that more growth would be mismeasured. Aghion, Bergeaud, Boppart, Klenow, and Li (2017) estimate that missing growth represented 0.5% in the US, with slightly higher numbers post 2006.

However, problems of mismeasurement are not new. They need to either have become significantly worse, or apply to a growing share of the economy, to explain the productivity slowdown. Any corrections to the deflators would need to be substantial, and to apply to large parts of the economy. Recent studies evaluating these conditions have concluded that mismeasurement of ICT prices is unlikely to be sufficient to explain the scale of missing productivity. Byrne, Fernald, and Reinsdorf (2016) in particular applied different versions of corrected PPI and investment deflators in various subsectors (computers but also communications, software, and other IT) to run counterfactuals and failed to find substantially revised productivity numbers. Indeed, they claim that mismeasurement was in some cases worse *before* the slowdown, echoing a theme recurrent in Gordon (2016).

As further evidence that the productivity slowdown cannot be entirely attributed to mismeasurement in the ICT sector, Syverson (2017) has pointed out that the productivity slowdown is no less marked in countries with a lower ICT intensity, which would be expected if ICT mismeasurement causes the slowdown. However, as noted by Byrne et al. (2016), ICT investment has shifted toward subcategories that are measured with more uncertainty, for example, from hardware to software.

2.3 Intangible Inputs

2.3.1 What are intangible inputs and how mismeasured are they?

A further source of mismeasurement arises from the distinction between intermediate inputs and capital. In the last decades, it has increasingly been recognised that many non-physical assets provide services over multiple years, and should therefore be treated as capital rather than intermediates. Corrado and Hulten (2014) consider three broad categories of intangible inputs: computerized information for software and data, innovative property for research and design, and economic competencies for advertising and organisational structures. One example for the last category is that they estimate that 21% of the wage costs of workers in management, marketing, and administration with tertiary education can be considered as investment into organisational capital. The 2008 revision of the System of National Accounts for the US, and the 2014 ONS National Accounts Blue Book for the UK, recognized the importance of accounting for intangible, and included the capitalisation of certain types of R&D investment. Accounting for natural capital, in the form of positive or negative externalities, is another issue that is often overlooked, even in the literature on intangible capital.

Measuring the stock of such capital and its depreciation rates is inherently difficult. Unlike tangible goods, where units are clearly defined, intangibles, such as intellectual property or branding, are difficult to quantify, even before any quality-adjustments are to be considered. The literature offers methods to calculate depreciation rates for various types of intangibles through specific R&D surveys or implementing a 'software' model from a traditional industry survey, complemented with an independent account production using data on employment and wages in specific occupations. An updated review of estimates of the depreciation rates can be found in de Rassenfosse and Jaffe (2018), who estimate a rate of R&D depreciation between 1-5%, although this rate can be higher in the first two years.

2.3.2 How intangible mismeasurement affect productivity statistics

If intangibles are not fully capitalized, this leads to a mismeasurement of both inputs and output (Goodridge, Haskel, & Wallis, 2016b). Using a framework originally developed by Schankerman (1981) and Corrado, Hulten, and Sichel (2005, 2009), Goodridge et al. (2016b) show that biases to measured TFP growth, from omitted intangibles, spillovers and capitalisation effects, add up to 1pp per annum between 2011-2014 and 2000-2007. Declining intangible capital services contributed 0.4pp per annum, and value-added mismeasurement 0.2pp per annum.

Brynjolfsson et al. (2017) proposed a simple model to think about the consequences of a General Purpose Technology (GPT) such as artificial intelligence on measured TFP, assuming it is not measured. Initially, investment grows quickly, and then slows down; investment growth rates are thus initially higher than capital growth rates, while the reverse is true in later periods. This creates a TFP mismeasurement cycle, because investment is an output and capital is an input. TFP growth is initially underestimated (investment and thus total output is underestimated), and then overestimated (capital and thus total input is underestimated).

However, not all intangibles contribute to mismeasurement. The contribution to production of certain intangibles can increase sales for certain firms while harming others in a zero-sum fashion. For instance, advertisement and faster trading algorithms improve one firm's productivity by taking value from competitors (Brynjolfsson et al., 2017). Haskel and Westlake (2017) offer a more nuanced approach, and review some evidence on returns from advertising not summing to zero when all firms spend on advertising simultaneously.

Another aspect of mismeasurement in intangibles appears because of offshoring. This point is investigated in Guvenen, Mataloni, Rassier, and Ruhl (2017), who show that measurement of GDP may be underestimated when firms offshore their profits, which is highlighted for R&D intensive industries producing intangible assets. By tracing differences between gross domestic and national product in the United States, they find that direct investment earnings abroad increased by 2.7% of business sector value added in the United States between 1973-1993 and 2012. Using data on labour compensation, they find that 65% of these earnings can be attributed to domestic activity, but are instead shifted to affiliates in low-tax countries. Productivity growth after adjusting value-added between 2004 to 2008 is 0.25% higher than presented in official statistics, although it remains unchanged after 2008. It thus largely fails to explain a large share of the total slowdown in productivity.

2.4 Summary

Recent studies have found that mismeasurement has not worsened to the point that it would explain a large share of the productivity slowdown. Neither has the economy dramatically shifted towards sectors where real output of final goods is thought to be underestimated. Nevertheless, there is a shift towards intermediate sectors and assets that are measured with more uncertainty, such as various forms of intangible capital, and there is evidence that the digital economy does provide large unmeasured benefits. Even though it unlikely to explain more than a small part of the productivity slowdown, the extent of this mismeasurement is likely to grow. Technological transitions are challenging for measurement systems and that more work is necessary in this area. However, it is unlikely that a major part of the observed productivity slowdown is due to mismeasurement.

3 Human capital

In this section, we discuss potential explanations linked to the characteristics of the workforce. We first show that aggregate measures of human capital like educational attainment have not slowed down, but the skill mismatch may have increased. We then discuss demographic factors, finding that migration is unlikely to have had an important effect, while ageing is instead affecting productivity through direct channels (age-productivity relationship), but also indirect channels (savings or shifting consumption preferences). We briefly discuss an emerging literature on the role of technology in lowering labour supply, and conclude the section by reviewing the discussion surrounding labour market institutions, and in particular their role during the financial crisis and more recently with respect to the rise of the gig economy.

3.1 Education and Skills

A key determinant of labour productivity is human capital itself, in that an explanation for the productivity slowdown could be a slowdown in educational attainment or a growing skill mismatch. The effect on productivity would be direct, while other indirect changes in the labour force may also affect human capital and productivity by changing the skill composition, notably through migration, ageing, as well as labour market institutions.

3.1.1 Educational Attainment

The importance of education for labour productivity and wages is one of the most established relationships in the economic literature (Mincer, 1958). In a traditional framework, wages are equal to the marginal product of labour, and subsequent wage premia imply higher output (Heckman, Lochner, & Todd, 2006).

In this context a slowdown in productivity could be caused by a general slowdown in educational attainment in the advanced economies, which is not apparent. The OECD provides data that differentiates between different types of education. The share of people with less than a secondary education appears to drop steadily (OECD total, France, UK), but eventually flattens (US and Germany), which is consistent with the literature on the plateauing of high school diplomas in the US (C. Goldin & Katz, 2008; OECD, 2017a). Meanwhile, the share of population with tertiary education has been increasing in a stable, linear fashion for each country mentioned. Goodridge et al. (2016a) also find that the labour force composition has overall improved in the UK. As a result, a secular slowdown in educational attainment is not a candidate explanation of the recent global productivity slowdown.

Whether this trend will be sustained going forward is unclear, and concerns have been raised about rising student debt (Gordon, 2016). Although it is too early to evaluate the long term consequences, so far tuition fee increases do not seem to have lowered the demand for education services. For example, the impact of the 2012 tuition fee hike in the United Kingdom, does not seem to have severely disrupted the growth in tertiary education. The trend is similar in the US, where fees have experienced one of the largest price increases in the economy. Given the high returns to education compared to the real interest rates faced by young scholars credit constraints seem to have played a less significant role in this process (Heckman et al., 2006).

3.1.2 Skill mismatch

In view of the continued rise in educational attainment, a potential explanation for the productivity slowdown is that while the overall supply of skills is still growing, there is mismatch between the supply and demand of specific skills. For instance, in case of fast technological change, we should expect the skills associated to new technologies to be in too short supply, but also that different occupations will be affected differently by biased technological change (Acemoglu & Autor, 2011).

There is a consensus that skill biased technological change led to the hollowing out of the wage distribution in the 2000s, when middle wage cognitive routine occupations were automated (Goos, Manning, & Salomons, 2014). This may have led to some extent to deskilling technological change, contributing to the skills mismatch and pushing workers with intermediate levels of education to take low productivity jobs. In combination with the emergence of digital platforms, a larger share of such workers now participate in the gig economy (Coyle, 2017).

Recent research on changes in the allocation of workers in the context of the productivity slowdown is inconclusive. On the one hand, Goodridge et al. (2016a) find that employment was re-allocated towards high-productivity industries in the United Kingdom, yet Patterson, Şahin, Topa, and Violante (2016) calculate that most labour was reallocated to low productivity occupations, accounting for up to two-thirds of the slowdown. These findings can be reconciled by the fact that the latter considers sectoral differences in matching frictions, yet the extent to which the effect is from reallocation from sectors with high productivity *levels* or *growth* is unclear. Research by the OECD on cross-sectional data suggests that low mismatch is correlated, along with other factors, with good policies on bankruptcy laws, residential mobility, and the flexibility of wage negotiations (McGowan & Andrews, 2017).

3.2 Migration

Net migration has increased in the OECD countries since the 1960s with significant fluctuations as a response to business cycles and national and geopolitical events. This change manifested itself with significant variation across countries and different categories of migration (OECD, 2018). In practice, migration enters the productivity discussion by predominantly affecting labour supply. The productive use of migrants' skills and their reflection in national accounts cannot be ascertained a priori.

One approach to identify the effects of migration on productivity is to evaluate the impact of refugee waves on local economies. Studying the impact of events like the Mariel boatlift of Cuban refugees in the US has not led to a wide consensus on the employment, wage or productivity impacts (Borjas & Monras, 2017; Card, 1990; Peri & Yasenov, 2015). There are several reasons for this outcome. First, surges in refugees can be hard to predict. Second, the changes in migration policies can directly affect the observed economic outcomes. A typical case is the gradual integration of European Union members, where the impact of immigration on productivity has in some cases been shown to be positive (Beerli & Peri, 2017).

Apart from the scale of migration, its impact can be traced to the provision of new skills and entrepreneurial activity (Borjas & Doran, 2012; Mitaritonna, Orefice, & Peri, 2017). In gross terms immigrants are found to be three times more productive than the average global citizen (MGI, 2016). Peri (2012) shows that immigration is positively correlated with TFP growth in the US, with the efficiency gains larger for unskilled workers than skilled. Comparing migration flows in OECD economies against their impacts on labour markets and controlling for the skills of immigrants, Boubtane, Dumont, and Rault (2016) found that the US and Germany exhibit productivity changes close to zero or even negative, while the UK and France benefited from these inflows.

The effects on entrepreneurship are also significant: 40% of all Fortune 500 companies were founded by first- or second-generation immigrants, and more than half of US startups valued at $1 billion or more before going public (often referred as unicorns) have at least one immigrant co-founder (I.

Goldin, Cameron, & Balarajan, 2011). Immigrants accounted for 28.5% of all new US businesses formed in 2015 despite accounting for just 14.5% of the overall US population. In addition, they are almost twice as likely as the native-born population to found their own business (in the US and the UK).

Despite this, the large fluctuations between countries and across time in migrant inflows, which do not match changes in productivity, suggest that migration does not explain the slowdown in labour productivity growth. For example, it is not clear why Japan would have a decline in aggregate productivity on the same scale as Germany, when it receives a fraction of the inflows observed in Germany.

3.3 Ageing

Two demographic trends are responsible for an ageing population globally: increasing longevity and declining birth rates. Research for the United States documents a persistent decline of ill health across all age groups, with the possible exception of US late-middle-aged white males (Case & Deaton, 2015; Freedman et al., 2013). These trends are already well under way in advanced economies globally, and the resulting surge in the number of people aged over 65 as a compared to those aged 16-64 is evidenced across the globe (United Nations, 2017). Here we discuss three potential effects of ageing on productivity: a direct effect due to a link between age and productivity, a macroeconomic effect of ageing on saving rates, and a structural change effect due to changing patterns of demand.

3.3.1 Age and productivity

Understanding how productivity changes with age is often problematic due to selection bias (old workers are selected because of good health, and are therefore not representative), omitted variables in determining wages (seniority and anti-ageism laws), and generational effects (Lee, 2016). Nevertheless, the concerns regarding lower productivity of the older population are largely dismissed in a report by the National Research Council (2013), although the evidence is not very strong. Analysing Austrian data, Mahlberg, Freund, Crespo Cuaresma, and Prskawetz (2013) find that firm productivity in Austria is not negatively correlated with the share of older employees, and also fail to find evidence of overpayments in this case. In a similar strand, Börsch-Supan (2013) summarizes the relevant empirical literature attempting to estimate a decline in productivity linked to ageing and rebukes this hypothesis.

On the other hand, Maestas, Mullen, and Power (2016), exploiting variation across US states, find that a higher share of population above 60 is associated with slower labour force growth and slower labour productivity growth. Liu and Westelius (2016) find that the share of mid-age population at the prefecture level in Japan was positively associated with higher productivity growth. Finally, recent research has investigated the link between ageing and entrepreneurship, with Liang, Wang, and Lazear (2014) finding that countries with an older population exhibit lower rates of business formation.

3.3.2 Macroeconomics of ageing

Population ageing affects the availability and rates of returns of both labour and capital inputs, but there is no consensus on the nature and extent of the effect on productivity (Lee, 2016). Lee (2016), Eggertsson, Mehrotra, and Summers (2016) and Teulings and Baldwin (2014) argue that ageing may have an indirect effect in causing secular stagnation by driving interest rates to the zero lower bound. Lower and negative population growth rates would increase the supply of savings, to the extent that individuals need to save for retirement. At the same time, a higher saving rate would lead to lower demand for consumption goods, reducing investment opportunities for firms. Both shifts lead to a lower equilibrium rate of interest. However, Eichengreen (2015) found that empirically increases in dependency ratios have roughly equally negative effects on both the demand and supply of savings.

An ageing labour force combined with low cost of capital also leads to a stronger incentive towards capital-biased technical change, leading to higher productivity. Acemoglu and Restrepo (2017) observed a faster rate of adoption of automation in countries with older populations, which more than offsets any effects on output by labour scarcity.

3.3.3 Consumption patterns and Baumol disease

Consumption baskets may change drastically as individuals age. Specifically, consumption by the elderly focuses more on services, in particular healthcare and leisure activities, in which productivity and productivity growth is generally lower. Siliverstovs, Kholodilin, and Thiessen (2011), using country-level panel data, found that an older population was associated to a shift of employment shares away from agriculture and industry towards personal services and the financial sector. Moreno-Galbis and Sopraseuth (2014) find that ageing helps explain job polarization, as it increases the demand for low wage personal services.

3.4 Leisure technology and labour supply

New leisure technologies could play a role in labour force participation rates. Hall (2017) points out that an additional 1.6 hours for men and 1.2 hours for women are spent every week on leisure activities, which largely include time watching television and playing video games. Aguiar, Bils, Charles, and Hurst (2017) relate directly improvement in technology to increasing leisure demand and find that it explains a large part of the decreasing labour supply of young males. However, Bridgman (2018) develops a method to impute the value of leisure time for the post-war period in the US, and found that household consumption of digital goods is not large enough to have a significant impact on the value of leisure; in fact he finds that the productivity growth of leisure time has been falling.

A more direct channel is that digital technologies may disrupt productivity directly, for example because of working hours spent on social media, and indirectly, by forming new habits of distraction that reduce capacity to work (Mark, 2015; Nixon, 2017; Terranova, 2012).

3.5 Labour Market Institutions

Aside from the quantities and qualities of inputs, labour market institutions such as unionization and wage flexibility can influence productivity too. For instance, Pessoa and Van Reenen (2014) argue that the situation of the UK post financial crisis, with low unemployment but low productivity growth, can be explained by high wage flexibility. After the financial crisis hit, workers accepted a lower real wage, and unemployment recovered quickly. Combined with credit constraints that made capital less attractive, firms substituted capital for labour, resulting in lower capital per worker ratios that are detrimental to labour productivity.

Using harmonized measures of job creation and destruction in a sample of industrial and emerging economies, Haltiwanger, Scarpetta, and Schweiger (2014) find evidence that stringent hiring and firing regulations tend to reduce the pace of job reallocation. Cette, Fernald, and Mojon (2016) looked into the productivity effects from anticompetitive regulations in product and labour markets through their impacts on production prices and wages. The existence of these regulations across countries and industries results in rent-seeking behaviour by firms that impedes productivity. They simulate the effects of large structural reform programs and show that all countries could expect sizeable gains in multifactor productivity from the implementation of pro-competitive regulation practices.

In the UK, a persistent increase in self-employment, zero-hour contracts, and the rise of the 'gig economy' may be responsible for a recent increase in unskilled labour (Coyle, 2017). In addition to the skill mismatch argument made in Section 3.1.2, the gig economy may be detrimental to overall labour productivity as it is associated with lower rates of investment in skill accumulation and experience than is the case for longer-term job contracts.

3.6 Summary

While the growth in attainment of college degrees kept pace with its pre-crisis trend, there is a growing literature pointing out that the new wave of technological change is making specific skills scarce and others obsolete, possibly increasing a skill mismatch. Ageing, besides its links to secular stagnation, has mixed effects: on the one hand, there are concerns that an older population may be less productive or entrepreneurial, and that older consumers may also shift consumption towards low productivity growth services, but on the other hand ageing increases incentives for automation. The argument that new leisure technologies may decrease labour supply remains contested empirically. Finally, labour market institutions play a role in explaining the different countries experiences post crisis, but can hardly explain much of the overall productivity slowdown.

4 Physical and intangible capital

Historically, much of growth in GDP per worker came from capital deepening. Here we review recent growth accounting exercises, which repeatedly suggest a slowdown in investment as a major candidate explanation for the productivity slowdown. We then discuss potential reasons behind this slowdown, including the role of intangible capital and financial market frictions.

4.1 Contribution of capital growth to productivity

Labour productivity decompositions, at least in the US, show that while TFP is the dominant factor, a slowdown in capital deepening has been a major cause of the decline in output growth per worker. Baily and Montalbano (2016) found that TFP and capital deepening contributed only 0.5pp each to labour productivity growth in the post 2004 period, against 1.7pp for TFP and 1.2pp for capital in 1995-2004.

For the OECD, Ollivaud, Guillemette, and Turner (2016) decomposed labour productivity growth based on estimates of potential output for the period 2000-2015. They found that (trend) labour productivity growth fell from about 1.8% to 1% from 2000 to 2008, with most of the decline being due to the slowdown of TFP growth from about 1% to 0.4%. In contrast, the post-crisis period was marked by a further decrease of labour productivity growth which can be entirely attributed to a slower growth of capital deepening – a finding that is not unrepresentative of individual country experiences.

Ollivaud et al. (2016) put forward several explanations for the slowdown of capital deepening. First, the composition of capital is shifting towards assets with shorter lifetimes, such as ICT, which implies a higher aggregate scrapping rate. However, this increase of the scrapping rate has taken place since at least 1990, rising from 3% to 5%. A second, more plausible explanation for the weak post-crisis investment is simply the fall in aggregate demand. They also found that countries with lower pre-crisis interest rates, which may have built up more capital misallocation, had a stronger slowdown in capital growth post crisis. Finally, government investment also fell post-crisis, contributing around a fifth of the fall of investment as a share of GDP. Besides the direct effect, a lack of investment in infrastructure and public capital may have longer-run (and harder to measure) consequences for productivity.

Using data on publicly traded firms in the US, Alexander and Eberly (2018) found that the slowdown of investment relative to fundamentals started in the early 2000s. They offer two decompositions to understand this trend. First, investment shifted towards industries in which capital cannot be relocated easily, such as energy production or telecommunication transmission. Second, high tech firms shifted their investment towards intangibles.

4.2 Intangible capital

Corrado and Hulten (2010) find that broadly defined intangibles have been the largest systematic driver of growth over the last 50 years. Haskel and Westlake (2017), reviewing the main findings in Corrado et al. (2009) for the US, Marrano, Haskel, and Wallis (2009) for the UK, and Fukao, Miyagawa, Mukai, Shinoda, and Tonogi (2009) for Japan, provide evidence that intangible assets are a growing share of investment. In fact, business investment in intangibles has been higher than investment into tangible capital since the late 1980's.

Corrado and Hulten (2014) computed that by accounting for the stock of intangibles, capital deepening in revised accounts is responsible for half of labour productivity growth in the United States, and TFP contributions decrease accordingly. This is aligned with the findings in C. I. Jones (2002) and Fernald and Jones (2014) who absorb R&D intensity into a separate TFP term and find that tangible capital deepening explains no productivity gains whatsoever. According to their calculations, R&D intensity alone explain up to 58% of productivity growth in the US between 1950 and 2007.

Haskel and Westlake (2017) argue that the fundamental nature of intangible capital allows established firms to accumulate market power. Several forms of intangible capital benefit from synergies, such as knowledge capital that can be recombined into new forms. Additionally, intangible capital is often easy to scale at near zero marginal cost, thus generating increasing returns for incumbents. Meanwhile, startups may face barriers to entry in the form of funding opportunities, since the difficulties related to valuing such capital make it hard to list as collateral. On the other hand, the effect of spillovers may enable smaller firms to benefit from intangible investments of larger firms, for example through the diffusion of new technology. Since intangible capital has higher spillover effects than tangible capital, a slowdown in intangible investment is worse than a slowdown in physical capital deepening. As a result, while there is evidence that investment into intangibles has been impacted by the financial crisis to a lesser extent than tangible investment, its adverse impact on TFP might be worse. This point is reinforced in Goodridge et al. (2016a), who suggested that part of TFP growth slowdown might be due to missing lagged spillovers, resulting from the slowdown of R&D investment in the 90's and 2000's.

Besides R&D, intangibles also include economic competencies and good management practices. Haldane (2017) argues that management practices are indeed a good predictor for productivity at the firm level, and slower diffusion of best practices could help explain the productivity gap between frontier and laggard firms. To translate into productivity improvements, technological change often requires a change in companies' internal processes and organization. During the "first" productivity paradox of the 90's, insufficient organizational change was identified as one of the key points holding back technology diffusion (Brynjolfsson, 1993; Brynjolfsson & Hitt, 1996; Brynjolfsson & Hitt, 2000). Similar arguments can be made today, where organizational change complementary to the development of AI are just starting and will take time to fully impact on businesses and productivity (Brynjolfsson et al. (2017).

Lazonick (2014) and Haskel and Westlake (2017) point out that declining investment rates could be due to an increase in short-termism amongst top managers. In firms where the pay of the top management is linked to firm performance on the stock market, with the purpose to align the incentives of managers with those of the firms, Lazonick (2014) finds that an increasing amount of resources are spent on stock buybacks instead of long term investment which would improve productivity. Gutiérrez and Philippon (2017) argue that this change in corporate governance within a large number of firms led to lower investment rates in long-term projects. However, Gutiérrez and Philippon (2016, 2017) argue that reduced competition is likely the more important factor.

4.3 Financial market frictions

If investment is slowing down, why? Here we look at some potential explanations. First, due to an increase in risk premia, cost of capital did not fall as much as safe assets rates would suggest. Second, the credit crunch following the financial crisis appears to have been important and may have affected intangible investment relatively more. Third, capital reallocation has been weaker since the crisis.

4.3.1 Returns on productive capital

Caballero et al. (2017) document that the returns on productive capital (including intangibles) have remained more or less stable around 6.5%, while the returns on safe assets have decreased. Calibrating a model of investor's behaviour, they estimate that there has been a substantial increase in the risk premia since 2000, and even more after 2008. Their framework also suggests that increasing markups, which we will discuss in Section 5.3, played a significant role, and assuming capital-biased technological progress helps explaining the fall of the labour share in tandem.

Haskel and Westlake (2017) further note that a shift of capital in the economy towards the intangible kind could also dampen risk appetites. Investment in intangibles is generally sunk and thus riskier, as economies shift to higher shares of intangibles in production the risk profile of the capital stock is deteriorating.

4.3.2 Credit frictions

The Global Financial Crisis (GFC) cannot be a stand-alone explanation of the productivity slowdown, simply because the slowdown started before the crisis. However, there are reasons to believe that the forces driving productivity growth down may have been different pre- and post-crisis, with the post-crisis period being relatively more marked by a lack of investment (Ollivaud et al., 2016).

Duval, Hong, and Timmer (2017) using firm-level data in a cross-section of countries found that more financially vulnerable firms had a higher decline in TFP growth after the GFC. They also found that this effect was stronger in countries with a higher credit supply shock, and they suggest that credit constraints may have affected productivity by reducing intangible investment, which is more difficult to use as collateral than physical investment. In particular, Besley, Roland, and van Reenen (2017) use a 'probability of default model' to derive an aggregate measure of credit frictions, and find that these may have already depressed output in the United Kingdom before the crisis. While they were understandably large during the crisis itself, the effects lingered after the crisis, accounting for up to 23% of the slowdown in productivity growth relative to its pre-crisis trend.

4.3.3 Capital misallocation

Barnett et al. (2014), looking at firm-level data from the UK, found evidence that capital reallocation slowed down after the financial crisis. Specifically, the positive relationship between investment incentives (capital rates of returns) and actual investment (capital growth rates) disappeared after the financial crisis, suggesting that firms are less responsive and that as a result, capital misallocation has increased.

Gopinath, Kalemli-Özcan, Karabarbounis, and Villegas-Sanchez (2017) and Cette et al. (2016) document a rising capital misallocation in Spain, Italy and Portugal since the 90's, which they attribute to low interest rates leading to capital misallocation. We will come back to this issue in Section 5.2, where we discuss recent firm-level studies.

4.4 Summary

In summary, labour productivity growth decompositions suggest that the lack of investment is, with the slowdown in TFP growth, a major reason behind the slowdown. The slowdown affects physical investment, but also intangibles, which to the extent that they provide higher economy-wide spillovers has an even more detrimental effect. The financial crisis is partly to blame, as weak aggregate demand lowered investment incentives, and there is evidence of higher risk premia and a suboptimal allocation of capital.

5 Productivity dispersion

A natural approach to understanding the evolution of aggregate productivity is to disaggregate. In this section, we first discuss the idea that productivity can be slowing down because low productivity growth sectors become more important. Second, we review the recent work on the distribution of firm productivity, which points to the simultaneous rise of superstar firms co-existing with zombie firms, and suggests that misallocation has increased and knowledge diffusion from frontier to laggard firms has slowed down. Third, we discuss one of the major explanations put forward for this trend, namely the rise in market concentration and markups.

5.1 Sector-level productivity growth and structural change

Are some specific sectors responsible for the slowdown? Are slow sectors becoming larger? William Baumol famously pointed out that aggregate productivity growth would under certain conditions asymptotically equal the rate of progress of the slowest industry (Baumol, 1967). In the context of the productivity slowdown, it may well be that the rapidly innovating sectors are capturing a declining share of total output, or are not systemically important (Oulton, 2001).

Baily and Montalbano (2016) decomposed the growth of US TFP by sectors and found that manufacturing, wholesale and retail trade, services and agriculture were responsible for a large fraction of both the acceleration of aggregate TFP growth between the 1995-2004 compared to 1987-1995, and its slowdown in 2004-2015 compared to 1995-2004. This highlights a point often emphasized by Gordon (2016): productivity growth can be thought of as an adjustment of the levels, with an innovation leading to a new normal level of productivity growth, that is, a transitory period of high productivity growth. Baily and Montalbano (2016) relate the experience of the retail sector to the rise big box retailers driving out small shops, until they reached overcapacity in the post 2004 period.

Using a different sectoral aggregation, Cette et al. (2016) found that in the US most of the 1990's productivity surge was due to ICT producing industries. Consistent with Baily and Montalbano (2016), market services such as retail had a strong productivity growth in the early 2000's, benefiting from ICT-related reorganization, but fell back to lower growth after 2004. Murray (2017) found that almost all the slowdown in average labour productivity growth between 1995-2004 and 2005-2015 can be explained by a within sector slowdown, with reallocation playing no role. Byrne et al. (2016), using new TFP growth rates while keeping industry shares fixed to 1987, do not find any evidence that growth of low

TFP growth industries as a share of output explains much of the productivity slowdown. If anything, it complicates the puzzle.

In the UK, Haldane (2017) and Billet and Schneider (2017) examined productivity growth trends at the sectoral level pre- and post- financial crisis, and found that all sectors have been affected by the recent slowdown in productivity growth. Goodridge et al. (2016a) nevertheless estimates that weakness in TFP growth in the oil and gas, as well as financial service industries, can explain 35% of the total TFP slowdown for the United Kingdom. Haldane (2017) notes that financial services account for almost a third (0.5% out of 1.7%) of the pre- vs post-financial crisis difference in UK labour productivity. Tenreyro (2018) traced three quarters of the productivity slowdown to manufacturing and finance (post vs pre- financial crisis, excluding 2007-09), with ICT and professional, scientific and technical services explaining the rest. In manufacturing, the slowdown in labour productivity growth is due to both a slowdown in capital deepening and TFP, which themselves may be attributed to both low levels post crisis but also high levels pre-crisis. A one-off improvement due to structural transformation and off-shoring was taking place during the 2000-07 period, creating a sharp contrast between pre- and post-crisis periods. The slowdown is also marked in finance, because of a pre-crisis high level, perhaps partly due to measurement issues. In contrast to manufacturing, the slowdown can be overwhelmingly attributed to TFP, not a lack of investment.

Taking stock of this literature, it does not seem like Baumol's cost disease is a valid explanation for the current productivity slowdown, since sectoral shares of GDP have not changed dramatically. However, key sectors that are important in size had a significant productivity slowdown, especially when compared to the previous decades where they tended to overperform.

5.2 Widening productivity distributions

Disaggregating further, there is a broad consensus that there are strikingly large productivity differences between frontier and laggard firms within industries (Andrews, Criscuolo, & Gal, 2016; Syverson, 2011). These differences tend to be persistent over time, indicating the presence of firm characteristics that make them productive over longer time horizons, but also that low productivity firms are not necessarily eliminated quickly.

5.2.1 Superstar firms

Andrews et al. (2016) documented a substantial divergence between firms at the 'frontier,' defined as the top 5% most productive firms in the distribution, and the rest in a sample of 23 OECD countries. Those at the frontier have increased their productivity by around 40% on average since 2010, while the rest experienced slow, if any, productivity growth. Haldane (2017) looks at some determinants of higher productivity growth, and finds that firms with high productivity growth tend to be (i) exporters, (ii) foreign-owned, (iii) located in productive regions (London in this case), (iv) concentrated in some sectors, (v) relatively larger, and (vi) invest substantially in R&D. Furthermore, Autor, Dorn, Katz, Patterson, and Van Reenen (2017b) point out that superstar firms tend to arise mostly in sectors that are characterized by high patent intensity. Even more generally, Haskel and Westlake (2017) attribute faster divergence in the industry-level profit distribution to the intensity in their use of intangible capital.

There is an observed decline in turnover at the productivity frontier (Andrews et al., 2016). Out of the firms at the top 5% of the productivity distribution, there are now significantly more which were already at or near the frontier two years before, as compared to a period at the beginning of the 2000s. Additionally, P. Schneider (2018) explicitly outlines that the productivity slowdown post-crisis in the UK emerges from the slowdown in productivity growth for the already-productive firms at the frontier.

One hypothesis is that the reduced entry of new firms relieves pressure on incumbents to innovate, leading to the observed reduction in the turnover of firms at the productivity frontier (Foster, Haltiwanger, & Syverson, 2008). The ageing of frontier firms, while still younger than the average firm, may be another indication of lower dynamism at the productivity frontier (Andrews, Criscuolo, & Gal, 2015).

5.2.2 Zombie firms

Zombie firms can be thought of as firms that manage to survive despite negative productivity. While the evidence shows that many unproductive firms failed during the financial crisis, it also documents that a significant fraction of them are still in operation. Among the reasons for this lack of exit are the lack of competitive pressure and bank forbearance (Andrews et al., 2016; Andrews, McGowan, & Millot, 2017).

These zombie firms hold labour and capital that could otherwise be employed productively. Citing evidence from Japan, Caballero, Hoshi, and Kashyap (2008) emphasise that zombie firms also hamper productivity growth rates in healthy firms by appropriating not just labour inputs, but also bank lending. However, as Haldane (2017) and Arrowsmith et al. (2013) point out, the effects on aggregate productivity of the exit of those zombie firms would not be very large, so forbearance is unlikely to account for a large proportion of the missing productivity growth. Yet, the persistence of low productivity firm suggests that productivity could be improved by reforming exit policies (Andrews et al., 2017).

5.3 Increasing market concentration and profits

5.3.1 Rise in markups and industry concentration

Average markups in the US have more than tripled since 1980 across almost all industries, while the largest markups are set by a small number of firms, and the distribution of markups has widened substantially (De Loecker & Eeckhout, 2017). In particular, the top decile of firms has seen their markups almost double from an already-high starting point, whereas the median firm experienced no noticeable change. Based on additional data on profit rates and share dividends, De Loecker and Eeckhout (2017) conclude that this rise in markups reflects a rise in market power, and not an increase in fixed costs that necessitates higher markups.

Prescribing the optimal pace of business dynamism resulting in direct reallocation of resources to the most productive sectors is not straightforward, and might be sensitive to geographical and temporal variations. However, there is evidence that the rate of business startups, the role of young businesses and the pace of job reallocation in the US economy have fallen in the recent decades and this trend has accelerated since 2000, suggesting that incentives for entrepreneurs to start new firms in the US have diminished over time (Decker, Haltiwanger, Jarmin, & Miranda, 2018). The reasons for this trend include declining investment and competition, with some evidence that there is a link between market regulations and increased concentration (Gutiérrez & Philippon, 2017).

Andrews et al. (2016) and Syverson (2011) find that firms in less regulated markets tend to be more productive, and claim that deregulation could help boost productivity growth in overprotected sectors. Similarly, more flexible input markets allow faster reallocation of resources from low-productivity to high-productivity firms, and can thus have positive impacts on aggregate productivity in other sectors. Lastly, Haskel and Westlake (2017) use data from a handful of OECD countries to demonstrate how the rise in markups is particularly pronounced in industries which are intensive in their use of intangible capital.

5.3.2 Consequences on productivity, the labour share and inequalities

Autor, Dorn, Katz, Patterson, and Van Reenen (2017a) found that while the increase in concentration took place in almost all industries for major OECD countries, those industries with the biggest increase in concentration coincide with those with the fastest fall in the labour share. This effect is reported to have been taking place between firms in their respective industries, not within firms. In other words, this trend is not secular, and rather reflects a tendency for revenues to be shifted towards firms with lower labour shares. In terms of productivity, this need not necessarily be bad news: a lower labour share for the superstar firms should translate into higher labour productivity.

Increased concentration is seen to lead to reduced competition, and incumbents will have fewer incentives to keep investing in productivity improvements. Gutiérrez and Philippon (2017) find evidence for the US that decreasing domestic competition leads to lower investment, especially into intangible assets, by the industry leader. Despite this, industry leaders are able to maintain their profit levels. They find no significant relationship between the productivity of an industry and its concentration after 2000, so a dispersion in the firm productivity distribution may not cause a dispersion in the size distribution, and vice versa. Through causal analysis with three different identification strategies, they find that investment would increase significantly with higher competition, even if it were only through the threat of entry of competitors. They argue that the scope for additional investment would be quite significant due to high profit margins and high Tobin's Q. This has been the case since the early 2000s, so it is unlikely to be a direct consequence of the financial crisis.

Together, the combined forces of divergent firm productivity and profitability also contribute to a worrying trend of increasing inequality in advanced economies. Song, Price, Guvenen, Bloom, and Wachter (2015) present evidence for wage inequality in the US, claiming that most of the increase in inequality is due to greater divergence in average wages between firms, and not within. Between-firm wage inequality is consistent with the evidence presented above on firm productivity and profitability divergence, as average wages have grown faster at the top end of the firm distribution. Berlingieri, Blanchenay, and Criscuolo (2017) using a multi-country micro-aggregated dataset confirmed the relation between the two 'great divergences' of wages and productivity.

5.4 Summary

Overall, accounting for changing sectoral shares does not help to explain the slowdown in labour productivity growth, and the slowdown permeates the economy across all sectors. However, the impact on aggregate productivity is understandably higher from the slowdown in core sectors, such as energy and finance. The ending of a period of high productivity growth in ICT and ICT-using sectors such as manufacturing and retail and wholesale trade, at least in the US, also had a demonstrable impact.

At the firm level, there is a divergence in productivity between firms at the frontier and the rest. Simultaneously, concentration, market power, and profits are also increasing across most industries. This begs the question of why the factors boosting the productivity of superstar firms are not diffusing, or not as fast as in the past. One hypothesis is that superstar firms are increasingly able to erect barriers to entry, perhaps because intangible capital is easier to appropriate. Another hypothesis is that diffusion takes a long time, and we should expect long lags between an initial innovation pushes the productivity frontier, and its full impact on aggregate productivity, a point emphasized by the optimists in the productivity paradox debate.

6 Globalization, trade and offshoring

Globalisation has been an important driver of productivity growth in the last decades. The ability for firms to access foreign markets, both for production and final good export, has increased through a number of factors, leading to the growth of trade in goods and services. The first part of this section discusses these factors, drawing from the literature to explain why growth in trade has slowed down. The second part of this section demonstrates several channels through which trade increases productivity, thus in part pinning the slowdown in the growth of labour productivity to the slowdown in the growth of trade.

6.1 Slowdown in global trade

Trade has been an important driver of economic growth for much of the past century, but its growth has stagnated as the export-to-GDP ratio for the world has not changed since the crisis (Baldwin, 2009; Hoekman, 2015). Causes for the slowdown include cyclical factors related to the financial crisis, as trade is historically highly responsive to changes in output. Structural components might also keep growth in trade supressed permanently, such as the one-off integration of China and ex-communist countries or technological advancements that enabled the spread of large Global Value Chains (GVCs).

Weakness in demand in the aftermath of the Great Recession may be a primary cause of the slowdown in trade, as it has been notably more pronounced in countries hit hardest by the crisis (Constantinescu, Mattoo, & Ruta, 2016). Import volumes for the United States and the Eurozone are 20% below their pre-crisis trend, as GDP levels are 8% and 13% lower, respectively. The collapse of investment accounts for a significant share of the slowdown in trade growth for the G7 countries, as imports are much more responsive to investment than changes in private consumption (Bussière, Callegari, Ghironi, Sestieri, and Yamano (2013)

Constantinescu et al. (2016) acknowledge that weakness in aggregate demand accounts for roughly half the gap between trend and realised import growth, concluding that structural components have played a role as well. The rate of increase in trade between the mid-1980s and mid-2000s may itself have been an outlier, largely due to the emergence of China as an exporter, as well as the collapse of communism. In addition to these geopolitical factors, technological advancements, notably in communications and transportation, have fuelled an expansion in the use of GVCs (Baldwin, 2016). Thus, the slowdown in trade can be linked to the slowdown either in the development of new technologies, or in the adoption of new technologies. Protectionist policies have not been found to explain much of the slowdown in trade, but may pose a significant headwind going forward (Hoekman, 2015). In all, these structural components would indicate that trade has become less responsive to output growth, and the slowdown in the growth of trade may be permanent.

6.2 Reorganization of Global Value Chains and importance for productivity

Criscuolo and Timmis (2017) discuss how the emergence of GVCs has enabled cheaper production, specialisation, competition, and the diffusion of technologies and knowledge. They also highlight the strong complementary between the rise of services in developed countries and the diffusion of GVCs, a point elaborated in Baldwin (2016).

6.2.1 Offshoring and Outsourcing

Offshoring is not only a way to exploit efficiencies abroad, usually through cheaper labour costs in developing countries, but also increases a firm’s access to foreign markets. A helpful model in understanding a firm's dual decision of supplier location and production location is developed in Antràs and Helpman (2004), who highlight the tendency for highly productive firms to offshore, contingent on their reliance on 'headquarter' inputs.

The model receives empirical support in numerous studies, such as Helpman, Melitz, and Yeaple (2004) for the US, and Delgado, Fariñas, and Ruano (2002) for Spain, who find that (i) firms choosing to export are highly productive prior to exporting, and (ii) among firms choosing to engage in foreign trade the most productive will commit to offshoring. Productivity gains from offshoring are significant, and are usually captured by already-productive firms (Schwörer, 2013).

6.2.2 Specialisation in high skilled work

The overall impact on domestic human capital is debatable. Exposure to Chinese import competition in the United States has contributed to a 25% decline in manufacturing employment within commuting zones, with similar findings for local labour markets in Europe (Autor, Dorn, & Hanson, 2013; Bloom, Draca, & Van Reenen, 2016). However, using evidence on the expansion in export activity in the United States, Feenstra, Ma, and Xu (2017) estimate that the net effect of access to foreign markets on employment is near zero within commuting zones. This results from the reallocation of labour into other occupations, notably high skilled occupations that are harder to offshore. Indeed, Feenstra and Hanson (1996, 1999) suggest that offshoring increased employment of high skilled workers within industries in the United States, increasing the skill premium by 15%.

6.2.3 Competition spillovers

The role of competition is scrutinized in Melitz (2003), who proposes that aggregate productivity in an industry rises through the exit of the least productive firms and the extra exports generated by the most productive firms. Exporting alone has been shown to have significantly boosted firm productivity by up to 19% (Bernard & Jensen, 1999).

Foreign competition could also affect the rate of domestic innovation, but the evidence here is limited. Bloom et al. (2016) find by observing patenting behaviour that Chinese import competition led to higher technological innovation within firms in Europe. Despite similar impacts for local labour markets, the United States experienced a lower issuance of patents following increased exposure to Chinese imports within regions (Autor, Dorn, Hanson, Pisano, & Shu, 2016).

6.2.4 Offshoring of services and knowledge spillovers

Traditionally, services provided abroad through foreign investment are often supplied at the location of production. Recent innovations in ICT technologies have changed that paradigm, whereby a growing number of service inputs are offshored, and outputs are sold to suppliers and consumers abroad (Freund & Weinhold, 2002). Amiti and Wei (2009) show that the offshoring of services has grown at an annual rate of 6.3% in the United States between 1992 and 2000. They find that service offshoring within industry has accounted for 10% of the average growth in labour productivity in those years, arguing that this is largely due to a re-allocation of labour to performing more productive tasks.

The offshoring of services is also shown to contribute significant knowledge spillovers, and Javorcik (2004) demonstrates that a 4% increase in the share of foreign-owned firms increases output of domestic firms by 15% in a sample of Lithuanian firms. In some instances, FDI inflows come in the form of acquisitions with the intent to acquire skilled workers and technological expertise (Griffith, Redding, & Van Reenen, 2004; OECD, 2008).

Antràs and Helpman (2004) note the importance of strong property rights in enabling the outsourcing of 'headquarter services,' and this point has been investigated in the context of R&D specifically: protection of intellectual property rights abroad leads to faster offshoring of R&D and higher aggregate rates of innovation, especially for high-tech industries (Canals & Şener, 2014; Şener & Zhao, 2009).

6.3 Summary

The global increase in trade has benefitted domestic productivity by providing cheaper production opportunities, shifting labour demand towards high-skilled occupations, generating competition, and producing technology spillovers. These channels are not expected to generate productivity growth as long as growth in global trade remains muted. While some reasons for the slowdown are cyclical effects from the recession, structural components have also emerged in the form of the integration of developing countries and fewer developments in communication and transportation technologies. Protectionism may be a further blow to the recovery of international trade going forward.

7 Technological factors

The debate around the productivity slowdown is often presented as an argument between techno-optimists and techno-pessimists. On the one hand, Gordon (2016) argues that past waves of technological change, such as steam power, electricity, or the internal combustion engine had a huge but temporary impact on productivity. Current new technologies, in particular digital, he argues, are unlikely to have such a significant impact as they affect only specific aspects of human life, such as communication and entertainment. Moreover, most of the productivity benefits of digitization may already have been harvested, through greater automation in manufacturing, retail, logistics and finance, in the late 1990's and early 2000's.

In contrast, Brynjolfsson and McAfee (2012, 2014) and Brynjolfsson et al. (2017) argue that the ICT and AI revolutions are still in their infancy, and that it will take a long time for their full potential to unfold. They argue that the technologies are still being developed, and a lot of complementary investment, innovation, organizational changes and diffusion are needed before the full productivity potential of the ICT industrial revolution will be realized. Mokyr (2014)'s analysis, similar to Gordon's in also being rooted in extensive historical analysis, suggests that there are new technologies being currently developed that have the potential to become GPTs, enabling sustained productivity growth and welfare improvements, for example genomics. Pratt (2015) argues that the fusion of ICT with other new technological areas, in particular robotics, will generate spectacular new gains in living standards.

In this section, we investigate four sources of a potential decline of innovation or its effects on the real economy: (i) a lower investment in R&D and inventive activities, (ii) lags in the diffusion of innovations, (iii) a faster depreciation of existing capital and infrastructure due to current innovation, and (iv) an increasing difficulty associated with innovating.

7.1 Research and innovation efforts

The OECD (2017b) reports that aggregate R&D expenditures have not slowed across OECD countries after the recession, yet the level of funding by governments has plateaued since 2010. The decline in government investment has been offset by the increase in business R&D spending, accounting for more than 60% of total R&D expenditure in the OECD. While all types of research grew steadily in the OECD area both before and after the crisis, funding into basic science grew faster relative to applied and experimental research. This changing composition stems from a larger contribution from universities to R&D funding, although large variations persist between countries. Notably, basic science research performed by businesses in the US has more than doubled between 2005 and 2015.

Besides differentiating between applied and basic science research, Mervis (2017) uses data from the National Science Foundation to show that medical research funding by the United States government has experienced the largest increase. This shift of funding towards the health sector may be expected to have a negative impact on productivity growth, because technological progress in health and pharmaceutical research is known to be increasingly costly and suffer from decreasing returns (DiMasi, Grabowski, & Hansen, 2016). Additionally, health services are consumed directly by households, so productivity improvement in this sector may not be as favourable for overall productivity statistics as productivity in intermediate sectors, such as energy or capital goods.

The availability of skills and R&D labour force is unlikely to explain the productivity slowdown. Although the supply of doctorates in science and engineering shows 'some signs of slowdown' (OECD, 2016), except for Japan the number of PhDs awarded continued to grow between 2002 and 2012. According to data from the OECD, the number of full time researchers in OECD countries has kept rising, from 3.2 million in 2000 to 4.8 million in 2015.

Policies play an important role in stimulating innovation. Edler, Cunningham, Gök, and Shapira (2013) examined seven different sets of policy measures to stimulate the generation and dissemination of innovation by businesses, and concluded that there are large differences in the effect of those policies. For example, policy measures can have different effects on the relative rate of 'radical' versus 'incremental' innovation. Meanwhile, some strategies like standardization and the introduction of production norms could have altogether negative effects on innovation despite boosting productivity growth. Complicating matters further, the OECD (2017b) finds substantial heterogeneity in the levels of tax incentives for R&D in different countries, yet the most innovative are not those with the highest tax incentives. This suggests that while innovation policy matters, it is unlikely that a dramatic change in policy is responsible for a large part of the current productivity slowdown through its impact on innovation.

The OECD (2017b) also documents that commercial R&D is a highly concentrated activity, both across firms and across countries. Across countries, most of the high-impact research papers and patents are produced in only four or five countries, and within advanced economies the 50 businesses with the largest R&D expenditures on average account for around half of the total business R&D spending. However, Veugelers (2018) points out that inequality in R&D expenditures has not increased in Europe, and may have even slightly decreased before 2012. She does note that churn among the R&D leaders is low, yet whether this phenomenon is new is unclear.

Overall, growth in R&D expenditure has not slowed noticeably on aggregate, although its composition may have changed. In particular, a larger share of R&D expenditure is taken up by private businesses, and more is allocated to the funding of basic science. There is also some evidence of reallocation in government research efforts to the healthcare sector, which could be one potential source of a slowdown in aggregate productivity stemming from changes in innovation.

7.2 Diffusion and lags

A major hypothesis to explain a productivity paradox, by which productivity growth slows down despite accelerating innovation, is simply that it takes time for new technologies to diffuse, for companies and workers to adapt, and for complementary investments to take place. This argument was put forward by David (1990) at the time when as Solow previously had highlighted the benefits of computers were not yet evident in productivity numbers. David draws a historical parallel between the diffusion of the computer and the electrical dynamo during the electrification of the US in the late 19th century. For both the dynamo and the computer, there were significant time lags between the first key inventions and their impacts on aggregate productivity.

The key explanation in David (1990) is the prevalence of old technologies in the existing capital stock. First, old methods and capital remain more efficient during the initial phases of the GPT's development, so firms have no financial incentive to switch early to the new technology. Thus, investments to improve the GPT as well as complementary innovations are needed before the new GPT becomes superior. Such investments require time to make. They are lumpy, and the larger and lumpier the investment costs, the longer the lag.

The improvement in the GPT itself can take decades, as was the case for the dynamo, which only superseded steam four decades after the first major inventions. The dynamo only started to have major productivity effects for the firms when a complete reorganization of factories was realized. Even then, not all firms switched to the superior technology immediately, but waited until old capital had depreciated before introducing large scale changes to their production process. In all, old and new technologies and capital vintages are expected to coexist for a long time before diffusion has been widespread. David (1990) also emphasizes inherent mismeasurement issues when new technologies are introduced.

The historical observations in David (1990) are complemented empirically in Jovanovic and Rousseau (2005), who find that measured aggregate productivity growth first slows down for extended periods, before it picks up significantly, as a GPT emerges. However, even during the productivity slowdown, the economy shows signs of restructuring and innovative activity, as firm dynamism increases, the number of patented inventions grows, initial public offerings take progressively younger firms, and investment into young firms increases relative to investment by old firms. They also derive and test a number of other empirical predictions for the previous two GPT waves, which they mostly confirm for both waves: (i) the skill premium rises, since demand for skilled workers to enable the firms' transition increases, (ii) TFP growth slows at the beginning of the wave, (iii) entry, exit, and mergers of firms increases, (iv) stock prices fall initially as old capital depreciates in value, (v) younger and smaller firms do better than larger and older firms in terms of stock market performance and investment, and (vi) interest rates rise while the trade deficit worsens because of higher consumption. In considering these factors, they do not find that ICT technologies diffused faster than electricity, challenging arguments for current innovations to manifest themselves immediately.

Bresnahan (2010) delivers an updated survey on the literature on GPTs, emphasising diffusion lags and the need for complementary innovation and investment. Furthermore, slow productivity growth in itself is not an unusual historical occurrence, but rather periods of fast TFP growth are the exception. Without new technologies, TFP growth arguably comes from improved allocative efficiency, which by itself cannot sustain TFP growth rates indefinitely. Brynjolfsson et al. (2017), reviewing existing explanations for the current productivity paradox, also conclude that lags in implementation are the most important explanation. Similarly, van Ark (2016) supports the idea that the digital economy is still in its 'installation phase,' and productivity effects will occur once the technology enters the 'deployment phase.'

7.3 Creative destruction and faster depreciation

In addition to lags, there are reasons to believe that when a new technology is introduced, older capital depreciates faster. If this is the case, it provides a good explanation for the productivity *paradox*:

it is precisely because innovation accelerates that productivity growth slows down. For instance, based on a few examples such as Amazon replacing brick-and-mortar bookshops, Komlos (2016) argues that creative destruction has become faster. This suggests that one should try to compute time varying scrapping rates, both for tangible and intangible capital.

The review of the literature by Li and Hall (2016) suggests rates of depreciation of R&D capital ranging from negative rates to 100% a year. Their own methodology produces estimates ranging from 6% to 88%, depending on the sector and dataset. A recent study by (de Rassenfosse & Jaffe, 2018) used survey the revenue stream associated with Australian patents, obtained through survey, and estimated a rate of R&D depreciation between 2-7%. Overall, this suggests that there is a large degree of uncertainty regarding the stock of R&D capital, implying a potential for mismeasuring TFP growth by a large amount. Goodridge et al. (2016a), investigating the productivity puzzle in the UK using ONS data, computed an alternate series for various types of capital using alternate depreciation rates. Assuming higher post-2009 depreciation rates (multiplied by 1.5), they found that this premature scrapping might explain up to 15% of the missing 12pp of productivity growth in the UK.

While the argument in Goodridge et al. (2016a) for this is motivated by the financial crisis, there is a more general theoretical argument: during phases of profound technological transformation, society as a whole has to adapt. During the previous industrial revolution and the 1970s and 80s introduction of computing, it took a long time for firms and workers to adapt and complementary innovations to develop (David, 1990). As an example, consider AI and autonomous vehicles: not only may the education system need to be reformed to train people with the right skills, but other institutions such as contract and the judiciary systems need to be re-invented, for instance to deal with the responsibility of autonomous non-human entities. Creative destruction makes entire sets of institutions and branches of knowledge obsolete, which is extremely hard to capture in the data, and would therefore manifest as a slowdown in TFP.

7.4 Research Productivity

While research efforts may not have declined noticeably, as seen in Section 7.1, innovation rates can be lower if research *productivity* declines. Here we discuss theoretical arguments regarding changes in research productivity as knowledge accumulates, and then turn to empirical evidence.

One of the simplest arguments about research productivity is the fishing-out hypothesis: there exists a fixed pond of ideas, and we are fishing the easiest first. In other words, the low-hanging fruit have already been picked (Cowen, 2011). Gordon (2016), for example, argues that many of the drivers of productivity of previous industrial revolution (steam, electricity) were innovations that could only be made once (urbanisation, hygiene revolution) and have a level effect, not a growth effect on productivity.

On the other hand, knowledge should become easier to find as knowledge progresses because new ideas arise out of existing ideas. The more ideas there are, the more ideas can be found (Arthur, 2009; Weitzman, 1998). However, as the space of ideas expands, it may become increasingly harder to explore. B. F. Jones (2009) suggests that an expanding scientific frontier also creates a 'Burden of Knowledge,' as generating original scientific contributions requires more and more knowledge. In support of this theory, empirical evidence suggests that (i) the age at which scientists and inventors make their most significant contributions has been increasing, (ii) the share of scientific papers and patents that is written by a team of several authors is increasing (B. F. Jones, Wuchty, & Uzzi, 2008; Wuchty, Jones, & Uzzi, 2007), suggesting that researchers cope with the increasing burden of knowledge by being more specialized and working in teams, and (iii) the likelihood of switching field is decreasing, again suggesting that the burden of knowledge is creating higher barriers to entry into fields.

Therefore, an interesting question is whether ICT, by making knowledge more accessible or by making science more automatable (see for instance King et al. (2009), could make research more productive. If we push the argument to the extreme, AI could eventually lead to rising research productivity and an intelligence explosion (Bostrom, 2014), but Nordhaus (2015) does not yet find evidence for this hypothesis in the data .

An important indicator that researchers have looked at to determine research productivity are measures of research inputs per patent. Griliches (1994) is an early example, showing that the number of patents per researcher in the US economy has been on a more or less continuous decline for several decades. However, the OECD (2017b) shows that research spending per patent is extremely heterogenous across countries.

Bloom, Jones, Van Reenen, and Webb (2017) tested directly if, as typical endogenous growth models require, a constant level of research effort leads to a constant productivity growth. Under this assumption, if research inputs stay constant, TFP should keep growing at the same rate. They first test the relationship at the aggregate level, with TFP growth measured as a Solow Residual and research effort measured as investment in intellectual property products. They overwhelmingly reject the hypothesis, as is evident in the raw numbers: TFP growth in the US has been at best stable or even declining since 1930, whereas measured research input has increased by a factor of 23. In other words, while productivity keeps growing at a constant, or even lower, rate, the efforts to achieve this have been increasing.

The decline at the aggregate level could mask important differences in research productivity trends at the micro level. The pharmaceutical sector is one area where declining research productivity has been emphasised. Research spending per drug has increased continuously and substantially, so much that it has been termed ‘Eroom’s law,’ to contrast with the seemingly steady increase in computing power associated with Moore’s law. Indeed, Bloom et al. (2017) present evidence that Moore’s law was only upheld by a significant expansion in research effort, so even here research productivity has declined substantially, although not as much as in other areas. Repeating the exercise at the firm level and measuring research output as increases in sales, they find that research productivity increased only for a small fraction of firms. A large majority have seen their research productivity decline, sometimes substantially so.

7.6 Summary

Ultimately, long run aggregate labour productivity growth comes from innovation. Aggregate investment in R&D activities does not appear to have slowed significantly, but has shifted from public funding to corporate, where it is highly concentrated, as well as towards health and pharmaceuticals, which may not have spillovers as high as ICTs did. Nevertheless, a new wave of technological development is taking place, especially in digital technologies, that have the potential to be considered GPTs. The rewards from investment should not be expected to be reaped immediately. Historically, complementary investments are necessary, there are significant lags in diffusion, and replacing the existing capital stock too fast can lead to the stranding of assets. Finally, while there are opposite theoretical arguments regarding the evolution of research productivity as knowledge increases, it appears that maintaining a steady rate of productivity growth has required an increasing number of researchers. In all, aggregate labour productivity growth from innovation is not expected to continue without increasing investment in knowledge creation and diffusion activities.

8 Conclusion

The possible reasons for an observed slowdown in productivity are wide and varied, but while identifying any one single factor as the main reason would be a mistake, our review identified a limited set of forces and mechanisms that taken together are likely to explain most of the slowdown. In the process we also have eliminated many candidate explanations as being largely inconsequential as explanations for the slowdown.

There are clear measurement issues in properly accounting for inputs and outputs in times of intense technological change, creating substantial uncertainty. However, mismeasurement alone is unlikely to explain a significant part of the labour productivity slowdown. This is with respect to both inadequate measurement of current output, as well as the increasing significance of intangible capital that leads to growing mismeasurement of inputs. There is some consensus that there are persistent failures in adequately measuring prices, leading to underestimated output, which would emerge in conjunction with accelerating technological change. However, it is unclear whether such mismeasurement has necessarily become worse in the last two decades. Although we do not identify this as a leading explanation for the productivity slowdown we are convinced that the tendency for emerging technologies to affect consumers directly means there is a strong need for improvements and complementary alternate GDP measurements.

For labour markets, a changing population structure due to ageing, a changing composition of the demand for skills, and new institutional arrangements in labour markets have all been related to aggregate productivity growth, yet none of these are found to be substantial enough to account for the productivity slowdown. In fact, labour productivity decompositions exercises tend to exclude labour quantity or quality as the main factor behind the slowdown, and point instead to slowdowns in TFP growth and capital deepening as the main culprits.

Investment, whether into tangible or intangible capital, does form part of the explanation. The impact of the recession on confidence and the availability of credit may still take time to recover, if it ever does. The role of intangible investment is an important research topic, because of the spillovers associated with them that could potentially tie the investment slowdown to the TFP slowdown.

Decomposing aggregate productivity, there is a consensus that while most sectors are affected and the sectoral shares have not changed enough, it is possible to identify a few sectors that are disproportionately responsible for the slowdown. At the firm level, the widening of the productivity and profitability distributions have raised several concerns: an increasing lack of competition has been detrimental to business dynamism and investment, and even though the technological frontier may not move as fast as before, diffusion is too slow to ensure catching-up and a better allocation of factors.

The slowdown in trade may have also damaged the rate at which domestic productivity accrues benefits from foreign completion and export markets through its many channels. Understanding how trade might recover in the future is particularly tricky under the global political environment. For this reason, low growth in trade may turn out to be a structural barrier to productivity growth despite an improvement in the global economy.

The role of institutions is one example of the factors not addressed, and could be particularly relevant for all countries. Faster technological change poses a growing challenge to regulations and existing institutional processes. Besides accelerating technological change, the financial crisis may have contributed to a further deterioration in institutions for advanced countries. A spread in mistrust in government and the financial sector undermines their legitimacy and thus effectiveness. Indeed, the political aftershocks are still being felt today, and do not seem to be attenuating. While the expectations set out in this paper are for aggregate labour productivity to improve slowly over the next few years, this is very much clouded in uncertainty.

Advanced economies are the focus of the paper, but the extension of our analysis to other economies is an important area for research. While some of the mechanisms presented above are relevant for developing and emerging economies, they are likely to be exposed to different dynamics. For example, it is questionable how long a reliance on cheap labour to attract foreign investment will remain a sustainable growth model for developing nations when an increasing amount of repetitive and rule-based employment, in manufacturing and services, is likely to be automated.

This paper provides a uniquely comprehensive although still not exhaustive identification of the many complex sources for economic growth and the productivity slowdown. Importantly, we draw on prior sector, industry or single country studies. We show that none of the previously identified single factors alone account for the slowdown. Coordinating microeconomic evidence to paint a macroeconomic picture is inherently challenging, yet necessary in this case due to the persistent failure of existing studies to go much beyond the Solow Residual in explaining the productivity slowdown.

Finally, faster innovation is not a given, due to a marked decline in research productivity. In addition, the current wave of new technologies may result in faster creative destruction and higher depreciation rates, and a wave of investment in new technologies that will take time to pay-off. This is particularly interesting, since it revolves around reconciling a slowdown in productivity growth and accelerating technological change. This implies that at times of more rapid technological change, higher rates of investment and renewal are required in both the hardware (capital equipment, infrastructure and so forth) and software (regulations, rules, processes) which become redundant more rapidly. The failure for both public and private investment, regulations and processes to keep pace with technological change is a compelling but not yet adequately understood potential reason for the slowdown in productivity.

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