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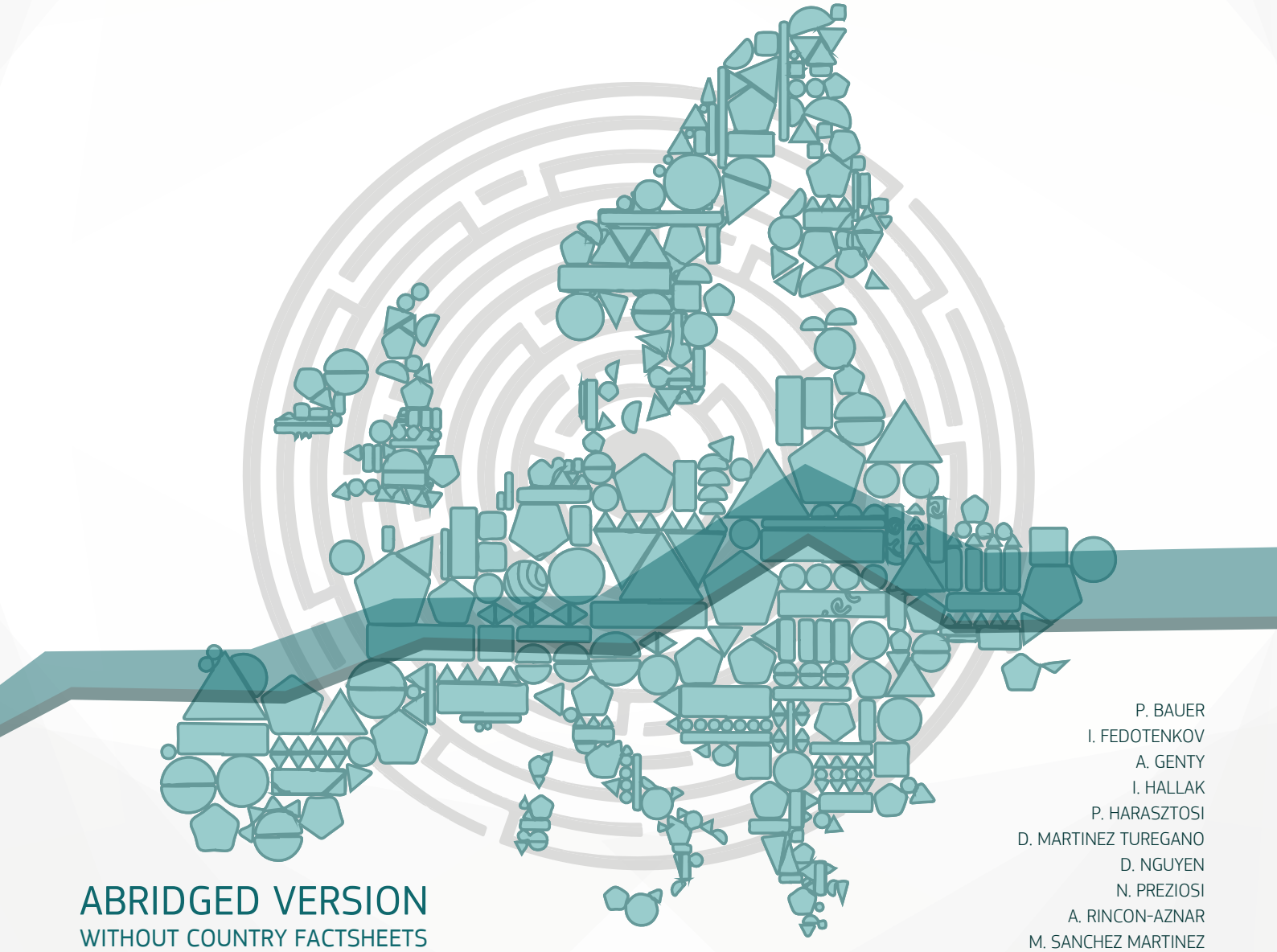
Productivity in Europe

Trends and drivers in a service-based economy



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Abstract

High levels of labour productivity growth are a key element to maintaining high standards of living in the long run in Europe. However, the EU has been experiencing a significant slowdown in labour productivity and total factor productivity growth, a phenomenon which has even exacerbated over the last decade, contrary to what would be expected in the recovery from the financial crisis. The trends and driving forces of the current sluggish productivity growth in Europe are analysed in this report with a special emphasis on services. After reviewing the literature in the field, the report zooms in on the role played by factors such as structural change, intangible investments, firm size distribution, firm demography, labour dynamics, zombie firms, business cycle dynamics and public expenditure and assesses their impact on productivity growth based on a variety of data sources and methodologies. The report focusses on the main results at EU level and includes some cross-country and cross-sectoral comparisons wherever possible.

Keywords: Productivity puzzle, Service sector, Labour productivity, TFP, Structural change, Intangible assets, ICT, Firm demography, Firm size, Zombie firms, Business cycles, Public expenditure.

JEL classification: D24, L80, O14, O47, O52.

Executive summary

Europe is currently facing sluggish productivity growth with no certainty about the real causes. The report analyses the trends in labour productivity at the EU[1], Member State, sector and firm levels and sheds some light on some of the main drivers. In particular, it investigates the role played by structural change, business cycle dynamics, public expenditure, intangible investments, firm demography, firm size distribution, labour dynamics and zombie firms.

Besides the well-documented Total Factor Productivity (TFP) growth slowdown, a reduced contribution from ICT capital also helps to explain the observed labour productivity growth weakness in EU services. Recent evidence points to both the deterioration in investment in physical and ICT capital and a lower contribution from the latter as major contributing factors to subdued productivity growth in services. A few service sectors, including wholesale and retail trade, business services, and to a lesser extent, financial services, were at the centre of the EU productivity slowdown around the mid-90s. At that time, when the U.S. experienced a productivity growth revival, in Europe these sectors missed many of the productivity growth opportunities offered by the ICT revolution, which explains most of the divergence in aggregate labour productivity between Europe and the US. Measurement error is also often put forward as one important explanation for declining productivity growth in the EU, spurred especially by the difficulties in properly capturing the rise of the digital economy. For instance, the inability to fully account for intangible capital assets can explain some of the differences in TFP across countries. However, the current consensus is that mismeasurement alone cannot explain the full extent of the productivity puzzle. Other factors that feature frequently in the literature on weak productivity growth include prevailing institutional and regulatory rigidities, which may induce misallocation of resources at various levels, as well as the low levels of innovation and internationalisation of firms.

Structural change has had a detrimental effect on long-term labour productivity growth in the EU15. An analysis using EU KLEMS data for the period 1970-2017 shows that the increase in the economic weight of the service sector at the expense of the primary and secondary sectors is the main reason behind this. Importantly, the size of this effect differs across countries – Italy and Spain being the most affected Member States – owing chiefly to differences in, one, the extent of aggregate sectoral shifts, two, the change in the weights of the different service subsectors, and, three, the intrinsic productivity performance of the different industries. Indeed, substantial heterogeneity is found in terms of labour productivity performance across different subsectors within services. In particular, labour productivity growth in sectors such as information and communication and financial services has in some instances outpaced that in agriculture and manufacturing. A growth accounting exercise shows in turn that TFP expansion is the main driver of labour productivity growth in these well-performing service sectors. The main policy implication resulting from this analysis is that the EU might be converging toward a *new normal*. In this scenario, slower secular economy-wide productivity growth will stem from large shifts in demand away from goods whose production technologies allow the realisation of continued productivity gains toward services with less inherent opportunities to do so.

Labour hoarding and rises in enterprise churn rates are found to be associated with future periods of positive labour productivity growth. When firms hoard labour, value added decreases faster than the employees lay-off rate. If output does not recover, firms then start to shed workers, and growth in labour productivity appears to revamp. On the contrary, when firms expect an upturn, thus expecting higher prospective demand, labour productivity initially drops due to the increase in the hiring rate, which is proportionally higher than the growth in value added; once the recovery materialises, labour productivity realigns with the rest of the economy. Thus, labour hoarding seems to be counter-cyclical and driven by firms' expectations about the business cycle. This result is based on a study that assesses the role of technology (through total factor productivity), enterprise dynamism (i.e. churn rate) and labour hoarding (i.e. under-utilisation) during specific periods of asymmetry in the growth rate of labour productivity and gross value added, typically assumed to be positively aligned. The analysis also shows that a moderate increase in the rate of enterprise churn might be beneficial for labour productivity growth; however, a too-steep rise can actually be correlated with lower labour productivity growth, particularly in the event of high labour utilisation.

Government expenditures have a greater bearing on productivity growth in business services than in industrial sectors. We find that higher government expenditures for economic affairs are associated with

[1] The UK is included in the analyses carried out in the report.

higher productivity growth. This effect is especially significant in business services. This result is quite intuitive given that such expenditures include infrastructure investment, which supports economic growth. Conversely, defence expenditure has a negative effect, which can potentially be explained by an expansion in the shadow economy, higher corruption and crowding-out effects on other public purchases. The impact of other public expenditure categories on productivity is, however, less clear. An increase in expenditure on social and environmental protection seems to be linked with a negative effect on productivity growth in business services; however, these findings are less robust. Our analysis also suggests that better quality of institutions has a positive effect on productivity growth in services.

Intangible investment is an important driver of labour productivity growth in the EU15 and needs to be better accounted. We estimate production functions augmented with intangible capital using a country-industry panel. We consider an extended set of intangible assets as production factors including, amongst others, design, brand, organisational capital and training. The relationship between intangible investment and productivity growth is heterogeneous in terms of asset type and sector. National Accounts intangibles, such as R&D and software, remain key for manufacturing while non-National Accounts intangibles, which include economic competencies, are more important for services. Given the highly predominant share of services in European economies, this result highlights the importance of investing in non-National Accounts intangibles, while underlining the importance of duly accounting for them. Greece, Italy and Germany are amongst the countries most concerned by under-investment in intangible assets.

Business dynamism in services, and specifically entry rates, declined across the board in Europe over the last decade. This finding based on SBS data is in line with existing evidence showing that several advanced economies already experienced a long-term decline in business dynamism well before the crisis. Our analysis shows that entry rates significantly declined between 2008 and 2017 in a number of Member States. In addition, the decline appears to be more country specific than sector specific.

This observed declining business dynamism may be a drag on productivity growth. Based on different data sources, our results show that higher entry rates improve productivity growth. Furthermore, the combined impact of entrant and exiting firms is an important driver of productivity growth.

A lower average firm size appears to be detrimental to labour productivity in a few EU Member States. We develop a decomposition analysis that splits sectoral productivity in a set of Member States relative to the EU aggregate into differences in the firm size distribution and differences in the productivity level within each firm size class. In general terms, the latter play by large the most important role in explaining differences across Member States. Nevertheless, we find that having a firm distribution skewed to smaller firms seems to be significantly detrimental for productivity performance in some EU countries, particularly Greece and Italy. From a policy perspective, we confirm findings from the related literature that points to the importance of the institutional framework – judicial and government efficiency in particular – in determining countries' firm size distributions. Improving this framework could thus prove relevant in stimulating productivity growth, especially in countries where the firm size distribution has a major effect on productivity.

Labour reallocation patterns across firms observed in the EU are consistent with increasing allocative efficiency. Allocative efficiency of labour measures to what extent labour input is used by more productive firms compared to less productive ones. Allocative efficiency thus positively contributes to aggregate productivity. In our study, based on a firm-level data analysis of the manufacturing and service sectors in 15 Member States, we find that the productivity level of firms was positively correlated with job creation in the period analysed (2007-2013). Conversely, low productivity firms destroyed more jobs than high productivity firms, albeit the difference is lower than for job creation. These two observations are thus a signal of an increase in allocative efficiency during the period considered. Sectors vary considerably in job destruction and creation patterns, however, likely reflecting various degrees of competition. The manufacturing and info-communication sectors exhibit the strongest productivity enhancing labour reallocation patterns; the administrative services sector exhibits the weakest. The productivity gap between firms by growth status (growing, stable, shrinking, entering and exiting) varies substantially across countries. Finally, the average productivity of entrant firms is lower than that of incumbents. Successful entrants however manage to close this gap within a few years.

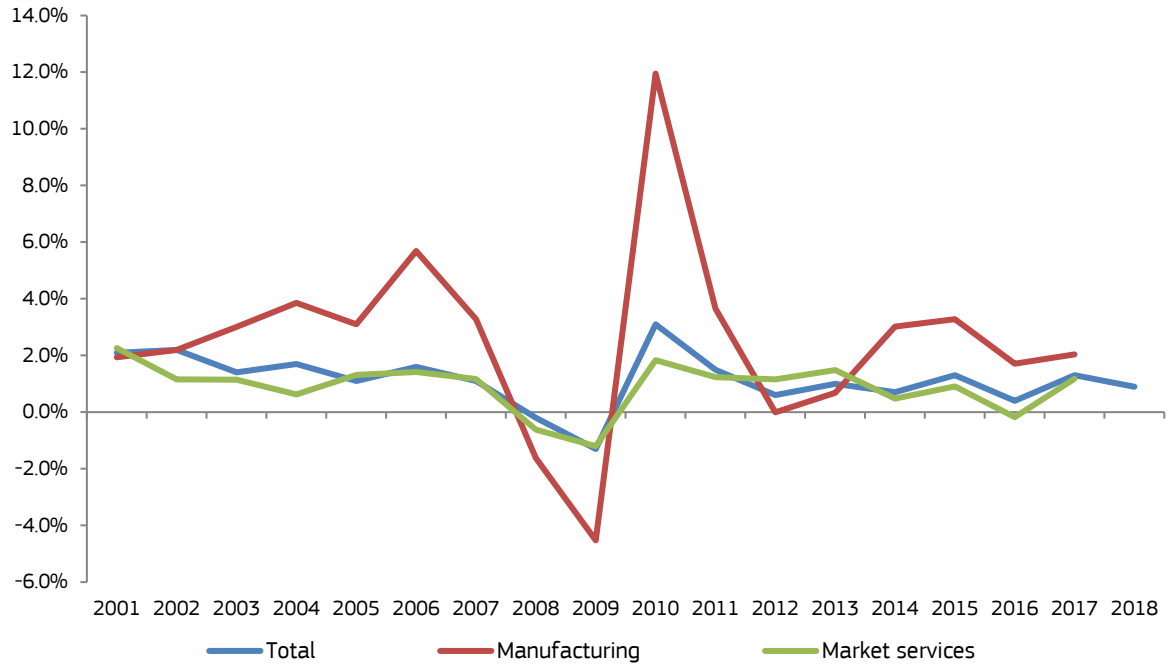
Zombie congestion has a negative impact on the economic performance of healthy firms in Europe. Zombies are defined as firms which are at least ten years old and report an interest coverage ratio below one in three consecutive years. We conduct an empirical analysis using a sample of firms in 14 EU countries in the period 2006-2015. In line with previous studies, the results show relatively higher shares of

zombie firms after the crisis, in particular in Portugal, Italy and Spain, but also in Member States such as France, Sweden and Finland. The shares of zombie firms are similar in the service sector and in manufacturing. Our results show that zombie congestion (i.e. high share of zombies in an industry) harms non-zombies in the same industry in terms of employment growth, investment and productivity. In addition, these adverse effects are stronger in the service sector than in manufacturing in most countries. Finally, we find that young non-zombie firms are less affected by zombies than old non-zombie firms in the case of employment and investment but relatively more strongly impacted in terms of productivity.

1 Introduction

Productivity in general and labour productivity in particular ranks high on the political agenda for quality job creation and growth. In its Annual Sustainable Growth Strategy 2020, the European Commission (2019) identified productivity gains as one of the four dimensions of EU economic policy which should guide structural reforms, investment and responsible fiscal policies in the years to come. In the long run, labour productivity growth is often seen as instrumental in maintaining high living standards in Europe. However, over the past twenty years, the EU has experienced a significant slowdown in both labour productivity and total factor productivity trend growth. Aggregate labour productivity growth was already quite low before the 2008-2009 crisis and has been even lower in the aftermath, since 2011-2012 (Figure 1)[2]. In the most recent years, productivity growth has been around 1 % per year. At sectoral level, labour productivity growth appears to be much more reactive to business cycles in manufacturing than in market services.[3] It can also be observed that the service sectors have a much lower productivity growth profile compared to manufacturing.

Figure 1. Growth rate of labour productivity (GDP per hour worked) in EU28 (%).



Source: EU KLEMS, 2019, for labour productivity in manufacturing and market services and Eurostat for the total economy.

This sluggish productivity growth, which is observed in most major economies (see, for instance, Gordon, 2016), is often referred to as the 'productivity puzzle' as there is no certainty about the real causes behind it, not least because we would have expected productivity growth to pick up after the financial crisis. In order to identify potential policy levers and draw policy recommendations, it is fundamental to analyse the potential root causes of low labour productivity growth. A comprehensive list of such questions includes: how does the on-going tertiarisation of the economy impact on productivity growth? Which type of capital investment could lead to higher levels of productivity growth? To which extent the education and skills of workers impact productivity? What is the size of the impact of innovation on productivity growth? Are resources efficiently allocated in the economy to spur productivity gains and, in particular, is human capital flowing well from less to more productive firms? Does firm size matter for productivity and to which extent? How does the business environment influence firm productivity? Is there enough competition in Europe? Is the Single Market delivering well on productivity gains? Is there a specific set of detrimental firms in the economy which can

[2] The peak in economy-wide labour productivity growth in 2010, around 3.1%, can be attributed to a base effect following the negative growth registered during the crisis.

[3] Market services comprise wholesale and retail trade, transportation and storage, accommodation and food, information and communication, financial and insurance activities, real estate, and professional, scientific, technical and administrative activities.

lead to crowding out of more productive firms? What role can public expenditure play in the productivity performance of private businesses? At the same time, are there any significant measurement issues for key variables which could lead to erroneous conclusions? These are some of the questions that are addressed in this report to attempt at untangling and better understanding the productivity puzzle.

Specifically, this report aims at shedding light on the trends and major drivers of productivity growth in Europe across sectors. Due to the ever increasing role of services in the EU economy, together with the fact that the problem of slow productivity in this sector is especially acute, the report puts a special emphasis on service sectors. The report focuses mainly on analyses at the EU level but also includes some cross-country comparisons wherever possible. Country-specific factsheets in annexes[4] supplement the report by giving more insights at Member State level to support country knowledge on selected topics and inform the European Semester process. The report is structured as follows.

Section 2 of the report provides a thorough overview of the literature that examines trends and drivers of productivity, with a special focus on the service sectors. The main issues investigated encompass the role of human capital (education and skills), physical capital (ICT and intangibles), innovation and internationalisation, business environment (regulation and competition), and measurement issues.

Section 3 inquires into the effect of structural transformation on long-term labour productivity performance in Europe. It quantifies, in the context of the EU-15 countries, the part of the decline in labour productivity growth in the period 1970-2017 that can be attributed to structural change. In addition, it provides some insights on the factors behind the observed heterogeneous impact of structural change across EU Member States at the sectoral level. At the same time, it tests the hypotheses stemming from Baumol's (1967) theory on the so-called *cost disease*.

Section 4 scrutinizes the potential impact of business cycle dynamics on labour productivity in the EU, with a focus on the manufacturing, information and communication, and professional services sectors. It assesses the pro/counter-cyclicality of productivity in these sections, and hints at the possible underlying causes in some Member States.

Section 5 looks at the impact of public expenditure on labour productivity growth in both market services and manufacturing, showing rather differing results, in particular as regards the effect of the institutional quality.

Section 6 analyses the importance of intangible investment (computerised information, innovative property and economic competencies) on productivity growth in the modern economy. One novelty of this work is the investigation at sectoral level of the role played by intangibles that are not recorded in the National Accounts, which include brands, organisational capital and training. The contribution of the growth of intangible capital (decomposed into National Accounts and non-National Accounts intangibles) to productivity growth is estimated for a set of countries. The productivity effect of an additional one percentage point increase in intangible investment-to-value added, as a measure of the relevance of additional intangible investment, is also quantified at Member State level.

Based on meso- and firm-level data, respectively, Section 7 and Section 8 seek to disentangle the role that weaker business dynamism might play in explaining lower labour productivity, in both levels and growth rates. In Section 7, the impact of entry and exit rates of firms on labour productivity is examined at EU, national and sectoral level, as well as broken down by firm size. Then, a novel decomposition analysis at Member State level splits sectoral productivity differences relative to the benchmark of the EU average into differences in the sectoral composition of the economy, firm size distribution, and differences in the productivity level within each firm size class.

Section 8 compares in a cross sector and cross country analysis how employment flows between firms, with paying particular attention at whether labour flows from the less productive to the more productive firm. In a second step, the detrimental effect that so-called zombie firms bear upon the economy, both directly, through the drag they represent as poor performers, as well as through the economy-wide negative externalities they impose on more productive firms, is assessed.

Finally, Section 9 contains concluding remarks.

[4] The list of Member States covered in the factsheets includes: Belgium, Czechia, Denmark, Germany, Greece, Spain, France, Croatia, Italy, Netherlands, Austria, Portugal, Romania, Finland and Sweden.

2 Productivity in European service sectors: A review

This section presents an overview of the literature that analyse drivers and trends in productivity. A focus is placed on empirical studies that examine productivity in services in the European context. In a first step this section looks at the origins of the productivity slowdown in the EU as well as more recent trends and developments. It then goes on to examine the role of education and skills and the contribution of ICT and intangible assets. This is followed by a deep dive into the connection between internationalisation and innovation and issues around regulation. This section closes with a discussion of measurement issues in productivity, again, with a focus on service sectors.

2.1 Overview of productivity trends in services

In this section an overview of labour productivity developments in the EU since the 90s is provided, with a particular focus on the service sectors. We also aim at summarising the main results from the literature that investigates the sources of the productivity gap that has arisen vis-a-vis the US.

2.1.1 The EU productivity slowdown and its drivers

Poor productivity performance is widely regarded as the main culprit of the European growth slowdown since the mid-1990s[5] (van Ark et al., 2008; Timmer et al., 2010; Mas and Stehrer, 2012). It is around that time that labour productivity in Europe started falling behind the United States (U.S.), reversing a previously observed pattern of convergence between these two economies. The U.S. experienced a productivity growth revival, while Europe missed out on many of the productivity growth opportunities of the information and communications technology (ICT) revolution. As a result, a significant labour productivity gap opened up between the US and the EU. By 2005, value added per hour worked in the EU had dropped to only 70 per cent of the U.S. level. In addition, the market services part of the economy started to account for most of the labour productivity growth gap between the US and the EU.[6]

A boost in investment in ICT capital, alongside robust growth in labour quality,[7] contributed substantially to labour productivity growth in market services during the late 90s and early 2000s (Inklaar et al., 2008). This was observed across the US and Europe. In some European countries, such as Denmark and the UK, the contributions made by ICTs to labour productivity were of similar magnitude to those in the U.S., while others, such as Italy and Spain, experienced significantly lower but still positive contributions.

However, Europe did not experience as substantial a boost in TFP (Total Factor Productivity) growth as in the US did.[8] Many studies concur that a few service sectors were at the centre of the divergent aggregate labour and total factor productivity performance (Inklaar et al., 2007; 2008; Timmer et al., 2010). Buiatti et al. (2018) identify wholesale and retail trade and business services, and to a lesser extent financial services, as the sectors driving most of the aggregate labour and total factor productivity gap.

The origins of the labour productivity slowdown

A recent study by Gordon and Sayed (2019) digs deeper into the origins of the slowdown in labour productivity growth, drawing from the EU KLEMS 2017 release.[9] They compare the case of the U.S. with that

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5 Before then there was not much evidence on the sources of cross-country productivity differences at the level of industry sectors. Research focusing on the services sector was particularly scant, which stood in contrast with a larger number of works for the manufacturing sector. The development of the EU KLEMS database, which provides harmonised industry-level data for the EU and the U.S. and other major economies, was key in facilitating the emergence of comparative cross-country cross-industry studies. It enabled the analysis of trends in employment, capital, labour and total factor productivity as well as the analysis of price movements and changes in industry structure over a period of thirty years (see O'Mahony and Timmer, 2009; O'Mahony and Van Ark, 2003).

6 The extent to which the performance of the services sector drags on the overall economy can be gauged by applying the method put forward by Stiroh (2002) and others (Jorgenson and Timmer, 2011). It is possible to compute the contributions of an industry to an economy's productivity growth rate by weighting up the sectoral labour productivity growth rates, using the period-average shares in aggregate value-added.

7 Labour quality serves as a proxy for the contribution of human capital to labour productivity growth in the growth accounting methodology.

8 These industries are mainly wholesale and retail trade, financial services, and some business and professional activities.

9 Data available at : http://www.euklems.net/

of Western European economies, going back to the 1950s. When comparing the early post-World War II years to the most recent decade, these authors conclude that there has been a substantial productivity growth slowdown, due to the slower pace of technological change, affecting both blocs of economies. The timing was slightly different, but the same industries have been affected both in the US and Europe.

They illustrate the performance of a group of 10 EU economies[10] that have been catching up with US technology adoption in different stages. During 1950-1972, rapid European growth reflected the adoption of the inventions that had propelled productivity growth in the U.S. during the first half of the 20th century. The following period of 1972-1995 was characterised by the imitation of the U.S. technology during the period 1950-1972. This is supported by the observation that the difference in EU productivity growth achieved in the period 1972-95 in relation to that in the period 2005-2015 (-1.68 percentage points) exactly matched the slowdown in U.S. productivity growth during the period 2005-2015 relative to its 1950-72 average growth rate. They find a strong EU-US correlation across industries in the dynamics of what they call "*early-to-late*"[11] change. Somewhat surprisingly, the above study found a dominant role for commodities in driving the slowdown in both the US and EU. This is mainly explained by a *"further to fall"* effect given the high labour productivity growth rates achieved by the commodities sectors in earlier decades (1950-72 for the US and 1972-95 for the EU-10).

While the EU had been successful in catching up with labour productivity growth rates in the US in the boom post-War periods, it failed to do so after 1995, despite a similar adoption speed of ICTs. There was some stimulus to productivity growth from the ICT-intensive industries in the EU after 1995, but this was not large enough to offset the decline in growth experienced by the non-ICT industries, particularly after 2005.

The role of structural change

Over the last decades most developed economies have undergone processes of structural change, with significant sectoral reallocations of labour away from agriculture and manufacturing and into the services sector (Herrendorf et al., 2013; 2014). The agricultural sector has become smaller, while services now comprise about three-quarters of GDP. Many have argued that these changes in industrial structure may help explain the relative stagnation or decline of aggregate productivity. This is due to the effect of shifts to more sluggishly growing productivity sectors (Dabla-Norris et al., 2015) as both the level and the growth rates of productivity in the service sector are notably below that of manufacturing[12] (Duarte and Restuccia, 2010). The services sector has traditionally been characterised by a limited scope for innovation and technical change, and this can explain historically lower productivity growth rates, compared to manufacturing.

Covering the period from 1980 to 2005, Jorgenson and Timmer (2011) emphasize that the analyses of structural change increasingly requires a radical shift of emphasis. They argue that the split of economic activities into agriculture, industry, and services has lost most of its relevance[13]. Most disaggregated industry analyses reveal substantial heterogeneity within the services sector itself, which is highly diverse in terms of labour productivity performance. Duernecker et al. (2017) show that productivity growth has grown rapidly in some service sectors but has been declining in others that have experienced an increase in economic weights. The latter are mainly non-market services along with finance and business services, which may more closely follow a classical pattern of low productivity growth, rising relative prices, and increasing shares in employment and GDP, as posited in Baumol (1967).

Buiatti et al. (2018) analyse labour productivity performance for both Europe and the US using a structural transformation model, which explains processes of labour reallocation across sectors as well as the observed time paths of aggregate labour productivity. They argue that the reallocation of labour towards the various types of services in the EU has followed a similar pattern to that in the U.S. Firstly, they find that a large increase in the labour share in services has been driven by business-to-business services. Second, they find a

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[10] The countries in included in their analysis are: Austria, Belgium, Denmark, France, Germany, Italy, the Netherlands, Spain, Sweden, and the U.K.

[11] The *"early-to-late"* slowdown refers to the change in U.S. productivity growth from 1950-72 to 2005-15 and to the change in EU-10 productivity growth from 1972-95 to 2005-15.

[12] One of the other empirical regularities documented by Kuznets (1971) and Maddison (1980) in the structural transformation of advanced economies is the slow growth of labour productivity in services compared to industry.

[13] The stylised facts of Kaldor (1961), Kuznets (1971), and Maddison (1980), emphasised the trichotomy of agriculture, manufacturing, and services.

much more important role for business services and a smaller role for finance in the EU productivity slowdown than prior studies have suggested.[14]

The bulk of the evidence shows that the main driving force behind the negative impact of structural change on declining productivity growth appears to be 'within' stagnation in those sectors which increasingly account for the lion share of employment and economic activity (Dabla-Norris et al., 2015).

2.1.2 Recent productivity developments in selected EU countries and industries

Van Ark and Jaeger (2017)[15] investigate whether the global financial crisis (2008/09) and the Euro Area recession (2011/12) have significantly damaged the growth potential of European economies[16] due to a slowing demand, weak investment, and the structural rigidities present in product, labour and capital markets (Van Ark, 2016a; Van Ark and O'Mahony, 2016). Before the global financial crisis (between 1999 and 2006), real GDP grew by 2.6 per cent per annum in the EU as a whole. However, between 2007 and 2016 the growth rate decreased to 0.9 per cent. In both periods, Europe's average growth performance was below that of the US, which had recorded an average GDP growth of 3.4 per cent in the 1999-2006 period, and 1.5 per cent between 2007 and 2016.

Most EU economies have not matched their pre-crisis output growth performance. The services sector, which has continued to increase its weight in European economies, recovered slightly better from the crisis in terms of output growth, compared to the manufacturing sector. During the post-crisis period 2011-2015, output in market services recovered slightly more in Germany (growing at 1.8 per cent) than in France, (growing at 1.4 per cent). Fostered by the stronger skill improvements in service sector jobs, France saw a higher contribution from labour inputs to market services growth (Askenazy and Erhel, 2016). In contrast, the German labour market reforms in the early 2000s promoted lower-skill jobs. The UK market services sector saw the best growth performance of the large EU economies in during 2011-2015.

Based on the EU KLEMS 2017 release, Figure 2 illustrates the evolution of labour productivity (growth in value added per hour worked) for a range of EU services sectors (at NACE Rev. 2 section level) during the period 2000-2015. The graph shows that prior to the financial crisis, there were some services sectors that experienced strong labour productivity growth in the EU. This is the case of the information and communications sector (J), growing between 4 and 6 per cent annually in the early 2000s, as well as the finance sector (K).

The labour productivity growth performance of the transport and storage and the wholesale and retail sector was remarkable as well. Nevertheless, the pre-crisis labour productivity growth performance of other EU services sectors was more disappointing. This is the case of the professional, scientific, administrative and support activities sector (M-N), the accommodation and food services sector (I) and the arts and recreation sector (R-S). Labour productivity growth rates collapsed in the aftermath of the financial crisis and have experienced a recovery since. Wholesale and retail and information and communication services are among the best- performing sectors since 2009.

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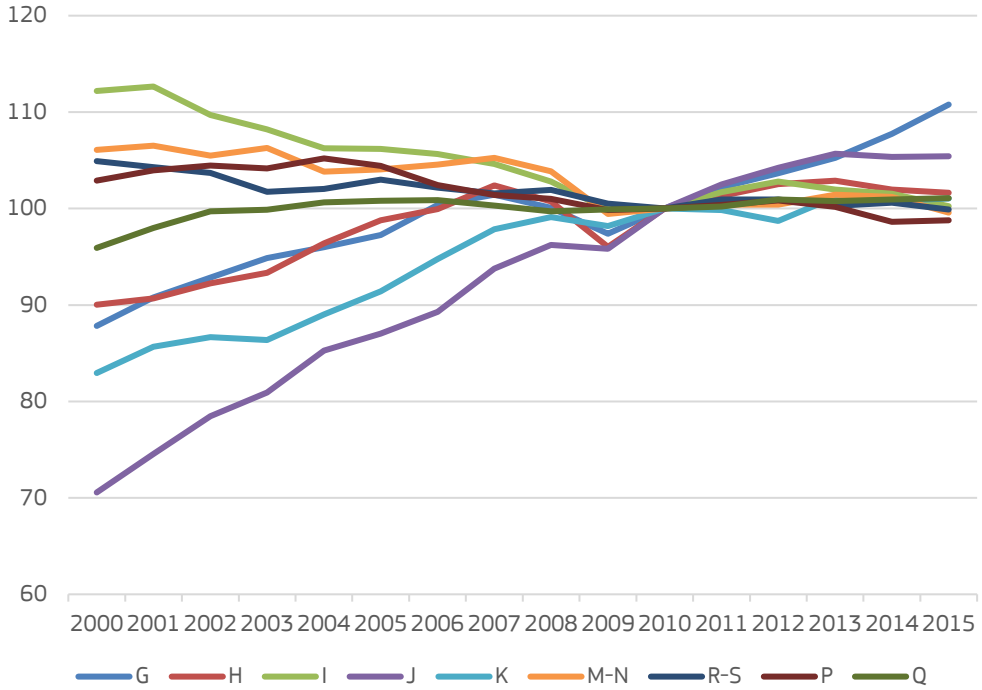
14 In comparison to other previous paper using growth accounting techniques and shift-share analyses.

15 Also using a recent EU KLEMS data release[15].

16 Their analysis extends to 2015, and includes total of 12 EU economies, accounting for 90 per cent of the EU's GDP (measured in nominal terms, in 2015). These are Austria, Belgium, Czech Republic, Denmark, Germany, Finland, France, Italy, the Netherlands, Spain, Sweden and the United Kingdom.

Figure 2. Labour productivity growth (indexed 2010=100) in EU-28 services sectors, 2001-2015.

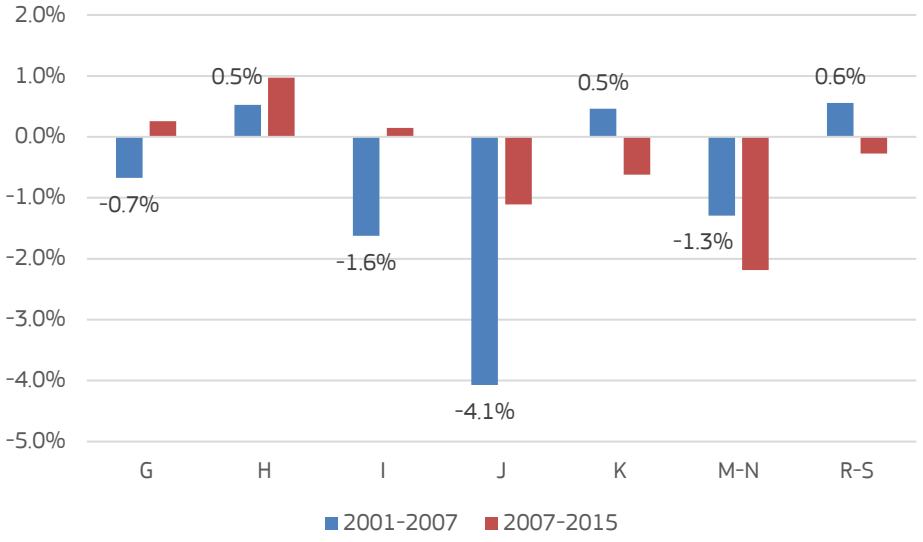


Note: G: Wholesale and retail trade; repair of motor vehicles and motorcycles; H: Transportation and storage; I: Accommodation and food service activities; J: information and communication; K: Financial and insurance activities; M-N: Professional, scientific, technical, administrative and support service activities; P: Education; Q: Health; R-S: Arts, entertainment, recreation and other service activities.

Source: Own elaboration based on EU KLEMS 2017 release; labour productivity in terms of gross value added per hour.

In order to understand the relative under-performance of Europe with respect to the US, it is crucial to break down the service sector as a whole. Figure 3 illustrates the difference in average labour productivity growth rates between the EU-28 and the US. This is shown for the periods 2000-2007 and 2007-2015, for a number of service sectors. This graph shows that the EU has improved its labour productivity performance relative to the US in a number of industries, including wholesale and retail, and transport and storage. In contrast, the EU continues under-perform in industries such as information and communication activities, but the labour productivity growth gap has become smaller. EU labour productivity growth in the finance sector is underperforming vis-à-vis the US to a larger extent than before the global financial crisis. This is also the case of the professional, scientific, technical and administrative activities sectors and the arts entertainment and recreation sector, that have continued to exhibit disappointing productivity.

Figure 3. Difference in average annual labour productivity growth rates between the EU-28 and the US (in percentage points); Services industries at 1-digit level, 2000-2015.



Note: G: Wholesale and retail trade; repair of motor vehicles and motorcycles; H: Transportation and storage; I: Accommodation and food service activities; J: information and communication; K: Financial and insurance activities; M-N: Professional, scientific, technical, administrative and support service activities; R-S: Arts, entertainment, recreation and other service activities.

Source: Own elaboration based on EU KLEMS 2017 release; labour productivity in terms of gross value added per hour.

Buatti et al. (2018) provide an account of the relative levels of sectoral labour productivity between the EU and the US, and also estimate the contributions stemming from information and communication technology (ICT) capital, and sectoral total factor productivity (TFP). Their findings indicate that European countries are generally more productive than the U.S. in communication, education, real estate, and health services. At the same time, EU countries are on average less productive in wholesale and retail trade and business services, with sectoral labour productivity levels of approximately 20 below of that of the U.S. They show that a lack of physical capital investment has played an important role in explaining the productivity level gaps between Europe and the U.S.

An important conclusion is that the relative levels of physical and ICT capital endowment per hour worked in the European service industries (mainly wholesale and retail trade and business services) have fallen significantly. Consistent with most of the earlier evidence, however, the authors find that the biggest part of the productivity gap between Europe and the US in services is due to TFP differences in these industries.

In contrast with manufacturing, growth in market services' TFP has recovered to pre-crisis rates in many sectors. Nevertheless, it still lies below TFP growth in manufacturing. Slower TFP growth, which was already visible in most European market services sectors before the crisis, broadened to the goods-producing sector in the last decade. Many experts agree on the fact that TFP growth remains the *Achilles' heel* of Europe's growth performance. The weakening in TFP growth is likely to be a reflection of a number of factors. For example, the slow diffusion of technology and innovation, and the weak growth of ICT capital and other important investments (e.g. in intangibles) in productivity-related capital. Moreover, the pace of global technological innovation appears to be in decline, while the catching-up speed of laggard countries and firms has also slowed down (Andrews et al., 2015). These trends point to the need for a more in-depth examination of the factors underlying stagnant or declining TFP growth.

There is also the view that it may be too early to judge whether output and productivity growth rates are still recovering to pre-crises rates, or whether growth in Europe will follow a slower long-term trend.[17] TFP growth in the market services was substantially stronger in Germany than in France during the period 2011-2015[18] and different factors may be at play. Germany's market services sector may have benefited from the

[17] However, both output and labour productivity growth rates in market services in 2011-2015 were still at about half of the 2002- 2007 growth rates (Van Ark and Jaeger, 2017).

[18] This is the most recent productivity data for the services sector

economy's integration into global value chains (van Ark et al., 2013). Compared with France and Germany in particular, other EU countries such as Italy and Spain have seen a slower recovery in market services. TFP growth in market services in Italy was flat from 2011 to 2015 and reached only 0.1 per cent per annum in Spain during the same time period.

2.2 Education and skills

The common assumption that labour quality (with a prime role for skills) is the main engine of productivity growth is relativised by evidence from growth accounting studies, which have shown that this factor is not able to explain much of the cross-country differences in labour productivity between the EU, US and Japan (Timmer et al., 2010). In the EU, 13 per cent of total labour productivity growth can be attributed to labour quality improvements during the period 1995-2005, while in the US the equivalent figure stood at 10 per cent. In countries like the US and the UK this was mainly driven by the increasing share of the workforce with tertiary education. There has been an increase in the average education levels of the EU's main economies comparable to that in the US, and skills deepening has played an increasingly important role. When considering the impact of ICT on productivity growth, the relative sluggishness in ICT diffusion in continental Europe compared to the US documented could have been partly driven by the slow pace of growth in ICT-related skills.

The processes of structural change taking place in modern economies not only have entailed changes in output and productivity (as analysed by Kuznets (1971) and Maddison (1980)), but also shifts in the mix of inputs used in the production process. Kaldor's most influential stylised fact is that the labour share in GDP is relatively stable over time (Kaldor, 1961). As a result, the demand for different types of skills is also changing over time, mainly driven by technological and organisational change. As discussed above, the latest large technological shift was caused by the diffusion of ICTs and the corresponding automation and augmentation of some tasks more than others. However, there are other challenges related to the environment, ageing population and social inclusion that require constant reskilling efforts (Cedefop, 2019). Generally, it is the role of the educational system to help workers acquire the necessary skills via training or retraining programmes. Cedefop (2019) estimates that around 128 million adults in the EU (as well as in other European countries such as Iceland and Norway) would benefit from up- or reskilling, highlighting the importance of digital and cognitive skills, in order to avoid skill obsolescence.

A study by Jorgenson and Timmer (2011) suggests that technical change has favoured inputs that complement the generation, processing, and diffusion of knowledge and information, namely, skilled labour and ICT capital. The authors show that the shares of skilled labour compensation and ICT in value-added have increased substantially in all sectors over time in both the US and the EU. This points to common patterns in the process of knowledge intensification of production, though they find large differences across industries. In all regions, manufacturing and other goods production are among the least skill- and ICT-intensive industries, while they are highest in services and in particular finance and business services. O'Mahony et al. (2008) also consider the issue of skill-biased technological change in the US, UK and France, and show that at least in the US and UK the higher demand for skilled labour is slowing down. Following the authors, this suggests that the bias could be transitory rather than permanent.

There is nonetheless a concern that growth accounting methods may not appropriately capture the contributions made by skills to productivity performance (Timmer et al., 2010). This is because they cannot take full account of *complementarities* between production inputs such as ICTs, skills and intangibles. Further, the full extent and nature of the contribution of skills to productivity growth remains hard to evaluate due to the many methodological issues that are still unresolved (Mason et al., 2018). These refer in particular to the way skills are measured and the most appropriate ways of modelling the potential channels of influence of skills on economic performance.

Finally, it is important to highlight that some service sectors appear to rely more on skills than others, which means that the sectoral composition of a country also matters when analysing the contribution of skills to aggregate productivity. For example, in a recent study on Portugal, Simões et al. (2019) investigate the link between sectoral productivity, services sector expansion, human capital, and aggregate productivity for the period 1970-2006. The most revealing finding they present is that, somewhat counter-intuitively, it is non-market services (i.e. community- and personal services including health and education) that positively contribute to aggregate productivity, while market services do not. The authors explain this by the fact that market services (i.e. financial and business services) have a low weight in the Portuguese economy and require higher levels of human capital, which they are unable to find locally.

In this section we have shown that Europe has seen an increase in the share of graduates in the workforce, which has positive contributed to labour productivity gains. However, not enough research has been carried out on whether different sets of skills, sometimes not captured by formal certification, may be needed to further exploit the potential of ICTs and complementary intangible assets, so as to be aligned with those skills demanded by employers.

2.3 ICTs and intangibles

Building from the evidence on the traditional drivers of labour productivity growth provided in the first section (capital deepening, labour quality and TFP) and their changing importance over time, this sub-section explores empirical evidence on the role of intangible and ICT capital (see Section 4 for a detailed analysis on the role of intangible assets in labour productivity). The first part summarises key evidence on the drivers of cross-country productivity differences, mainly relating to service sectors. What emerges is that empirical works have shown that mainly TFP and not factor intensity was the key to explain the widening labour productivity growth differential between the US and the EU. However, it is possible that some of these TFP differences were driven by other capital assets of intangible nature, not specifically accounted for in the empirical growth accounting models. Studies have considered a range of intangible assets that are assumed to boost productivity. Some of them have already been included in harmonised databases such as EU KLEMS (e.g. software), and some of them are still unaccounted for (e.g. organisational capital, training, design, financial innovation). Van Ark and Jaeger (2017) argue that a slow updating of equipment of certain types of intangible capital, such as R&D, and training and economic competencies, such as brand equity and organisational capital, may have hampered TFP growth in Europe.

This section discusses investment in ICT and intangible assets jointly, as they are closely related. On the one hand, some investments in ICT can be considered intangible (e.g. software, databases) while on the other hand they are often considered to be complements, due to ICT exhibiting many characteristics of a general-purpose technology (Brynjolfsson and Hitt, 2000; Brynjolfsson et al., 2002). Various studies argue that European economies have so far been unable to benefit as much from reorganisations associated with ICT as the U.S. (e.g. Matteucci et al., 2005), but could hold a 'hidden' potential to unleash new growth opportunities. Atkinson (2018) finds that, particularly service sectors in Europe have for various reasons invested relatively less in ICT capital when compared to their US counterparts. These include higher upfront costs due to product and labour market regulations, levels of taxation and depreciation rates, market fragmentation inhibiting economies of scale, and different management practices (Atkinson, 2018).

According to Uppenberg and Strauss (2010) intangible investment plays a crucial role in service sector productivity growth, while empirically there exist large differences in investment rates across EU countries. Corrado et al. (2018) compare the share of intangible to tangible investment across manufacturing and services sectors in the US and EU. For the US they report a ratio of 1.25 for service sectors, which is only 0.85 in the EU-14 and as low as 0.53 across for four new member states (Czech Republic, Hungary, Slovenia, Slovakia). However, across all three groups of countries the share of intangibles to tangibles is higher in services than in manufacturing. The different uses of ICT between Europe and the U.S., and its impact on labour productivity, is also the main conclusion reached by Bloom et al. (2012).

The relative dearth of early empirical studies on a broader range of countries and types of intangible assets was overcome following the seminal work by Corrado et al. (2009), which provided a methodology for measuring business investment in intangible capital. Hao et al. (2009) and van Ark et al. (2009) use growth accounting methods for four and ten EU countries, respectively, to find that intangible investment positively contributes to labour productivity growth. More specifically, van Ark et al. (2009) find that intangibles contribute around 0.1-0.2 percentage points per year to labour productivity growth in Spain, Italy and Greece, 0.4-0.6 in Germany, France and Austria, and 0.7 in the UK, Denmark and the Czech Republic. A full overview of cross-country studies on the link between intangible investment and productivity growth is provided in Table 1.

Later studies by Roth and Thum (2013) and Corrado et al. (2013) expand on these by including thirteen to fourteen EU countries. They demonstrate that intangible investment can explain around a quarter to half of labour productivity growth during different time periods. Corrado et al. (2013) also demonstrate that ICT and intangibles are complementary to each other in their contribution to labour productivity. However, both studies do not break their estimates down by sector due to lack of data.

The first studies to examine the relationship between intangible capital investments, ICT and labour productivity growth at the sectoral level are Chen et al. (2016) and Niebel et al. (2017). Chen et al. (2016) use data from the INTAN database for ten EU countries to uncover a positive relationship between intangibles and

labour productivity growth. Their regression analysis also shows that intensity of ICT use is complementary to investment in intangibles. Niebel et al. (2017) find that intangibles contribute more to labour productivity growth in financial services relative to other sectors across ten EU countries. Intangible investment is also found to be important in manufacturing (apart from Italy and Czech Republic) and business services (mainly UK and the Netherlands). The contribution of intangible investment in the wholesale and retail trade sector is important in the UK, Finland and Spain, while they matter more in the construction sector in the Czech Republic. Interestingly, it appears that studies which also control for sector differences tend to find lower overall elasticities between intangible capital and growth in labour productivity. In addition, they uncover large differences across sectors (within countries) and within the same sector (across countries).

Edqvist et al. (2019) look at whether there are indirect effects from growth in communications capital on TFP via network effects or spillovers. They also look at spillovers from IT hardware and R&D activity. Their results show that there is statistically significant correlation between lagged communications capital and TFP which points to the existence of network effects or spillovers. They find that these network effects are economically significant and could potentially account for a one-third of total TFP growth in Northern European economies, two-thirds in Scandinavian economies, around one fifth in France, Italy and Spain, and nine-tenths in the US. They also interpret these estimates in the light of the productivity slowdown of the last decade. They find that it only explains 9 per cent of the overall slowdown in the US, while around 50 per cent of the US slowdown.

Table 1. List of studies on intangibles and productivity for multiple EU countries.

Study	Period	Countries	Sectors	Methods	Findings
Hao et al. (2009)	1995-2003	5 EU MS	n/a	Growth accounting	Intangible investment contributes 0.2 to 0.9 percentage points to labour productivity growth, accounting for 68 % (ES), 58 % (IT), 36 % (FR), 31 % (DE), 20 % (UK)
Van Ark et al. (2009)	1995-2006	10 EU MS	n/a	Growth accounting	Intangible investment contributes 0.1 to 0.7 percentage points to labour productivity growth, accounting for approx. 25 % in larger countries
Roth and Thum (2013)	1998-2005	13 EU MS	n/a	Growth accounting, regression analysis	Intangible investment explains 50 % of labour productivity growth
Corrado et al. (2013)	1995-2009	14 EU MS	n/a	Growth accounting	Intangible investment explains 24 % of labour productivity growth; ICT complementary
Chen et al. (2016)	1995-2007	10 EU MS	1-digit	Regression analysis	Positive relation between intangibles and labour productivity; ICT complementary
Corrado, et al. (2017)	1998-2007	10 EU MS	n/a	Regression analysis	ICT and intangibles are complements
Van Ark and Jäeger (2017)	2002-2015	12 EU MS	Market services, manufacturing	Descriptive	ICT capital contributed 0.1 percentage points to value-added growth, or 10 % of total.
Niebel et al. (2017)	1995-2007	10 EU MS	1-digit	Growth accounting, regression analysis	Intangibles substantially contribute to labour productivity, large variations across countries and sectors
Corrado et al. (2018)	2000-2013	18 EU MS	n/a	Growth accounting	Intangibles account for 0.3 percentage points of labour productivity growth, or 30 % of total in EU-14 and 10 % in CZ-HU-SI-SK

2.4 Innovation and internationalisation

The links between innovation and productivity in manufacturing enterprises have been analysed for a large number of countries, whereas only a few studies have examined innovation and productivity in service enterprises (see Siedschlag et al., 2010; Siedschlag et al., 2011, for Ireland; Polder et al., 2010, for the Netherlands; Lööf and Heshmati, 2006, for Sweden; Mairesse, and Robin, 2009, for France; Masso and Vahter, 2012, for Estonia). As a result, the existing empirical evidence on the links between internationalisation, innovation and productivity in services is still limited.

One recent study by Peters et al. (2018) explores the links between internationalisation, innovation and productivity in service enterprises in Germany, Ireland and the UK, based on micro data from the 2008 Community Innovation Survey. Innovation in services is shown to be increasingly important for a firm's survival and for achieving sustained economic growth. One important aspect is that technological advances, particularly in information and communication technologies, have enabled a greater tradability of services, which also means they are exposed to greater levels of competition.

While Peters et al. (2018) are not able to draw conclusions about causality[19], they identify a number of issues which can be highly relevant for policy making. First, their econometric analysis reveals that larger enterprises in the services sector are more likely to invest in innovation, and those also tend to be enterprises that participate in international markets via trade. Further, the authors illustrate the role of knowledge and technology transfer as a productivity driver for the most successful and innovative service firms. This evidence is consistent with the notion that investments in knowledge capital and innovation, including in ICT capital, skills development, and R&D are a potential source of productivity spillovers, especially in countries closer to the technology frontier. Innovation in service enterprises appears positively and significantly linked to labour productivity for all types of innovation in Germany and the UK. They consider different types of innovations, while in all three countries analysed, the largest productivity returns in service enterprises are found for marketing innovations. In Ireland, this positive link is statistically significant for both 'process' and 'marketing' innovations. Overall, their results stress the important role of internationalisation in the context of innovation and productivity in services in all three countries.

Another recent study by Malchow-Møller et al. (2019) compares the role of international trade for productivity growth within both service and manufacturing sectors. This study distinguishes between trade in goods and services in both sectors, and between exports and imports. Drawing firm-level data they find that firms that start to export or import goods experience significant increases in productivity and size, which is consistent with the 'learning-by-exporting' hypothesis found in the international trade literature. However, the effects for trade in services are typically smaller and confined to exporting only. The authors also find that international trade plays a potentially larger role for productivity gains within the service sector than within the manufacturing sector, but it is trade in goods not trade in services that appears to matter the most (see also Ariu et al., forthcoming).

Castellani et al. (2018) find that the transatlantic productivity gap may be due not only to a lower level of corporate R&D expenditures by European firms, but also to a potentially lower capacity to translate corporate R&D expenditures into productivity gains. This finding extends to the service sector and refutes the hypothesis that the US-EU differences in productivity are solely related to the different sectoral structures in the US and the EU, with the US economy being disproportionally characterised by high-tech industries.

Finally, Ottaviano et al. (2016) explore the relation between employing migrant labour and imports, exports and productivity of service-producing firms in the UK. Their hypothesis is that immigrants may substitute for imported intermediate inputs (i.e. via the use of offshore production) and they may impact the productivity of domestic firms as well as their export behaviour. This paper finds that immigrants raised overall productivity in service-producing firms, and it reveals a cost cutting impact of these. Further, immigrant labour has the potential to reduce the extent of country-specific offshoring, induce a more efficient reallocation of tasks and boost exports by reducing communication and trade costs for services.

2.5 Regulation

As well as reflecting the stalled pace of catch-up to the technological frontier, weak TFP growth can be the consequence of prevailing institutional and regulatory rigidities. These can stifle the intensity of competition, and negatively influence a variety of economic outcomes, such as productivity, innovation and income distribution. For instance, product market regulations can reduce the incentives to uptake new technology, and to exploit the most efficient production techniques. Strict labour market regulations can constrain the effective adoption of ICTs, which often requires firm reorganisation.

Policy distortions are well known for being a major source of inefficient resource allocation across sectors. Regulations may induce misallocation of resources at the economy-level, and various within-industry structural settings can also influence TFP and labour productivity, altering the incentives to invest and realising returns to innovation in different industries. It can affect the behaviour of incumbents as well as affecting firm dynamics. In advanced economies, the agriculture and personal services sectors tend to have

[19] Given that CIS is a cross-sectional database, it is difficult to follow individual firms over time.

the most distortions, possibly reflecting the effect of subsidies, preferential policies, and the lack of competition (Dabla-Norris et al., 2015). Non-market services and distribution services are also relatively sheltered services sector in European countries, and these can be heavy drags in terms of TFP growth.

One of the main avenues to enhance productivity in the services sector is to improve on the allocation of resources, which can be achieved through market de-regulation. Arnold et al. (2008) provide both cross-country, cross-industry and firm-level evidence of the harmful effects of stringent regulations in product markets. They distinguish between relatively "deregulated" English-speaking countries and relatively "restrictive" continental European countries. In particular, they distinguish four groups of countries that had widely different reform and productivity patterns: United States, United Kingdom, other English-speaking countries (Canada, Ireland, Australia and New Zealand) and Nordic EU countries (Denmark, Finland and Sweden) and large continental EU countries (France, Germany, Italy and Spain). They find the knock-on effects of service sector regulation in other industries to be largest in continental EU countries and lowest in Nordic and English-speaking countries. The cross-country differences are particularly large for ICT-using industries. Their findings also suggest that those countries with a relatively liberal approach to competition have experienced a greater acceleration in aggregate hourly labour productivity growth after since mid-1990s. In continental Europe where growth performance was most disappointing, product market reforms were slower during most of the 1990s, a period during which the diffusion of information and communication technologies (ICT) was most intense.

In the above study the stringency of the regulations in the product market are captured by the OECD indicators of non-manufacturing regulation covering energy (gas and electricity), transport (rail, road and air) and communication (post, fixed and cellular telecommunications), retail distribution and professional services, with country and time coverage varying across industries.[20] Arnold et al. (2008) provide evidence that one of the channels through which burdensome service regulations affect productivity growth is by hindering the allocation of resources towards the most dynamic and efficient firms. At the industry level, they find that regulations in the markets of goods and services have a strong impact on the intensity of competition and the speed and effectiveness of reallocation of resources, including that of labour. Their firm-level econometric analysis shows that anti-competitive service regulations hamper productivity growth in ICT-using sectors, with a stronger effect on firms that are catching-up to the technology frontier. Gutiérrez and Philippon (2019) find in a recent study that European product markets are however becoming more competitive, relative to those in the US.

Liberalising service markets has been linked to greater levels of value-added, which is reflected in a firm's or an industry's TFP outcomes. The link between reforms in service[21] sectors and economy-wide productivity effects has gained increasing attention. Greater levels of regulatory restrictions in services have been shown to harm productivity in downstream firms (e.g., firms using inputs from the regulated sectors in their production processes) – see Bourlès et al. (2013) and Arnold et al. (2008). The idea is that regulations in certain non-manufacturing sectors can also have important indirect negative effects on the productivity of other sectors, through strong input-output linkages. Drawing from an endogenous growth model,[22] Bourlès et al. (2013) postulate that excessive regulation in non-manufacturing sectors providing intermediate inputs can curb incentives to improve productivity across downstream industries. They confirm their predictions by estimating a model, in which the effects of upstream competition vary with distance to the frontier, on a panel of 15 OECD countries and 20 sectors over the period 1985-2007. They conclude that there are four factors that are most relevant to understand aggregate TFP differences: a) an excess regulatory burden relative to best practice in upstream sectors, b) the intensity of linkages between upstream and downstream sectors, c) the weight of the regulated sectors in the economy, d) and the distance in terms of productivity performance in those sectors to the global frontier. The more stringent the regulation is, the higher the intermediate consumption of regulated products, the greater the sectoral composition shifts towards sectors heavily regulated or sectors that use intensively regulation inputs, and the smaller the distance to the productivity frontier, the stronger the gains in productivity from lowering regulations in upstream sectors.

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[20] These are also known as the OECD indicators of the "knock-on" effects of non-manufacturing regulation,

[21] Reforms in sectors such as network industries, banking, telecommunications, electric power, railway transport, road transport, and water distribution.

[22] They provide a formalisation of the links between upstream competition and downstream productivity using an extension of the neo-Schumpeterian endogenous growth model by Aghion et al. (1997) where firms compete on each market and the catch-up probability depends on the followers' efforts.

Using cross-country industry-level data, Igna et al. (2019)[23] investigate the production effects of upstream (service) regulation considering two different transmission mechanisms: the productivity channel as well as the factor demand channel. The results show that the effects of anti-competition barriers in service markets depend on the technology conditions of downstream firms. Upstream regulation is found to lower productivity *directly,* mainly by reducing efficiency levels in network industries, and *indirectly* by curbing the demand for labour, mainly in the manufacturing sector. They show that downstream firms react to high anti-competition barriers in intermediate input service markets by investing more intensively in ICT capital goods, probably to produce intangible tasks internally. In essence, the effect of upstream PMR on industry ICT investment follows a U-shaped pattern, being positive at low levels of regulation but negative at higher levels. This means that those industries that are subject to a less stringent service regulation, such as manufacturing industries invest more in ICT, compared to industries exposed to higher levels of regulation where the impact of regulation on ICT investment is negative.

The aggregate effects of service sector regulation are found to be quantitatively important and can help explain the wide productivity differentials existing across OECD countries in that sector. Cette et al. (2017)[24] show that market rigidities in certain upstream service industries lower ICT diffusion and R&D spending across a wide range of industries.

A number of studies on the effects of service sector liberalisation have emerged in recent years using firm-level data to take into account heterogeneity in firms' characteristics and the process of firm dynamics. Using firm-level data for the Czech Republic, Arnold et al. (2011) explore the links between services sector reforms and the productivity of manufacturing industries that rely intensely on services inputs. Several aspects of services liberalisation are considered, such as the presence of foreign providers, privatization and the level of competition. They find that there is a positive and significant relationship between reform in the services sector and the performance of firms in downstream manufacturing sectors. Importantly, they also find evidence that opening services sectors to foreign providers could be a key channel through which services liberalisation can contribute to improved performance of downstream manufacturing sectors.

Van der Marel et al. (2016) is one of the first papers which uses firm-level data to show the effects that service sector regulations have on downstream firms in both goods and services sectors in a multiple-EU country setting. Their results indicate that regulatory barriers in services have diverse effects on downstream manufacturing performance, chiefly depending on the *type* of regulatory measure. They distinguish between pure *entry* barriers and those that relate to the anti-competitive policies on the operations of firms, which they call *conduct* regulations. They show that the latter have a stronger impact on EU firms' TFP outcomes than the former when all sectors are considered. They however find that entry barriers are the main factor explaining TFP performance when only downstream manufacturing firms are taken into account. This last point may suggest that as economies shift from manufacturing to services, the relative importance of conduct regulations versus entry regulations may also evolve.

Inklaar et al. (2008) focuses on the impact of regulatory barriers to entry and find that there is no effect from the average level of barriers to entry in services on TFP growth in market services. These results may contradict theoretical predictions, but it may be that entry liberalization occurred in different industries at different times, so using the trend averaged over industries may obscure relevant variation in the data. This paper covers the EU-15 and the US during the period 1980 to 2003. They then look at the effect of industry-specific barriers to entry on TFP growth, focusing on transport and storage services and post and telecommunications services. They find TFP growth in post and telecommunications benefited substantially from entry liberalisation during the 90s. They show that there is little effect of changes in barriers to entry in the transport industry, but in post and telecommunications, lower barriers are strongly related to higher TFP growth. Banerji et al. (2015) find that TFP gains associated with product market liberalisation are highest in the ICT, personal services, and finance and business services sectors. These are sectors in which productivity performance in European countries has lagged behind the United States.

Considering regulations in the labour market, Haltiwanger et al. (2014) find that strict hiring and firing regulations tend to reduce the pace of job reallocation, thereby damaging productivity. They use harmonised job flow data along country, industry and firm size dimensions to test the predictions that those economies with stricter hiring and firing regulations have lower pace of job reallocation. This result is not specific to

[23] Relying on the same upstream regulatory burden indicators as in Bourlès et al. (2013). These are computed from the OECD indicators of anti-competitive regulations on product market in the six following non-manufacturing industries: energy, transport, communication, retail, banking and professional services.

[24] Also relying on the same upstream regulatory burden indicator as in Bourlès et al. (2013).

services, but could be more important in certain service industries with higher job turnover rates, such as the hospitality and retail industries.

Damiani et al. (2016) investigate the influence that employment protection for temporary contracts has on TFP growth at industry level. They show that labour market liberalisation has had a detrimental influence on TFP growth, especially in sectors where firms open short-term positions more frequently. This is the case for example of services sectors such as hotels and restaurants, public administration and community, social and personal services. The results indicate that the increasing use of temporary contracts may negatively influence TFP growth in fourteen European countries[25] and that, at a sectoral level, the influence of this liberalisation is greater in industries in which firms are more used to opening short-term positions. The result is especially important for economies showing high levels of Employment Protection Legislation for temporary contracts (EPLT) at the beginning of the sample period (Germany, Belgium and Italy). In Italy in particular, more than 22 per cent of the difference in TFP changes between the hotels and restaurants sector and manufacturing is explained by the weakening of EPLT. The authors also argue that while pro-competitive product market policies may spur efficiency growth, the liberalisation of the labour market for temporary contracts could potentially offset this positive influence. Low levels of employee protection discourage long-term relationships and thus cause low investments in training because they do not offer incentives for workers to upgrade their skills. Thus, it is likely that firms do not offer work-related training when they expect job positions to be short-term, confirming that more stable employment prospects positively influences the take-up of training.

In general, it appears more difficult to evaluate the productivity impact of labour market reforms, given the relative complexity of policies. The evidence however seems to point to labour market reforms playing a greater role in employment, with smaller effects on productivity, suggesting the need to avoid either excessive regulation or excessive neglect of labour conditions (Dabla-Norris et al., 2015).

2.6 Measurement issues

Measurement error is sometimes suggested as an explanation for declining productivity growth. Marrano et al. (2009) argue that UK market sector GVA was underestimated by 6 % in 1970 and as much as 13 % in 2004. Byrne et al. (2016) and Syverson (2017) also consider this issue but conclude that mismeasurement (e.g. not accounting for free online services) would only be large enough to explain a relatively small proportion of the post-crisis slowdown in overall productivity. Moreover, several of the industries with the largest recent slowdowns in productivity growth, such as agriculture and transportation services, and, within manufacturing, petroleum refining and rubber/plastics, are relatively easy to measure (Gordon and Sayed, 2019).

However, measurement issues can be particularly severe in the services sector.[26] Even normally considered to proxy for technological change, TFP may capture a range of other effects including any deviations from the assumption that marginal costs reflect marginal revenues, changes in unmeasured inputs (such as intangible investments), and measurement errors in inputs and outputs. Hence, TFP growth is hard to measure, especially for service sectors, and should be interpreted with caution (O'Mahony and Timmer, 2009), while measurement differences across countries can also be large.[27]

Brynjolfsson et al. (2018) argue that in addition to *false hopes* and time lags in implementation, mismeasurement can be one of the reasons that the adoption of ICT technologies such as artificial intelligence in different sectors is not necessarily reflected in the productivity statistics yet. On this issue, Alan Greenspan already observed in 1996 that even though services sectors were among the first sectors in adopting a widespread use of computers, they exhibited low or negative measured productivity growth (reported in Corrado et al., 2009). Byrne and Corrado (2017a, b) provide a more detailed examination of the links between the ICT prices, technology and productivity. They discuss how the fact that the tendency of ICTs to spread through our economies via the purchase of hard-to-measure services (e.g. cloud computing or data analytics services) means that their full contribution to aggregate labour productivity is not measured correctly. According to their analysis, ICTs contribute around 1.4 percentage points to growth in US output per hour per annum, which is very high considering historical annual growth rates have been around 2 %.

[25] Austria, Belgium, Czech Republic, Denmark, Spain, Finland, France, Germany, Hungary, Ireland, Italy, Netherlands, Sweden and the United Kingdom.

[26] Most of the literature we review here focuses on developments in the market services sector, as the non-market part of the economy is notoriously difficult to measure.

[27] For example, Inklaar et al. (2008) document fundamental differences in the way the U.S. and European economies measure the output of distribution services.

A related issue is the quality-adjustment of price indices over time. This is a problem if improvements in the quality of goods and services sold in an economy are not captured by price indices that statistical offices use to calculate real output. In general, it is much more difficult to measure changes in quality for services than it is for goods, as there is more ambiguity in the metrics that are being used to observe the quality of a service. As the process of tertiarisation in advanced economies gains ground, this measurement issue is becoming more prevalent.

Another issue that researchers and statistical offices are only beginning to understand is connected to the rise of the digital economy and the consumption of digital services. For example, Abdirahman et al. (2017) show how the real price of telecommunication services has fallen much more rapidly than current deflators are assuming. Coyle and Nguyen (2018) show similar trends for the cloud computing market and Byrne et al. (2019) for smartphones, which is currently not captured by statistical offices. Coyle and Nguyen (2018) further discuss that there can be measurement issues when businesses start buying more cloud-based IT services instead of physical IT equipment, particularly when those services are traded across borders. A final measurement issue related to digital technologies is that digital services are updated more frequently and can be highly customised. This represents issues in particular for index-based methods such as hedonic adjustments, which use observable characteristics and expenditure weights to estimate consumer utility in relation to prices (Djellal and Gallouj, 2013). However, for many digital services these observable and definable characteristics tend to change rapidly and be tailored to the individual.

At this point it is difficult to conclude to what extent (mis-)measurement issues are prevalent and relevant in the European context as there is very limited (empirical) research on this. However, it is likely that there is a large heterogeneity across EU countries due to different diffusion rates of digital technology as well as methodological differences between statistics offices.[28] Supporting further research on the digital economy and promoting the update of statistical surveys should be top research-oriented policy priorities.

[28] Some of the issues related to mismeasurement and the digital economy are discussed in more detail in a research seminar by David Nguyen: https://www.escoe.ac.uk/escoe-research-seminar-14-january-2020-why-is-measuring-the-digital-economy-so-difficult-when-everything-is-stored-as-data-david-nguyen/

3 Structural change and productivity in services

This section analyses the effect that structural transformation[29] has had on the long-term labour productivity performance of a number of EU economies.[30] In particular, the goals are threefold. First, to quantify which part of the long-term labour productivity growth decline can be attributed to structural change, including at the sectoral level, during the period 1970-2017. Second, to shed light on the factors behind the observed heterogeneous impact of structural change across different EU Member States. Third, to test the hypotheses stemming from Baumol's (1967) theory on the so-called *cost disease*, which are intimately related to structural change as a driver of poor long-run labour productivity growth. A special emphasis is placed on analysing productivity developments in the service sector, specifically by comparing subsectors within services which exhibit dissimilar productivity performances.

3.1 The problem of secular stagnation

The main message in the seminal contribution by Baumol (1967) is that productivity growth is higher in the *progressive* (i.e., primary and secondary) than in the *non-progressive* (or stagnant) sectors of the economy (i.e., tertiary). Assuming that wages grow approximately equally the secondary and tertiary sectors, it can be further shown that unit costs and prices are bound to rise much faster over time in the latter sector than in the former one. Baumol's theory was based on the observation that the demand for most services in the US, such as health care, education, and services related to leisure activities, is relatively price-inelastic, since consumers are willing to pay higher prices for these types of services than for basic manufacturing good. This in turn implies that an increasing share of total nominal consumption expenditure and employment flows into the stagnant sector. This is what is known as the *cost disease*, a process by which ever-increasing nominal costs in the tertiary sector cause this sector to gain relative economic weight over time, in relation to the other sectors. This implies that the aggregate productivity growth rate will gradually decline over time as these industries are characterised by very low productivity growth profiles.

Baumol's original theory comprised six main hypotheses:

1. Cost and price disease (i.e., costs are expected to grow faster in stagnant industries).
2. Constant real shares (i.e., real Gross Value Added (GVA) shares between sectors are expected to remain the same over time).
3. Unbalanced nominal growth (i.e., the share of nominal value added in the more productive industries should diminish over time).
4. Declining employment shares in progressive industries (i.e., if real output shares are constant, this means that stagnant industries absorb proportionally more resources).
5. Uniform wage growth (i.e., as a consequence of the assumption of perfect mobility and substitutability of labour across sectors).
6. Growth disease (i.e., due to the larger weight in the economy of stagnant industries over time).

In this section we use the latest releases of both the STAN and EU KLEMS datasets to explore a number of questions.[31] First, we demonstrate the process of secular stagnation that is afflicting most EU-15 economies by examining average labour productivity growth rates over relatively long periods of time in the forty-seven year period considered. Second, we investigate the quantitative impact of structural change on long-term labour productivity growth for the Member States for which available data exist. To do this, we first compute counterfactual average annual labour productivity growth rates in the 1970-2017 period by fixing the nominal value added weights of different industries to the values that prevailed in different years in the

[29] The definition of 'structural transformation' used in this section is that of secular shifts in the economy's sectoral composition.

[30] Unless otherwise noted, labour productivity in this section refers to real gross value added per hour worked, both at the economy-wide and industry levels. For a discussion on the correctness of the choice of gross value added over gross output see Nordhaus (2008).

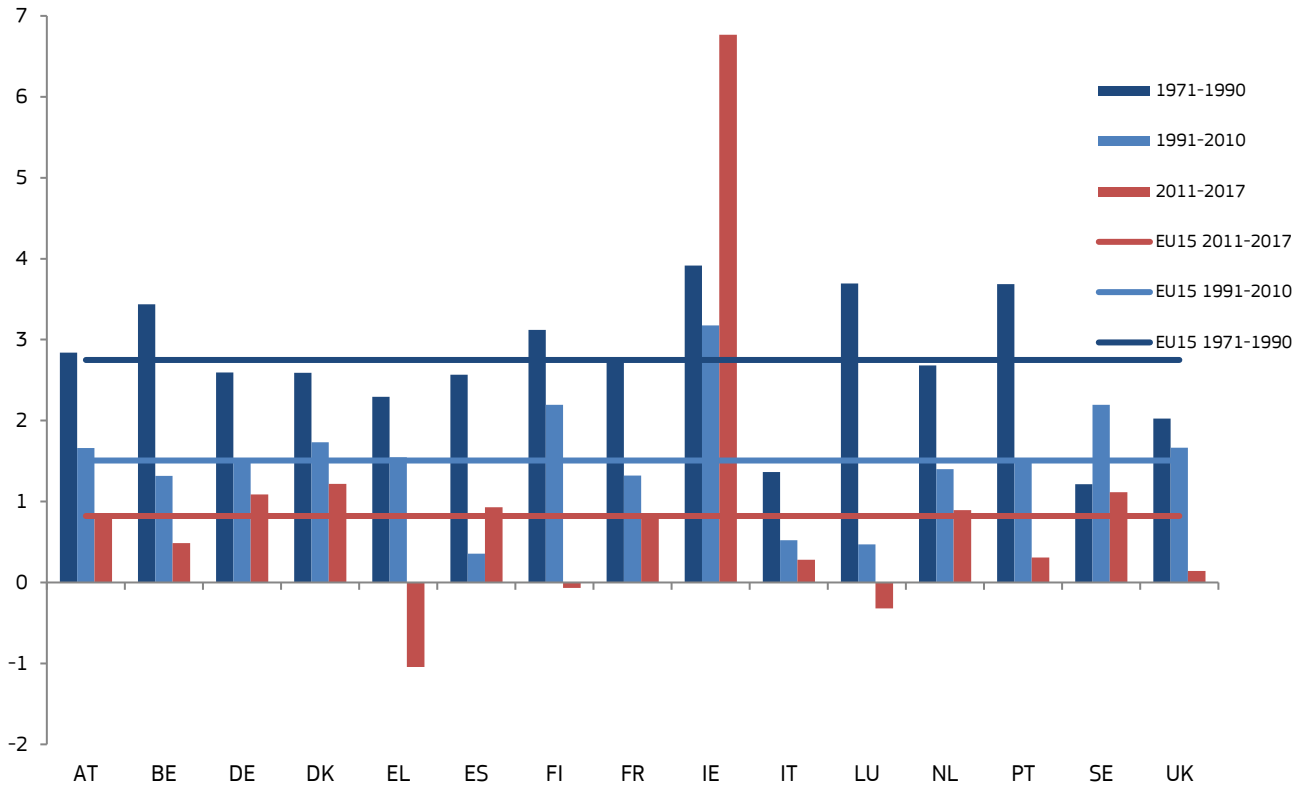
[31] For more information on these two datasets, please see: http://www.oecd.org/industry/ind/stanstructuralanalysisdatabase.htm ; http://www.euklems.net/

past.[32] We then compare the resulting growth rates with the growth rate that actually materialised. This counterfactual exercise illustrates the long-term labour productivity growth rates that could have been attained once the effect of structural change is factored out. Third, we conduct an empirical test of the first five Baumol hypotheses outlined above for every EU country for which the time series span is long enough.

Secular stagnation is oftentimes referred to a situation of negligible or no economic growth in a market-based economy.[33] The same concept has also been applied to refer to a slow but steady process of increasingly lower growth in output per capita over time.

The following graph confirms that EU-15 countries are no exception to this dismal process in terms of labour productivity performance. This chart shows the downward trend in labour productivity growth by displaying annual average growth rates for the two 20-year periods in the period 1970-2010 as well as for the period 2011-2017.

Figure 4. Average labour productivity growth in selected periods, EU15 countries, percentages.



Note: Data for the UK are only available until the year 2016.

Source: STAN and EU KLEMS, 2019.

The main observation stemming from this graph is that average annual labour productivity growth over relatively long periods of time has decreased in the past fifty years. Across the board,[34] the reduction in labour productivity growth is clear, decreasing monotonically for the different time periods considered. We thus document a rather apparent downward trend in labour productivity growth in most EU-15 countries.

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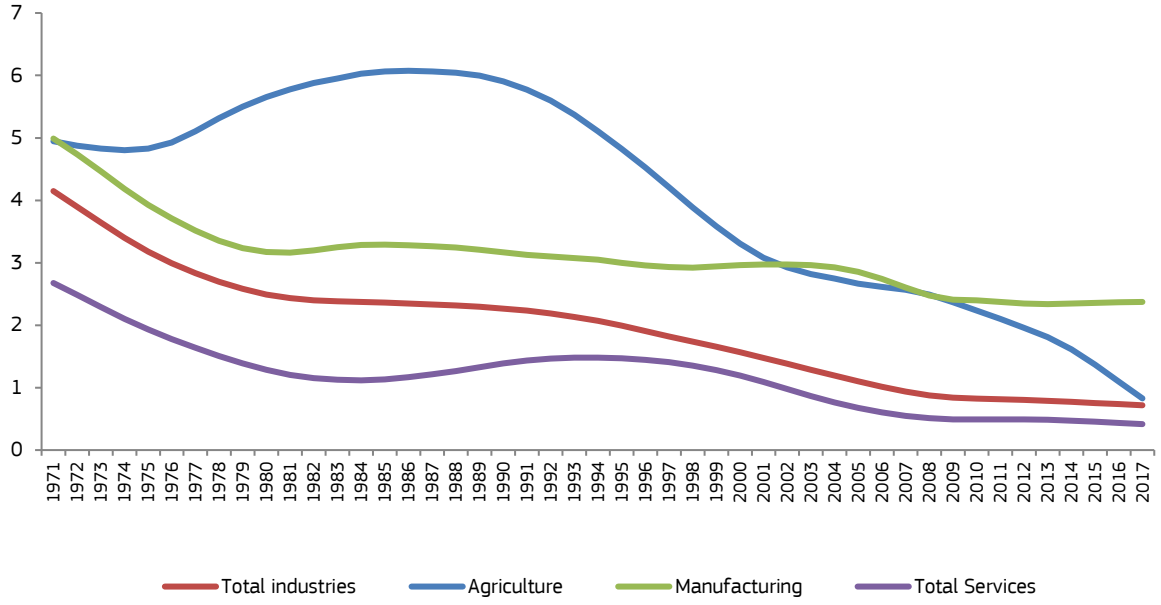
32 The counterfactual question this exercise addresses is: what would have average annual labour productivity growth in the 1970-2017 period been in a given country if the economic weight of all sectors had been fixed at their 1970 values compared to the *actually* realized rate?

33 Original mention of the *secular stagnation* concept was made in Hansen (1939). The concept has in more recent years been popularised by Pr. Larry Summers, especially in its speech at the IMF Economic Forum of November 2013.

34 The case of Ireland constitutes an important exception related to the fact that it is a small, highly open economy with very marked specialization patterns. Sweden and Spain also merit special mention. The former for having exhibited an unusually high productivity growth in the last twenty years of the 20th century, and the latter for being a well-known example of a country where productivity growth has actually improved after the 2008 global financial crisis (together with Ireland).

Figure 5 provides another way to illustrate the problem of secular stagnation. It plots the (smoothed) labour productivity growth rates for the total economy, and the agricultural, manufacturing and service sector.

Figure 5. Labour productivity growth rates across main sectors in the EU15, 1970-2017, percentage points.



Note: HP-filtered data with smoothing parameter set to 100.

Source: EU KLEMS, 2019.

It follows from this graph that trend growth in labour productivity has diminished over time across all sectors. This fall is most pronounced in the agricultural sector, and less so in the service sector. This means that the productivity slowdown also features an element which is intrinsic to each of these industries. Nevertheless, it is worth noting that the labour productivity growth rates of the service sector lies below the growth rates of the other sectors in every year. This confirms Baumol's view of the service sector as an especially productivity-stagnant sector. In the next section we argue and show that the widespread process of within-industry labour productivity stagnation, of differing degrees across sectors, is reinforced by the process of structural change. This section attempts at quantifying the effect of the latter, taken the other drivers as given.[35]

3.2 The impact of structural change on labour productivity growth

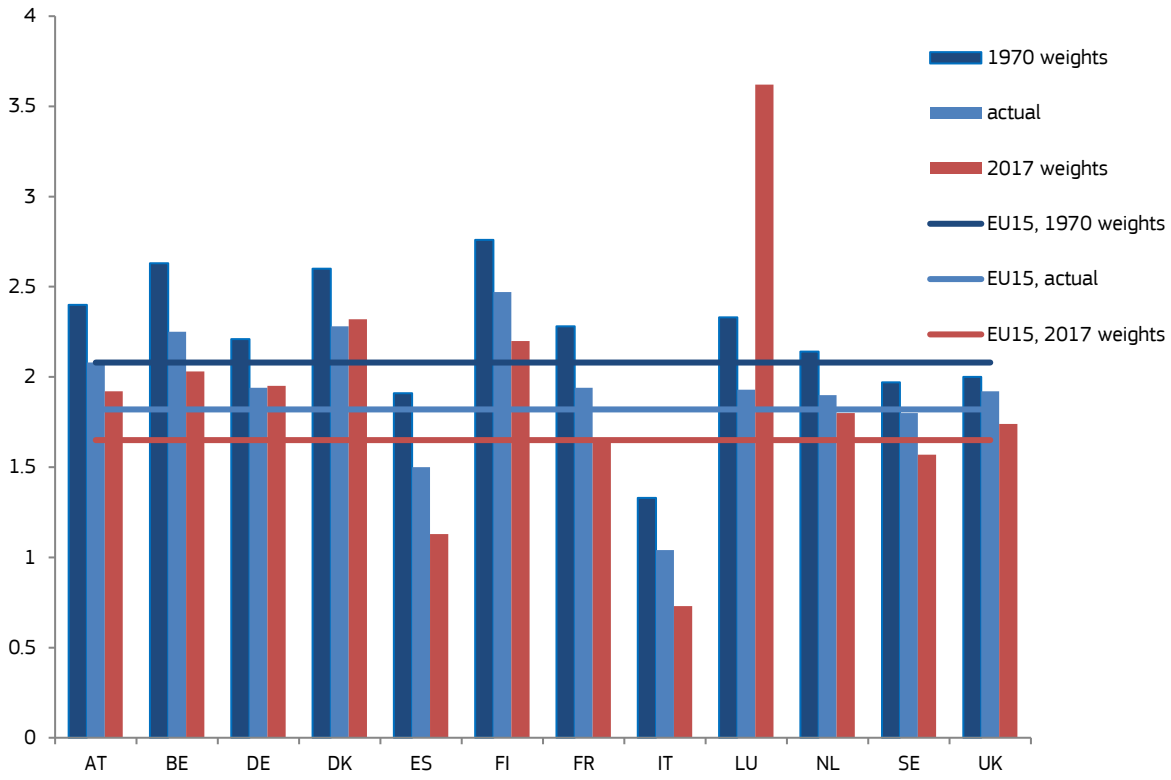
Having established the existence of secular stagnation for most EU-15 economies, we proceed to analyse the role played by structural change as a driving force underlying such a long-term phenomenon. In order to calculate the bearing that economic structural change (and specifically the secular shift of economic weight from manufacturing and agriculture to the tertiary sector) has had on long-term average labour productivity growth, two main sets of analyses are presented. First, the results of counterfactual computations of the average growth rate are shown for different sectoral weights taken from different base years in the 1970-2017 period. These are the compared to the actually observed labour productivity growth rate during the same period to quantify the extent of the problem. Second, we document the change in the weight of the manufacturing and service sectors, measured in terms of both value added and employment, both for the EU-15 and for individual countries for which we have long enough data to identify non-negligible changes. Third, we provide a discussion on productivity performance for different service subsectors across the countries analysed. These sectors are selected on the basis of their performance relative to the average service subsector. As argued in Duernecker et al. (2017), there is a great deal of heterogeneity in productivity

[35] As argued in the next subsection, we do not claim in this section that structural change alone is the main driver of the observed productivity slowdown, but rather, that it is a non-negligible determinant.

performance among service industries that needs to be duly captured to avoid treating the tertiary sector as a single block. Doing this would run the risk of missing the special characteristics and widely dissimilar technological potential of the different sub-industries within services (Sorbe et al., 2018). Finally, we provide an econometric test of the first five hypotheses outlined above on Baumol's theory using EU-15 data.

The following chart shows, for a number of countries, i) the counterfactual average labour productivity growth rates in the period 1970-2017 calculated as the weighted sum of 1-digit sectoral average productivity growth rates weighted by the nominal value added shares prevailing in 1970, ii) the same object using the shares prevailing in 2017, iii) the actual labour productivity growth rate. This exercise illustrates the effects that the different sectoral compositions prevailing in the two end years wield on average labour productivity growth. [36]

Figure 6. Average labour productivity growth rate, percentages, 1970-2017.



Note: Average labour productivity growth rates are obtained by computing the weighted sum of industry-level yearly growth rates, using nominal value-added shares at the 1-digit industry level as weights, and then calculating the average growth rate across the whole period. Weights are fixed to their 1970 and 2017 values in the computation of the respective counterfactual growth rates, while contemporaneous period weights are used for the calculation of the actual growth rate.
Following the literature, the real estate sector is excluded due to measurement issues. Non-market services are however included.
Data for the UK are until the year 2016. EL, IE and PT are excluded due to poor sectoral coverage in the distant past.

Source: Author calculations on STAN and EU KLEMS, 2019.

The main observation arising from this graph is that the secular shift in economic structure has had a negative impact on average labour productivity growth in the period 1970-2017 for most of the economies shown. This is evidenced by the generally positive gap between the counterfactual growth rate computed by fixing value nominal added weights to their 1970 values and the actually realized rate.[37] In addition, using instead the weights prevailing in 2017 results in a counterfactual average labour productivity growth rate that is generally below the actually realised one. This means that the sectoral distribution of nominal value added has shifted over time toward sectors with lower labour productivity growth profiles.

[36] For details on the derivation of the labour productivity growth rates, please see Annex B2.

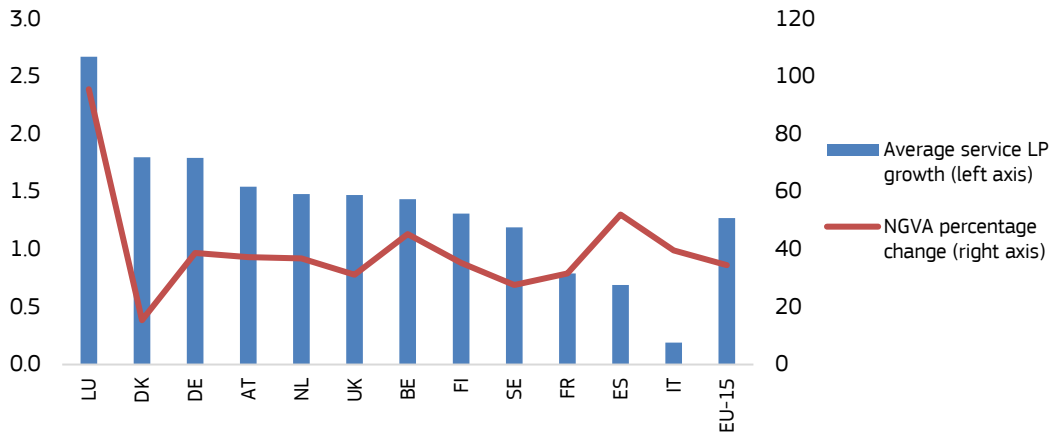
[37] Results are robust to using alternative weightings to the fixed 1970 and 2017 endpoints. In particular, using the average nominal value added shares of each 1-digit industry of the first and last five years of the sample does not meaningfully modify the results.

The exception to this general pattern is Luxembourg, a country which has a very specific sectoral composition, dominated by the relatively large size of its financial sector. The latter's share in the economy over the time period considered has substantially increased, from 5 per cent of aggregate nominal value added in 1970 to 28 per cent in 2017, while real labour productivity in the sector has grown at an average pace of around 6 per cent per year.[38]

It is also important to note the existing cross-country heterogeneity in terms of the importance of the effect of structural change on labour productivity growth. It is apparent from Figure 6 that countries such as Germany and Denmark are not affected by the negative impact of structural change to the same extent as countries such as Italy or Spain. However, the effect is still non-negligible, especially considering the long time span and the fact that labour productivity is generally perceived as the ultimate determinant of citizens' well-being. This difference in impact owes to both smaller changes over time in the sectoral composition of the former two economies (*cross-industry* effect) as well as to better performance in labour productivity growth in every sector (*within* effect).[39]

To illustrate the amount of country dispersion in the latter two components, the following chart displays both the average labour productivity growth rate and the percentage change in the nominal value added weight of the overall service sector in the period 1970-2017 for all the economies analysed.

Figure 7. Average labour productivity growth rate and nominal gross value added for the service sector as a whole, percentages, 1970-2017.



Note: The real estate sector is excluded from the computations.
Data for the UK are only available until the year 2016. EL, IE and PT are excluded due to poor sectoral coverage in the distant past.

Source: Author calculations on STAN and EU KLEMS, 2019.

Figure 7 reveals that labour productivity in the service sector in countries such as Denmark, Germany, Austria and the Netherlands has grown at a higher average rate in the period analysed than the EU-15 average, while the economic weight of this sector in nominal terms has not increased as markedly as in other countries. At the other end, countries such as Italy and Spain have experienced the opposite: slower labour productivity growth and a larger increase in the size of the service sector.

The table below confirms the pattern identified in Figure 6 for twelve EU-15 economies and includes relatively newer EU Member States, for which the data span a shorter period of time.

[38] Productivity measurement issues in services, in general, and in the financial and public services sectors, in particular, are also subject of continued discussions in the academic, statistical office and policymaking spheres. Since these sectors are central for the current analysis, we include them in our calculations, and proceed with the usual caveats. For a discussion on general measurement challenges in the service sector please see Sorbe et al. (2018).

[39] For a decomposition of average labour productivity growth in the EU-15 following the Foster, Haltiwanger and Krizan (2001) approach, please see section 3.2.2.

Table 2. Average labour productivity growth rate (1970-2017, %).

EU-15 countries	Base year of industry weights		EU-13 countries	Base year of industry weights	
	1970	2017		1970	2017
BE	2.63	2.03	BG*	2.11	2.33
DK	2.60	2.32	CZ*	1.59	1.95
DE	2.21	1.95	EE*	4.50	4.26
IE*	3.96	5.51	CY*	0.98	1.11
EL*	0.58	0.63	LV*	3.83	3.72
ES	1.93	1.13	LT*	4.53	4.54
FR	2.28	1.65	PL**	2.97	3.08
IT	1.33	0.73	RO*	4.95	4.64
LU	2.33	3.62	SI*	2.63	2.37
NL	2.14	1.80	SK*	4.44	4.31
AT	2.40	1.92			
PT*	1.05	0.82			
FI	2.76	2.20			
SE	1.97	1.57			
UK	2.00	1.74			
EU-15	**2.08**	**1.65**			

Note: Average labour productivity growth rates are computed based on nominal value added weights taken from the base year indicated. * denotes weights from 1995 instead of 1970; ** denotes weights from 2000 instead of 1970. The real estate sector is excluded from these calculations. Data for the UK span until the year 2016. HR, HU and MT are excluded due to a too short time coverage.

Source: Author calculations on STAN and EU KLEMS, 2019.

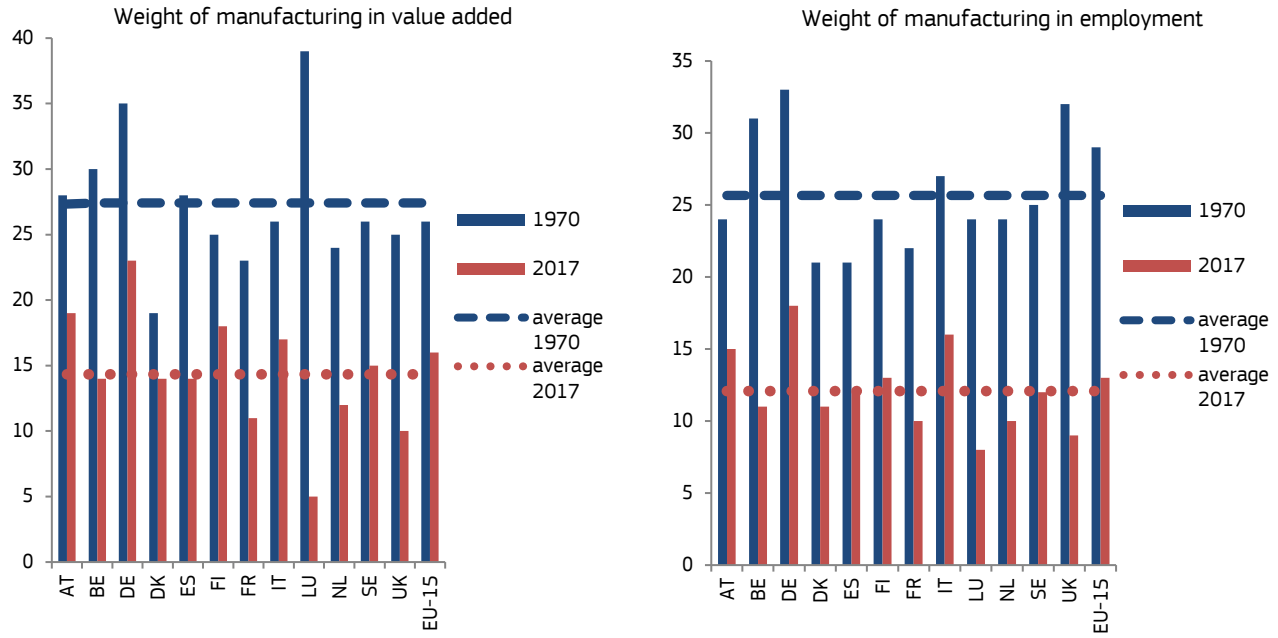
Table 2 shows that the structural change process by which relatively more productivity-stagnant industries gain greater relative economic weight over time has had a more perverse effect in the EU-15 countries than in the newer Member States, especially if we leave out outliers such as Ireland and Luxembourg.[40] For the EU-13 countries, there is no evidence yet of a significantly negative effect from structural change at play: the average productivity growth rate resulting from fixing the economic structure prevailing in 2017 is in general higher than the one computed using weights further back in the past (e.g., CY, CZ, LV, PL). Even though there might be several reasons for such a dissimilar sign of the effect of structural change across countries, such as greater weights of manufacturing industries and shorter time series data, one of the main drivers is the fact that EU-13 Member States are mostly transition economies. This makes them more capable of reaping productivity gains across all economic sectors, as they find themselves in the midst of a catching-up process with the most advanced countries in the EU. Economies belonging to the EU-15, on the other hand, have exhausted most of the productivity gains associated with earlier development processes, irrespective of the type of industry, whereas the weights of stagnant industries is typically much larger than in the EU-13..

3.2.1 The rise of services

The following charts show the change in the weight of the manufacturing and service sectors, measured in terms of both value added and employment, both for the EU-15 and for individual countries for which we have long enough data to identify non-negligible changes.

[40] As mentioned before, the evolution of productivity growth in these two countries is driven by very country-specific factors.

Figure 8. Weight of the manufacturing sector in 1970 and 2017, measured as a share of both economy-wide value added and employment (%).



Source: STAN and EU KLEMS, 2019.

Figure 9. Weight of the service sector in 1970 and 2017, measured as a share of both economy-wide value added and employment (%).

Source: STAN and EU KLEMS, 2019.

The general pattern observed in these graphs is clear: the weight of the manufacturing sector has diminished over time, in favour of the service sector, in all the economies analysed. This holds true for economic weights interpreted both in terms of nominal value added and employment shares.[41]

Another important observation is that the falls in manufacturing employment shares between 1970 and 2017 are generally proportionally higher than in value added. In the EU-15, for example, the difference in the change in employment (-14 percentage points) and value added (-10 percentage points) shares between these two years is equal to -4 percentage points.[42] This presumably indicates that the relative loss of labour input in the manufacturing sector has not led to a proportional decline in output, likely due to relatively faster technological progress. This is also in line with Baumol's predictions, by which technological progress in the *progressive* sectors of the economy translates into lower labour input needs and increasing output in real terms.

As expected, the inverse phenomenon is observed in the service sector; employment shares increased proportionally more than nominal value added shares. This is exemplified by a difference between the changes in employment (29 percentage points) and value added (19 percentage points) shares in the period 1970-2017 for the EU-15 of 10 percentage points.[43] This lends support to the view that the service sector tends to hoard more labour input.[44]

As pointed out in Duernecker et al. (2017), among others, the service sector comprises a set of industries which exhibit large discrepancies in terms of their labour productivity performance. It is thus worth investigating which subsectors within services are most responsible for weighing on labour productivity growth and which other sectors, on the contrary, display relatively better productivity performance, even compared to the more *progressive* primary and secondary sectors.

The following chart shows the average productivity growth rate as well as the change in the relative size of all 1-digit service subsectors in the EU-15.

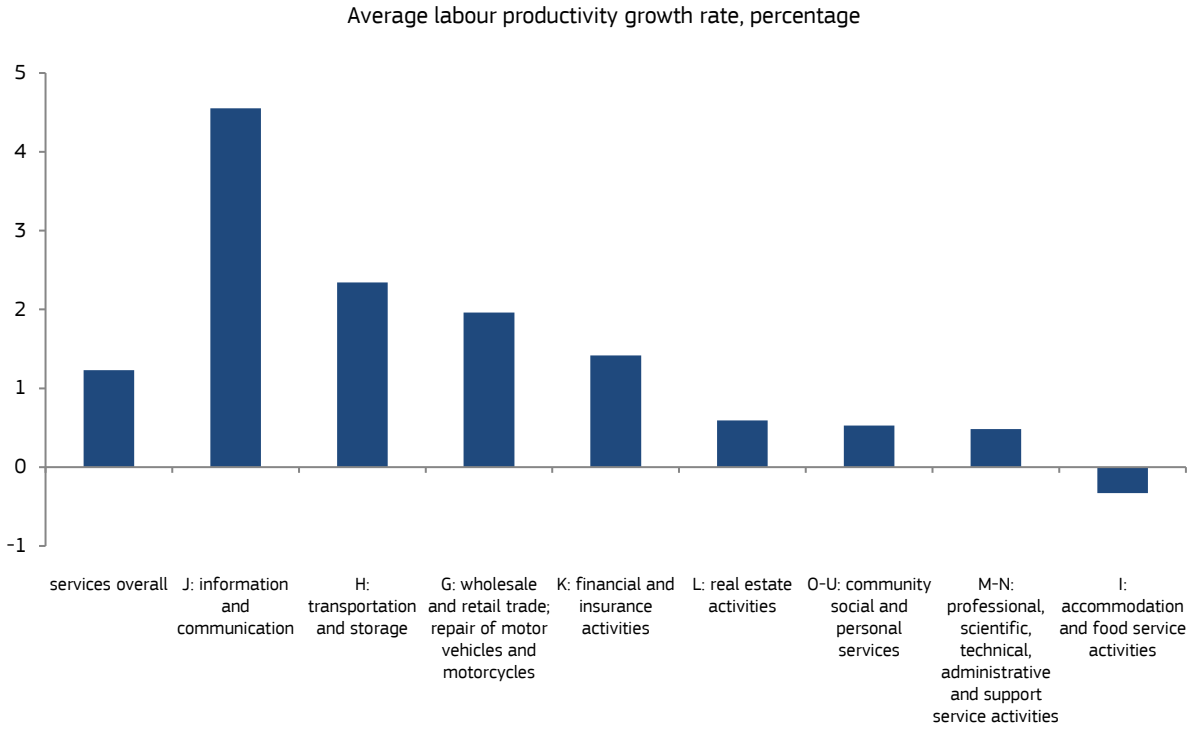
[41] This provides preliminary evidence in favour of hypotheses three and four mentioned above for Baumol's *disease* in all these countries.

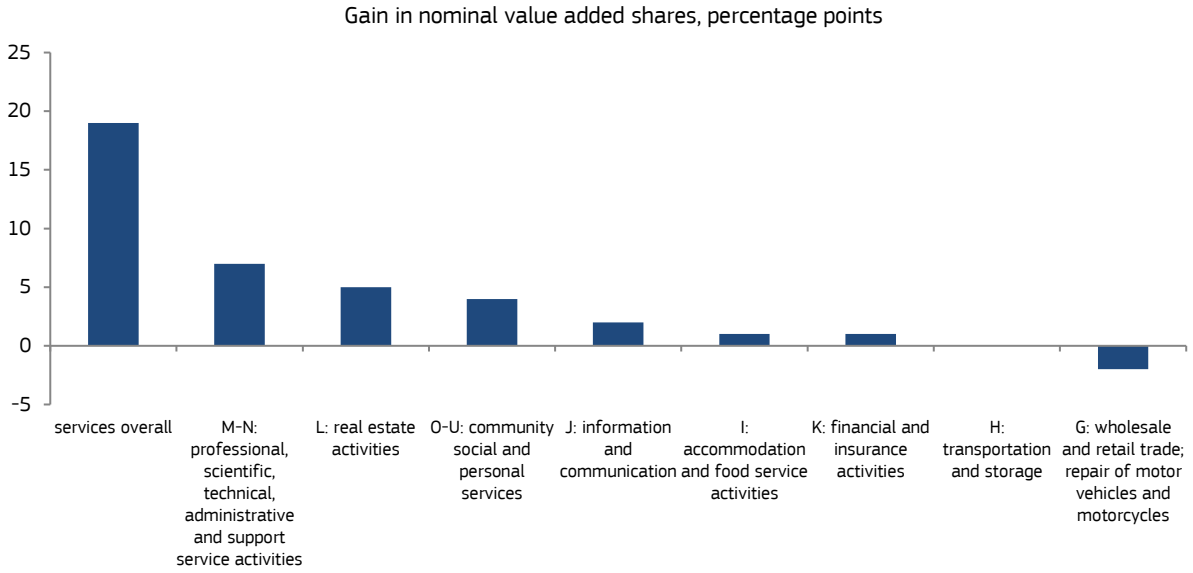
[42] In countries such as the UK this gap rises to 8 percentage points.

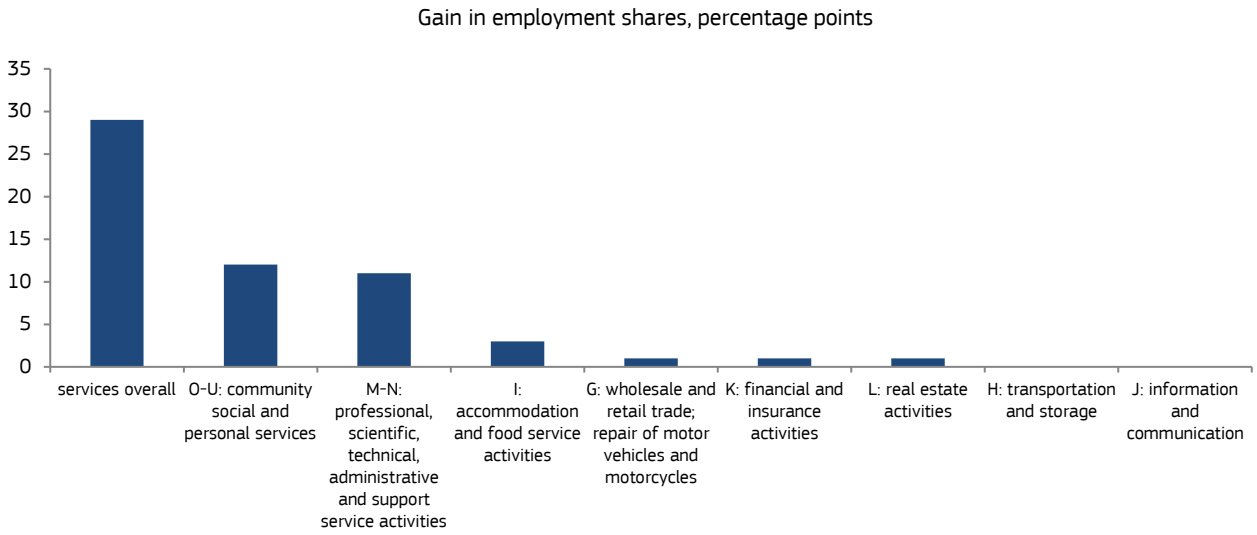
[43] This gap reached 11 percentage points in Spain, Finland, France, Italy. The exception is Luxembourg, whose service sector's value added increased by 24 percentage points more than its employment share.

[44] Part of these flows of workers into the tertiary sector originates from the manufacturing sector, so long as the assumption of a sufficiently high degree of substitutability of labour across sectors holds.

Figure 10. Evolution of the average labour productivity growth rate, value added and employment shares across 1-digit service subsectors in the EU-15 (1970-2017).







Source: EU KLEMS, 2019.

As apparent from the graphs above, the information and communication service (ICT) subsector shows the highest average growth rate in the period analysed.[45] In fact, at 4.46 per cent, this rate exceeds that of both the manufacturing (3.11 per cent) and the agricultural sectors (4.13 per cent). However, the gain over time of the ICT sector in terms of both nominal value added and employment shaes is almost negligible. This in turn implies that despite the large increase recorded in labour productivity, the ICT sector has contributed very little to economy-wide productivity growth.

It can also be seen that the professional service sector is one of the worst performers in terms of labour productivity growth, whereas it has significantly increased its nominal value added weight. This means that this sector is a significant negative contributor to overall labour productivity growth. There is however room to raise productivity in this sector through the expansion of important technologies such as digitalisation and automation.[46]

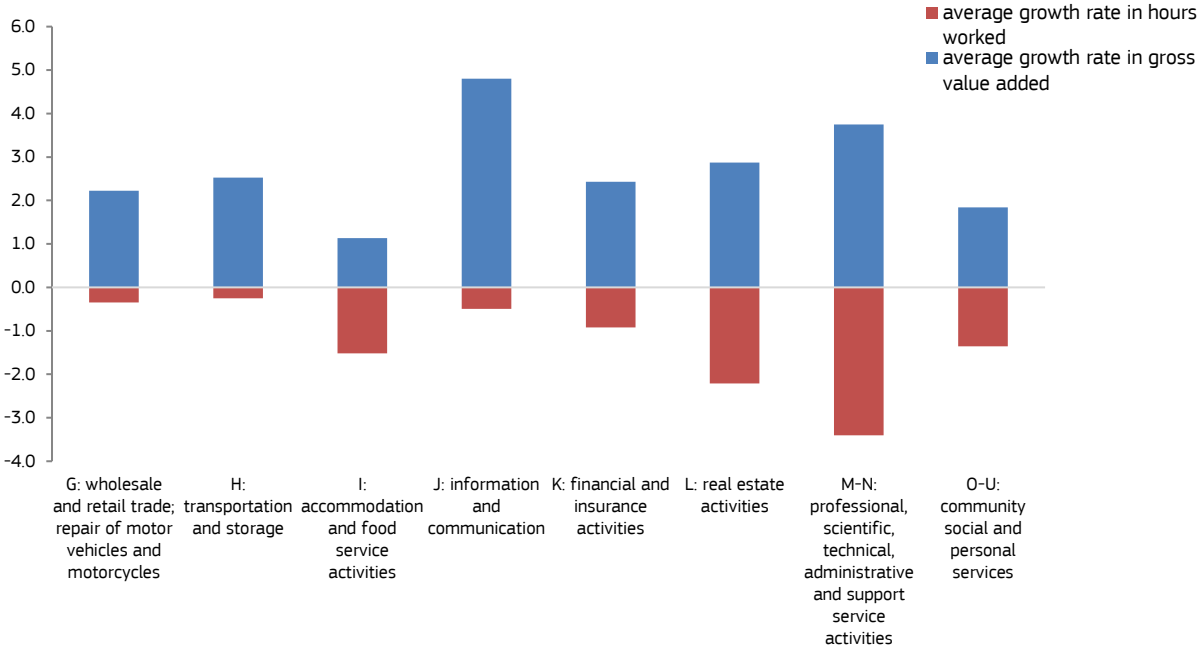
The community, social and personal services subsector, which comprises important public services such as health and education, also bears a negative impact onto aggregate labour productivity growth. With a nominal value added share of 18 per cent in 1970, it was already the largest service subsector. It expanded its weight further to 22 per cent of total nominal value added in 2017. This sector has represented an important drag since the beginning of the period, both through poor intrinsic productivity growth and through a relatively large increase in its economic weight.

An interesting question that follows from this is to what extent the labour productivity growth performance of the different subsectors within services can be attributed to, one, lower growth in real gross value added, and, two, more intense labour hoarding, or a combination of both, relative to the average. To see this, the following figure plots the contribution of real gross value added growth and hours worked to average labour productivity growth in each 1-digit subsector within services.

[45] Studies on the causes behind the above-average productivity performance of the ICT sector stress its being one of the most R&D intensive sectors (see, e.g., Duch-Brown et al. (2016) for the case of the Spanish ICT sector).

[46] It is important to remark that current technological advancements have the potential of boosting productivity even further, both in knowledge-intensive sectors such as ICT and less knowledge-intensive sectors that tend to absorb more labour input, such as the professional labour services sector (Sorbe et al., 2018).

Figure 11. Average growth in real gross value added and hours worked (negative sign) across 1-digit service subsectors in the EU-15 (1970-2017), percentage points.

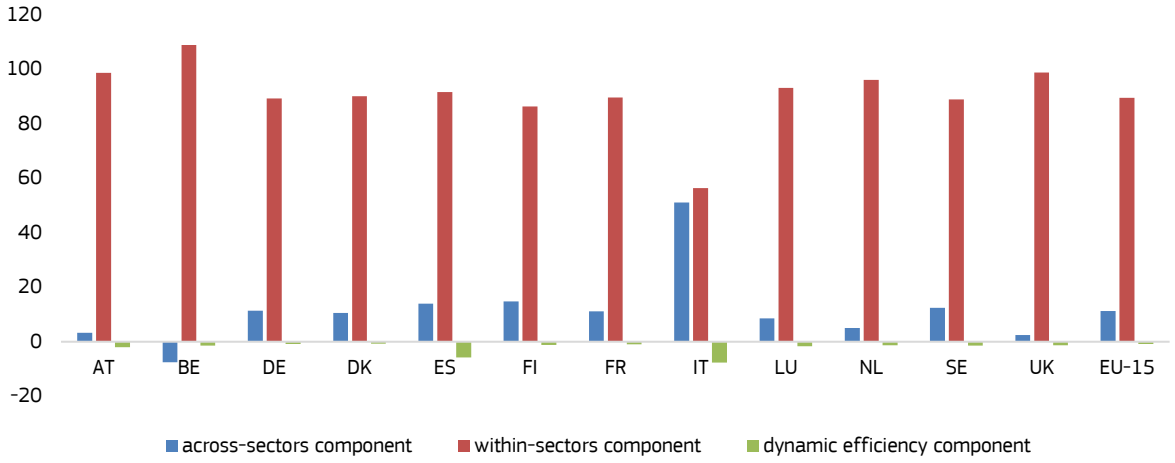


Source: EU KLEMS, 2019.

The graph above presents a mixed picture regarding the relative importance of real value added in comparison with hours worked as drivers of long-term labour productivity growth in service subsectors. In the accommodation and food service activities sector, negative average growth in labour productivity has been the result of both very weak growth in real value added and a relatively high increase in hours worked. In the professional activities sector, tepid labour productivity growth is the consequence of relatively intense labour hoarding offsetting the relatively large increase in real value added. The sectors which have experienced fastest productivity growth (e.g., ICT and transportation and storage), on the contrary, are mainly characterised by very low increments in hours worked.

Focusing next on the productivity performance of services, an FHK (Foster, Haltiwanger and Krizan, 2001) decomposition into the *across-sectors*, *within* and *cross-term/dynamic shift* components of labour productivity growth in the service sector as a whole is conducted. This decomposition casts light on potential differences in the relative importance of these drivers across the countries analysed. A special emphasis is placed on the role played by allocative inefficiency, captured by the *cross-term* component. The figure below shows such decomposition for the twelve EU-15 countries analysed and the EU-15 average.

Figure 12. FHK decomposition of average annual labour productivity growth in the aggregate service sector using employment weights, percentage contributions, 1970-2017.



Source: STAN and EU KLEMS, 2019.

The main observation arising from the figure above is that the *within* component is the main driver of average annual labour productivity growth in the service sector in most countries. This means that it is sector-intrinsic growth in productivity, rather than across-sector reallocations among service subsectors, which determines the lion share of the average annual labour productivity growth rate in the service sector as a whole. The roles played by both the *across-sectors* and the *dynamic efficiency* components are minor, except in Italy where the former has contributed to almost the same extent as the *within* component. Nonetheless, the *dynamic efficiency* component has had a negative impact in all cases, implying that labour input has not flowed to the fastest growing subsectors within services. The size of this component is largest for Spain and Italy, the two countries for which we have documented in turn the largest negative impact of structural change.

3.2.2 In-depth analysis for the EU-15

This subsection provides a breakdown of the main sectors responsible for the negative impact of structural change documented in the preceding sections.

The following table shows that excluding services from the computation of the counterfactual average labour productivity growth rates in the 1970-2017 period leads to an increase in the resulting rates for both base years, to 2.83 % and 2.68 %, with 1970 and 2017 value added weights, respectively. This is noticeably higher than the 2.08 % and 1.65 % rates obtained when services are included.

Table 3. Average labour productivity growth in the 1970-2017 period with different nominal value added weights including and excluding service, EU-15 (%).

Base year	All industries	Excluding services
1970	2.08	2.83
1975	1.99	2.84
1980	1.93	2.80
1985	1.91	2.84
1990	1.85	2.77
1995	1.77	2.73
2000	1.75	2.72
2005	1.69	2.64
2010	1.64	2.65
2017	1.65	2.68
Actual	1.82	2.73

Note: The real estate sector is excluded from these computations.

Source: EU KLEMS, 2019.

It can be seen from Table 3 that average annual real labour productivity growth in the 1970-2017 period in the EU-15 would have been about 0.26 percentage points higher (about 14 per cent higher) compared to the actually realized growth rate if the economic structure prevailing in 1970 had remained the same over time.[47] In other words, the long-run shifts in the sectoral composition of output have had a detrimental effect on economy-wide labour productivity development.

It is also important to note that the gap between the two counterfactual growth rates when not including services compared to including them significantly narrows down. The observations of both much higher growth rates and a shrinking difference between counterfactual growth rates when excluding services imply that it is mainly the structural shift towards the tertiary sector that drives the differences observed in average labour productivity growth when using past and current economic weights. This is hence indicative of the major role played by Baumol's *disease* in the EU-15.

To investigate which sectors have played a larger role in the long-run slowdown in productivity growth, the following table shows the nominal value added shares of each sector at the 1-digit level and their respective average labour productivity growth rates:

[47] This difference, which might seem small at face value, is non-negligible, given that labour productivity is generally perceived as the most important determinant of long-run welfare. At a value of around 10760 Euro per hour in 1970 (in 2010 constant terms), had the growth rate reached 2.08 per annum during the 47-year period considered, output per hour would have been about 3200 euros higher at the end of the period compared to the amount obtained at the *actual* annual growth rate of 1.82 per cent. All else equal, this difference in income per capita would likely have allowed lifting from poverty an additional number of citizens in the order of the tens of thousands.

Table 4. EU-15: Change in value added shares and average labour productivity growth in each one-digit sector, 1970-2017 (%).

Sector	VA share 1970	VA share 2017	Average LP growth
A: Agriculture, forestry and fishing	6.9	1.7	4.13
B: Mining and quarrying	1.6	0.5	3.06
C: Total manufacturing	28.1	18.1	3.10
D-E: Electricity, gas and water supply	2.7	3.0	2.94
F: Construction	8.7	6.0	0.85
G: Wholesale and retail trade; repair of motor vehicles and motorcycles	13.5	12.4	1.92
H: Transportation and storage	5.8	5.4	2.26
I: Accommodation and food service activities	2.0	3.4	-0.25
J: Information and communication	3.7	5.7	4.46
K: Financial and insurance activities	3.8	5.6	1.46
M-N: professional, scientific, technical, administrative and support service activities	4.3	12.9	0.42
O-U: Community, social, and personal services	18.8	25.4	0.51

Note: VA refers to value added and LP to labour productivity. The sum of shares may not equal to 100 % due to rounding. The real estate sector is excluded from these computations.

Source: EU KLEMS, 2019.

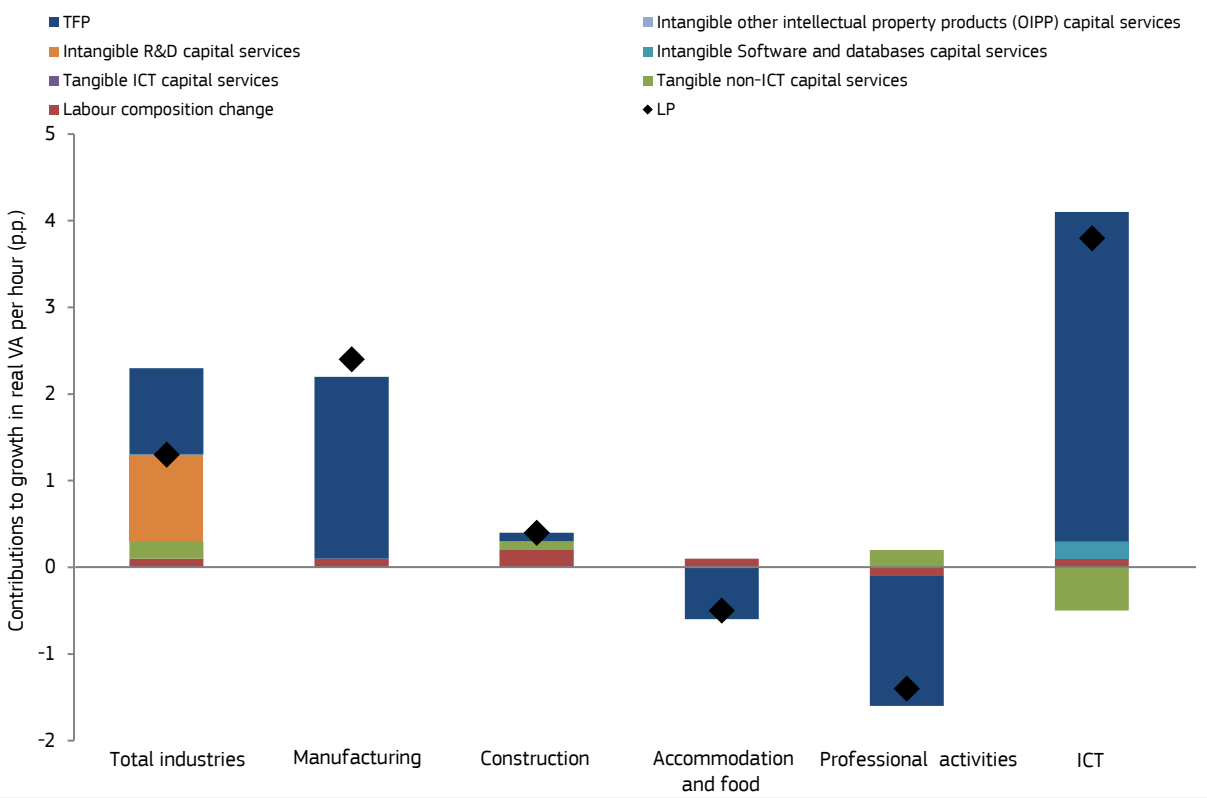
From Table 4 some trends concerning the drivers, at the 1-digit sectoral level, of the negative impact of structural change on productivity growth can be identified. First, both the agricultural and manufacturing sectors have seen their relative economic weights substantially shrink from 1970 to 2017, by approximately 75 % and 36 %, respectively. Since, at 4.13 and 3.1 per cent, these sectors have performed better in terms of labour productivity growth during this period relative to the average sector, the reduction in their shares has, all else equal, contributed to slowing down economy-wide productivity growth. Second, certain service sectors have negatively affected the growth rate of labour productivity growth, chiefly the accommodation and food service activities (I), regulated professions (M-N), and non-market services (O-U). These service subsectors have significantly increased their economic weight, while they have performed relatively poorly in terms of productivity growth.

To delve further into the main factors behind the productivity performance across time of the different sectors shown in Table 4, a growth accounting decomposition at the sectoral level can be conducted. However, due to data limitations such breakdown is not possible for the EU-15 block. For exemplification purposes, Box 1 shows this analysis for the case of Germany.

Box 1. Growth accounting example: Germany

The growth accounting methodology (O'Mahony and Timmer, 2009) used in the construction of the 2019 EU KLEMS release allows disentangling labour productivity growth into changes in the following components: TFP, intangible R&D capital, tangible ICT capital, tangible non-ICT capital, intangible software and databases, intangible other intellectual property products, changes in labour composition (a proxy for labour quality). Following the approach of Riley et al. (2018), the chart below displays this breakdown for the total economy, the manufacturing and construction sectors and different subsectors within services whose productivity performance lies below the average for the German economy. The ICT sector is also included as an example of a well-performing service sub-industry relative to the rest.48 Available data cover only the 22-year period spanning from 1995 to 2017.

Figure 13. Growth accounting contributors to German labour productivity growth, 1995-2017.



Source: EU KLEMS 2019.

Figure 13 shows that the relative strength of the different factors behind average labour productivity growth differs across the four subsectors. The main result arising from this decomposition is that TFP is the largest contributor (except in the construction sector) among the four components, with varying signs depending on the specific sector. TFP's contribution is largest for the ICT and manufacturing sectors, while it has represented a major drag in the professional activities and accommodation and food services sector. Labour composition and tangible non-ICT capital, on the other hand, have played a minor role across all sectors. The contribution from tangible ICT, intangible other intellectual property products and intangible software and databases is negligible.

An FHK (Foster, Haltiwanger and Krizan, 2001) decomposition into the *across-sectors*, *within* and *cross-term/dynamic shift* components of labour productivity growth in the EU-15 can be informative to examine to what extent *actual* economy-wide labour productivity growth has been driven by intra versus inter-industry developments. Such a decomposition for the 1970-2017 shows that around 20, 81 and -1 per cent of the average labour productivity growth rate in that period can be attributed to the across-term, the within and the cross-term components, respectively.

48 The current release of the EU KLEMS dataset only provides this breakdown of contributors to growth in value added per hour worked for a limited period (1996-2017) and for a restricted number of industries. For details on the growth accounting methodology, see O'Mahony and Timmer (2009).

This means that the within component of labour productivity growth, which captures the part of the change caused by intra-industry productivity growth, is its largest determinant. Interestingly, however, the cross-term component, which can be interpreted as a measure of whether industries with higher productivity growth gain increasing employment shares, is negative. This lends support to Baumol's prediction that it is the industries with lower productivity growth that gain increasing shares of employment, thereby weighing on aggregate labour productivity performance.[49]

A more adequate way to assess the *long-term* impact of structural change is to calculate the size of the cross-term component resulting from the difference between the productivity levels of the two endpoints of the sample, 1970 and 2017. For exemplification purposes, doing this for the EU-15 results in proportions equal to 36, 100 and -36 per cent for the within, the across-term and the dynamic shift components, respectively. Thus, the latter component becomes much larger and negative compared to the average of the year-by-year decomposition, although the within component remains the primary factor. Albeit this is still not the most appropriate way to gauge the impact of structural change, it shows why some of the literature on the true impact of structural change on productivity growth needs to be reconsidered.[50]

3.2.3 Testing Baumol's theory

This section presents an analysis of the first five hypotheses outlined in the introduction section stemming from Baumol's original theory. The hypotheses are tested for the EU-15. The econometric approach follows the methodology proposed in Hartwig (2011) and Nordhaus (2008). The latter shows that for Cobb–Douglas production technology with cost minimization and mark-up pricing, and an *almost ideal* demand system, hypotheses i) to v) described in the introduction can be interpreted as reduced-form equations which – under certain assumptions that Nordhaus sets forth[51] – can be written as:

$$\hat{x}_{i,t} = \gamma_1 \hat{a}_{i,t} + \gamma_2 D_i + \gamma_3 D_t + \varepsilon_{i,t}^p \qquad (1)$$

where $\hat{a}_{i,t}$ is the growth rate of productivity in industry *i* at time period *t* and $\hat{x}_{i,t}$ is a placeholder for different variables; it may stand for either real or nominal output growth, or price, wage or employment growth. D_t and D_i are vectors of fixed time and industry effects, respectively, $\varepsilon_{i,t}^p$ is a random disturbance, and γ_1 and γ_2 are coefficients. Equation (1) can be estimated via pooled OLS.

This testing strategy of Baumol's model rests on the fact that each of the hypotheses i) to v) listed in the introduction can be rephrased in terms of a prediction about the correlation between productivity growth at the industry level and the growth rate of one of the key variables in Baumol's theory. Whether the hypothesized correlations are present in the data can be tested using Equation (1). Hypothesis i) suggests that industries with relatively low productivity growth will show relatively strong price growth, and vice versa. The *cost and price disease* hypothesis will be lent empirical support to if we find a statistically significant negative correlation between productivity growth and growth in price indices across industries. Put in terms of Equation (1), the regression of industrial price growth rates on industrial productivity growth rates (and controls), should deliver a statistically significantly negative coefficient γ_1.

The following table summarizes the predictions about the sign of γ_1 contained in hypotheses i)-v).

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[49] An important remark concerning the interpretation of the *cross-term* component is that some body of literature equates this component to a measure of the impact of structural change on productivity growth. However, this term only captures the *year-on-year* reallocation of labour resources to different sectors. This is different from the *through-the-years*, cumulative reallocation of employment necessary to gauge the phenomenon of secular stagnation and the long-term impact of structural change. Hence, taking the average impact of the *year-on-year* effect is not an appropriate way to capture the effect of structural change. The only way to ensure an accurate calculation of the impact of the latter is to isolate it through the calculation of counterfactual growth rates as it is done at the beginning of this section.

[50] It is important to clarify that in this report we do not claim that structural change is the main driver of the currently observed productivity slowdown, but rather, that it has played a non-negligible role in explaining long-term productivity performance.

[51] For the sake of brevity, the reader is referred to the explanations in Nordhaus (2008). These include the derivation of his analytical framework and a discussion on econometric issues in the specification.

Table 5. Implied coefficient signs from the reduced-form equation.

1. *The cost and price disease hypothesis*
$\hat{x}_{it}$ = growth rate of price level of industry i. H_0: $\gamma_1 < 0$
2. *The "constant real share" hypothesis*
$\hat{x}_{it}$ = growth rate of real output of industry i. H_0: $\gamma_1 = 0$
3. *The unbalanced nominal growth hypothesis*
$\hat{x}_{it}$ = growth rate of nominal output of industry i. H_0: $\gamma_1 < 0$
4. *The hypothesis of declining employment shares of productive industries*
$\hat{x}_{it}$ = growth rate of hours worked in industry i. H_0: $\gamma_1 < 0$
5. *The uniform wage growth hypothesis*
$\hat{x}_{it}$ = growth rate of wages in industry i. H_0: $\gamma_1 = 0$

Source: Hartwig (2011).

While the related literature is mainly centred on the evolution of total factor productivity (TFP), the empirical analyses contained in this section focus exclusively on labour productivity. This choice is grounded in two main reasons. First, this paper focuses on *long-term* productivity performance. In the literature, the preferred metric for gauging this tends to be labour rather than total factor productivity.[52] Second, there is general consensus that output per hour is the single most important element in determining a country's standard of living.[53]

The data are arranged in a similar fashion to Nordhaus (2008) and Hartwig (2011). In particular, average labour productivity growth rates are calculated over the whole observation period 1970–2017. Additionally, a panel of cross-sectional and time-series data is constructed. Nordhaus (2008) stipulates two criteria for choosing the sub-periods: (1) the periods should be of approximately equal length, and (2) they should cover a whole business cycle (from 'peak to peak'). Applying the same criteria to our analysis, the chosen subperiods correspond to 1971-1979, 1980-1988, 1999-2000, 2001-2007, and 2008-2017.

3.2.4 Econometric results

Table 6 provides summary results of estimating Equation (1) via pooled OLS on various samples. These samples correspond to different combinations of number of industries and use of cross-section and time-series data. Nordhaus (2008) stipulates two criteria for choosing the sub-periods in the panel data: (1) the periods should be of approximately equal length, and (2) they should cover a whole business cycle (from peak to peak). Applying these criteria to our sample, we distinguish five periods: 1971-1979, 1980-1988, 1989-2000, 2001-2007, and 2008-2017. For choosing the different sets of industries, we mimic Hartwig (2011).[54]

It reports the results for the tests of hypotheses i)-v) outlined in the introduction. For each of the five dependent variables, there are six estimated coefficients, one for each industry-sample combination. Nordhaus (2008), even if aware that the equations are not independent from one another, calculates two averaged coefficient values (weighted and unweighted by the number of observations) over all six specifications. These are presented in the last two columns of Table 6.

[52] TFP is widely used in analyses of the relationship between business cycle dynamics and productivity.

[53] This is reflected in Paul Krugman's famous quote that: "Productivity isn't everything, but in the long run it is almost everything. A country's ability to improve its standard of living over time depends almost entirely on its ability to raise its output per worker", Krugman (1994).

[54] For the list of industries, please see Annex B1. As explained in Nordhaus (2008), the rationale for including the different industry groupings is to check for the robustness of the results as well as compute weighted and unweighted averages of the estimation results (see Table 6). The mapping between Hartwig (2001)'s industries and the ones used here was carried out using a correspondence tables between the NACE Rev. 1. and NACE Rev. 2 classifications. Due data gaps in the latest EU KLEMS 2019 release, some of the industries present in Hartwig (2011) could not be included in our analysis

Table 6. Impact of productivity growth on five variables; aggregate of EU15 countries, 1970-2017.

Variable	All 28 industries		18 well-measured industries		18 industry groups		Summary results	
	Cross section	5 sub-periods	Cross section	5 sub-periods	Cross section	5 sub-periods	Cross section	5 sub-periods
$\hat{p}$	-0.855***	-0.681***	-1.012***	-0.772***	-0.724***	-0.450***	-0.678	-0.749
	(0.0871)	(0.148)	(0.142)	(0.200)	(0.0845)	(0.125)		
$\widehat{rgva}$	0.332*	0.589***	0.676***	0.703***	0.103	0.325***	0.512	0.525
	(0.171)	(0.0632)	(0.222)	(0.0709)	(0.224)	(0.0703)		
$\widehat{ngva}$	-0.459**	-0.0317	-0.243	0.0128	-0.594**	-0.123	-0.084	-0.332
	(0.167)	(0.163)	(0.241)	(0.219)	(0.209)	(0.143)		
$\widehat{hemp}$	-0.731***	-0.460***	-0.414*	-0.360***	-0.919***	-0.705***	-0.533	-0.598
	(0.174)	(0.0614)	(0.227)	(0.0687)	(0.236)	(0.0705)		
$\hat{w}$	0.219***	0.149*	0.129*	0.0656	0.226***	0.217**	0.138	0.188
	(0.0493)	(0.0815)	(0.0621)	(0.0994)	(0.0707)	(0.0959)		
Observations	28	140	18	90	18	90		

Note: $\hat{p}$=log change in price level (price indices of gross value added, 2010=100), $\widehat{rgva}$=log change in gross value added, volume (2010 prices) $\widehat{rgva}$=log change in gross value added at current basic prices (millions of national currency), $\widehat{hemp}$=total hours worked by persons engaged, $\hat{w}$ =labour compensation per hour (millions of national currency). Estimates for constant terms are not shown.
***, **, and * denote significance at the 1 %, 5 %, and 10 % levels, respectively. Standard errors are in parentheses.
Well-measured industries correspond to the ones identified in Hartwig (2011), excepting those with no sufficient data availability.

Source: EU KLEMS, 2019.

The results from Table 6 offer mixed evidence as to the fulfilment of the predictions and assumptions behind Baumol's theory for the EU-15. On one hand, across all the specifications a statistically strong negative correlation between inflation and labour productivity growth is obtained. This means that industries with above average labour productivity growth exhibit below average price growth, in line with Baumol's model's predictions. As regards the "constant real shares" hypothesis, the econometric results predominantly reject it, given the generally positive and significant link found between real value added and labour productivity growth.[55] In line with the findings in Hartwig (2011), the results for nominal value added growth are hard to interpret, given seemingly conflicting and weak evidence between the cross-section and pooled estimates. The relationship is stronger in the former specification because the (negative) effect of labour productivity growth on price growth is stronger than its (positive) effect on real value added, rendering the net impact on nominal value added negative. The evidence for hypothesis iii) must therefore be regarded as inconclusive. [56] Hypothesis iv) asserts that we would expect to observe industries with above average productivity growth display below average growth in labour input. This hypothesis is indeed confirmed by the estimated coefficients in the fourth row of coefficients in Table 6. Hence, we can conclude that less *progressive* industries tend to hoard on more labour input than their more *progressive* counterparts. Finally, no significant evidence (at the 1 % confidence level) is found of a positive link between labour compensation and labour productivity growth. Given the statistically significant negative relationship found between inflation and labour productivity growth, it is apparent that, across European industries, technical progress leads to lower price increases rather than higher wages.

3.3 Tertiarisation as a drag to aggregate productivity growth

This section has focused on the role played by structural change as a driving force behind the phenomenon of secular stagnation in the EU-15, linking it in turn to Baumol's *disease* theory. The main findings following from the analyses are the following. First, structural change is shown to have had a negative impact on average labour productivity growth in the period 1970-2017 for most EU-15 countries. Although structural change alone is not able to fully explain the observed slowdown, it has contributed to it to a non-negligible

[55] Nordhaus (2008) contains a discussion on the choice of real value added over real gross output as a more appropriate measure of real output.

[56] As explained in Nordhaus (2008), the sum of the coefficients for the regressions of growth in real value added and prices should be roughly equal to the coefficient for nominal value added growth. Looking at the weighted averages shown in Table 6, this assumption only holds approximately (i.e., -0.678+0.512=-0.167).

extent. This effect is even more relevant when considering that output per capita is generally accepted to be the ultimate determinant of citizens' wellbeing. Second, we have established that the negative impact of structural change on labour productivity growth has been largely via an increase in the relative economic weight of the more productivity-stagnant service industries. Importantly, it has also been shown that the service sector is not uniform in terms of its productivity performance, with subsectors, such as ICT, whose productivity growth rates are as high as those of the primary and secondary sectors. Third, making use of the growth accounting decomposition provided in the EU KLEMS dataset, the main drivers of labour productivity growth across a number of sectors have been identified for the case of Germany. In this case, TFP growth seems to play a major role, as opposed to labour composition. Fourth, an attempt at testing five of the six hypotheses (à la Nordhaus (2008) and Hartwig (2011)) stemming from Baumol's theory has been made. The results confirm a significant negative correlation across sectors between growth in prices and employment shares and labour productivity growth. However, the sign of the effects on real and nominal value added and wage growth is more blurred.

From a policy viewpoint, these results imply that the EU, and in particular the most advanced economies within it, have long been in the process of converging to a *new normal*, in which slower economy-wide productivity growth stems from large shifts in demand away from manufacturing goods toward services, whose intrinsic characteristics offer less room for realizing productivity gains. An important caveat to this overarching result is that certain subsectors within services have been shown to display a large potential to increase their efficiency through automatisation and digitalization.[57] Ultimately, the main message following from this analysis is that any discussion on how to foster productivity growth needs to take the sectoral dimension, and specifically the increasing role of services, into account.

[57] See, for example, Duernecker et al. (2017) and OECD (Sorbe et al., 2018) for a discussion on the increasing relevance of faster productivity growing sectors within services.

4 Business cycle dynamics in productivity

4.1 The cyclical nature of productivity

Traditional macroeconomic analysis assumes productivity to be pro-cyclical. This implies that productivity would increase during periods of economic expansion and fall while in recessions. To the extent that labour and capital are more intensively utilised during economic expansions, pro-cyclicality is then a consequence of the propagation mechanisms at the core of business cycles.

Standard explanations for this phenomenon take into account the following aspects:

- Pro-cyclical exogenous technology shocks, through the connection with Total Factor Productivity (TFP), which affect both GDP and productivity growth (e.g. Gordon, 2004; among others);
- Labour hoarding, i.e. firms do not decrease their size as fast as output declines which allows productivity to rise again when the demand for output recovers (Bernanke and Parkinson, 1991; Caballero and Lyons, 1992; Sbordone, 1997). In this regard, EU cross-country adjustments to labour demand shocks also play a role, where differences in national employment rates reflect each country's labour market institutions (Beyer and Smets, 2015);
- Competitive pressures that result into better access to resources such as R&D and credit, both pro-cyclical (Aghion et al., 2005; Barlevy, 2007). Competitive pressures might indeed raise productivity growth for most innovative firms (i.e. those that are already close to the technological frontier), but not for those with average or poor innovative capabilities (Aghion et al., 2004, 2009). Productivity is positively correlated with competitive pressures (Nickell, 1996) and R&D (Crépon et al., 1998), particularly for countries with a high intensity in business R&D expenditure (Guellec and De la Potterie, 2002) and sectors characterised by a low average firm's size (Oliveira Martins and Scarpetta, 1996);
- Economies of scale leading to increasing returns (externalities or spill-over effects which cause endogenous variations) such that productivity would rise during expansions and fall during recessions (Murphy et al., 1989; among others);
- High fluctuations in inputs utilisation over the cycle (e.g. Basu, 1996; among others);
- Reallocations of resources from uses of inputs (e.g. labour) with a lower marginal product to those with a higher one, typically associated with higher mark-ups. Firm's restricting, reallocation and entry-exit patterns all play a prominent role for productivity growth (e.g. Caballero and Hammour, 1996, 2001; Campbell, 1998; among others).

With an application to the case of Manufacturing, Information and Communication, and Professional Services sectors in the EU, a study of the cyclicality in productivity across Member States aims to show when and whether productivity is pro-cyclical for different sectors at the same time as highlighting which of the underlying causes is predominant for certain Member States.

This is particularly relevant for the cases in which cyclicality is not detected, as that could constitute evidence of misalignments in the factors previously mentioned that advocate for further investigation. Possible policy recommendations would revolve around firm's behaviour and advice towards the need to introduce measures allowing productivity to adjust to the economic cycle during expansions or be more resilient during contractions.

4.2 Methodology and data

This chapter analyses productivity-growth dynamics across a sample of 12 EU countries: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Italy, the Netherlands, Spain, Sweden, and the United Kingdom. These countries are chosen according to the data availability provided by EU KLEMS for sectoral disaggregation in productivity series. In addition, these Member States represent a very large and diverse share of Gross Domestic Product of the European Union, resulting in about 80 % of the whole EU28 GDP in Purchasing Power Parity Standards in 2018.[58]

[58] Eurostat – Annual National Accounts.

Furthermore, economies other than those included in this analysis have shown different productivity-growth dynamics compared to the countries selected, which would in turn require an in-depth and separate study. Indeed, while latest accession countries still display relatively higher levels of productivity growth, on the other hand the productivity of the traditionally mature EU economies has been fluctuating over time narrowly around zero (Marrocu et al., 2013).

In addition to a country aggregate analysis, different sectors are then considered across the sample of economies to identify what patterns are similar across countries and sectors and what features are instead sector-specific, in order to understand what drives aggregate productivity trends over time.

Three sectors— Manufacturing (C), Information and Communication (J), Professional Services (M-N) — are chosen for this study since they represent a large and diverse cut of the economies in the sample of countries considered and are alleged to play a significant role in explaining the so-called aggregate 'productivity slowdown' (see Chapter 1). In that regard the analyses aim at providing evidence across sectors and countries for some of the most prominent explanations for productivity-growth pro- and counter-cyclical movements. In this study Professional Services are represented by 'Professional, Scientific, Technical, Administrative and Support Service Activities' as defined by Eurostat (i.e. M-N).

From an economic policy perspective, it is highly relevant to look into productivity developments for services due to the strong interlinkages to other economic sectors, particularly manufacturing. Such interlinkages, or sometimes reciprocal needs, are present when services industries play the role of customers or users of other sectors' inputs – so called 'backward linkages' – or when they serve as suppliers or inputs into the production process of other sectors – i.e. 'forward linkages'). The rising forward and backward linkages for services in the EU are part of the phenomenon referred to as 'servitisation' or 'servicification' of modern economies in which boundaries between services and manufacturing are progressively shredding.

For the purposes identified in this study a consistent analytical approach is therefore adopted across countries and industries to evaluate the interconnections among factors at the core of productivity dynamics and revolving around the full cycle of economic growth, starting from the production of goods and services which leads to changes in the degree of labour utilisation, and results into patterns of 'creative destruction' and business dynamism (Aghion, et al., 2015; among others). Such a methodology aims at reviewing various hypotheses on why productivity growth has slowed or diverged from the economic cycle and during which period, in addition to consider possible explanations beyond the traditionally supply-side focused approach that characterises seminal work in this field.

In this study, the dynamics due to the financial and Eurozone crises (2007–09) slowdown are compared with the post-crisis years (2010–14), which includes the so called 'double dip' recession in the EU, in addition to the relatively more stable period that followed afterwards.

By looking closely at both the productivity cycle and slowdown, this approach allows for the detection of short- as well as long-term factors behind productivity developments and pinpoint issues that might be tackled or resolved, as well as medium to long-term trends that are expected to persist, providing useful indications that could outline the potential for revamping EU productivity growth in the coming years.

While this methodology aims at providing a better understanding of the productivity-growth cyclicality and slowdown as well as its implications for the future of the EU, questions for further research surely remain such as how to better take into account the role of developments across the digital economy and encompass the economic effects of digital transitions.

This analysis makes use of data from EU KLEMS (2017 release) and Eurostat – Structural Business Statistics (SBS), Business Demography, Annual National Accounts, respectively. More details are provided over the next paragraphs.

4.2.1 Total factor productivity

EU KLEMS provides data for Total Factor Productivity (TFP) disaggregated at the sectoral level. Such a measure of productivity is based on an input-output framework where the production possibility frontier is a function of capital (K), labour (L), intermediate inputs (X) and technological change (A). This results into a production function (Y) with the following form:

$$Y_i = f_i(K_i, L_i, X_i, A_i) \qquad (2)$$

Under the assumption of Hicks-neutral technological change, competitive factor markets where each factor is priced at its marginal cost, full input utilisation and constant returns to scale, the growth of output can be represented as the cost-share weighted growth of inputs and technological progress (A). Applying a log-linearisation technique to the production function yields:

$$\Delta lnY_{it} = \varphi_{it}^{K}\Delta lnK_{it} + \varphi_{it}^{L}\Delta lnL_{it} + \varphi_{it}^{X}\Delta lnX_{it} + \Delta lnA_{it} \qquad (3)$$

where $\varphi_{it}^{K} = \frac{P_{it}^{K}K_{it}}{P_{it}^{Y}Y_{it}}$, $\varphi_{it}^{L} = \frac{P_{it}^{L}L_{it}}{P_{it}^{Y}Y_{it}}$, $\varphi_{it}^{X} = \frac{P_{it}^{L}L_{it}}{P_{it}^{Y}Y_{it}}$ refer to the average share of input i in real output and $\varphi_{it}^{K} + \varphi_{it}^{L} + \varphi_{it}^{X} = 1$.[59]

Under these assumptions, each term in the equation above indicates the proportion of output growth accounted by the growth in capital, labour, intermediate inputs and technological change as measured by Total Factor Productivity (TFP). In such a framework the contribution to output growth of each intermediate and capital input is given by the product of its share in total costs and growth rate. The contribution of labour input is divided into hours worked and changes in the composition of hours worked, and any residual output growth is finally represented by the Total Factor Productivity term A which therefore measures 'disembodied' technological change as it stems from the neo-classical assumptions on the production function previously expressed. As a residual measure, TFP growth also accounts for the effects from changes in unmeasured inputs, such as research and development and other intangible investments (Corrado et al., 2009).

EU KLEMS makes use of sector-specific Purchasing Power Parities (PPPs) to adjust output and inputs for differences in relative price levels between countries and at the sectoral level. PPPs for value added are constructed by double deflation of gross output and intermediate inputs within a consistent input-output framework[60].

4.2.2 Wage-adjusted labour productivity

Wage-adjusted labour productivity is an indicator of labour productivity derived from the Structural Business Statistics database of Eurostat. It is defined as value added divided by personnel costs which is successively adjusted by the share of paid employees in the total number of persons employed.

In more simple terms, this represents apparent labour productivity divided by average personnel costs, expressed as a ratio in percentage terms. Since such an indicator is based on expenditure for labour input rather than a headcount of persons employed, it is therefore more relevant for comparisons across activities and countries, particularly those with very different frequencies of part-time employment or self-employment shares.

The apparent 'wage-adjusted' labour productivity for a country 'c'-sector 'j' pair is given by the ratio of value added (VA) and the average personnel cost, i.e. $AC(L)$ at a given point in time 't':

$$LP_{c,j} = \frac{VA_{c,j}}{AC(L)_{c,j}} \qquad (4)$$

Value added is measured in purchasing power parity-adjusted euros using GDP-based price levels referred to the EU-28 aggregate provided by Eurostat.

4.2.3 Business churn rate

The business churn rate is computed as the sum of all enterprise births and deaths as a percentage of all active firms, as defined in the Eurostat-OECD Manual on Business Demography Statistics:

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59 Note: EU KLEMS accounts for the presence of both labour and capital services and separates the impact of ICT and non-ICT capital. It also divides intermediate inputs into three categories such as energy, materials and services.

60 More details on EU KLEMS methodology available here: http://www.euklems.net/TCB/2018/Metholology_EUKLEMS_2017_revised.pdf

The churn rate for a country 'c'-sector 'j' pair is given by the sum of firm's birth rate and death rate with respect to all active enterprises at a given point in time 't':

$$Business\ Churn_{c,j,t} = \frac{Birth_{c,j,t} + Death_{c,j,t}}{Active\ Enterprises_{c,j,t}}\% \qquad (5)$$

The churn rate indicates how frequently new firms are created and existing enterprises shut down. New-entrant firms are often found to raise aggregate productivity growth as they enter with new technologies and trigger productivity-enhancing changes in incumbents. The reallocation of resources across enterprises, driven by firm dynamics, is expected to increase aggregate productivity according to a process of 'creative destruction', where innovative firms enter the market and thrive while lower productivity firms contract or leave. In this light the churn rate represents a country's degree of 'creative destruction', and supports the analysis of the contribution of business dynamism to aggregate productivity growth.

4.2.4 Labour utilisation

When measured in per capita terms, growth in gross domestic product can be separated into growth in labour productivity – measured as growth in GDP per hour worked – and changes in the extent of labour utilisation, measured as changes in hours worked per employee. Inspecting for the possible presence of labour hoarding implies looking at that part of labour input which is not completely utilised by a firm during its production process at any point in time. Under-utilisation of labour can occur in different ways, such as reduced effort – i.e. hours worked – and/or the reallocation of labour to other uses, such as education and training of employees.

For a country 'c'-sector 'j' pair an index of labour utilisation is given by the ratio of hours worked over the number of persons employed (EMP) by active firms at a given point in time 't':

$$LU_{c,j,t} = \frac{HW_{c,j,t}}{EMP_{c,j,t}} \qquad (6)$$

This index is based on series from Eurostat Structural Business Statistics (SBS) and Annual National Accounts.

From a firm's perspective, some labour hoarding may be optimal given the fixed costs associated with adjusting staff numbers. These costs include costs of recruitment, screening and training of new workers, as well as costs related to the termination of contracts such as severance pay. Therefore, in the face of a downturn in activity, companies may prefer to reduce labour input, at least to some extent, by shortening the hours worked, which is less costly than reducing staff numbers.

4.2.5 Decomposing cyclical variations: the Hodrick-Prescott Filter

The Hodrick-Prescott (HP) filter is one of the most widely used econometric methods in applied macroeconomic research. Such a technique is non-parametric and aims at decomposing a time series into a trend and a cyclical component. Similarly to other non-parametric methods, the HP filter depends critically on a tuning parameter that controls the degree of smoothing. The filter is often used in the context of estimating potential output and relies on a relatively simple computational approach providing an appealing and practical method for business cycle analysis. On the other hand, HP filtering maintains an uncertain position with respect to the exact functional form of the trend and cyclical components identified. In this regard this filtering technique suffers from criticism in the literature, particularly when results are accepted blindly and without a comparative perspective (Hamilton, 2018; among others).

The HP filter relies on the assumptions that actual values of the filtered variable do not deviate too much from its trend level while growth in the trend values is relatively smooth and therefore not too volatile –i.e. *stochastic* (Cogley and Nason, 1995; Philips and Jin, 2015; among others).

The outcome of the HP filter can be formulated as resulting from the minimisation problem in the squared loss function of a residual or cyclical component c_t with respect to a trend component f_t^* and subject to a constraint that discounts changes in the growth rate of the trend component:

$$min_{\{f_t\}_{t=1}^{T}} \sum_{t=1}^{T} (x_t - f_t)^2 + \lambda \sum_{t=1}^{T} (\Delta f_t - \Delta f_{t-1})^2 \; ; \; \lambda = \frac{\sigma_1^2}{\sigma_2^2} > 0 \qquad (7)$$

where $c_t = x_t - f_t$; x_t is the time series to be filtered; σ_1^2 is the variance of the cyclical components and σ_2^2 is the variance of the growth in the trend component.

The choice of the smoothing parameter λ depends on knowledge or assumptions regarding the cycle length. Empirical evidence using the HP filter adopts standard settings for the smoothing parameter λ that are the result of extensive research with macroeconomic data and heuristics towards the form of economic cycles and trends. For quarterly data the standard choice is λ = 1600, as recommended by Hodrick and Prescott (1997) based on their research on US data. This value is considered as a gold standard for converting the smoothing parameter to other sampling frequencies such as annual or monthly data (Ravn and Uhlig, 2002). For yearly data the standard choice is λ = 100 as adopted in this study. Interestingly, the values for the HP filter smoothing parameter are typically applied irrespective of the sample size of the data in contrast to standard nonparametric methods.

In the next sections the HP filter is used to produce evidence in regarding Manufacturing, Information and Communication, and Professional Services cycle decomposition for an aggregate of the 12 EU countries considered, and individually for a sample of these Member States. This stylised framework makes use of TFP (representing technological change), wage adjusted labour productivity, business churn and labour utilisation in comparison to Gross Value Added (GVA) developments across sectors and countries to assess patterns of cyclicality and productivity growth.

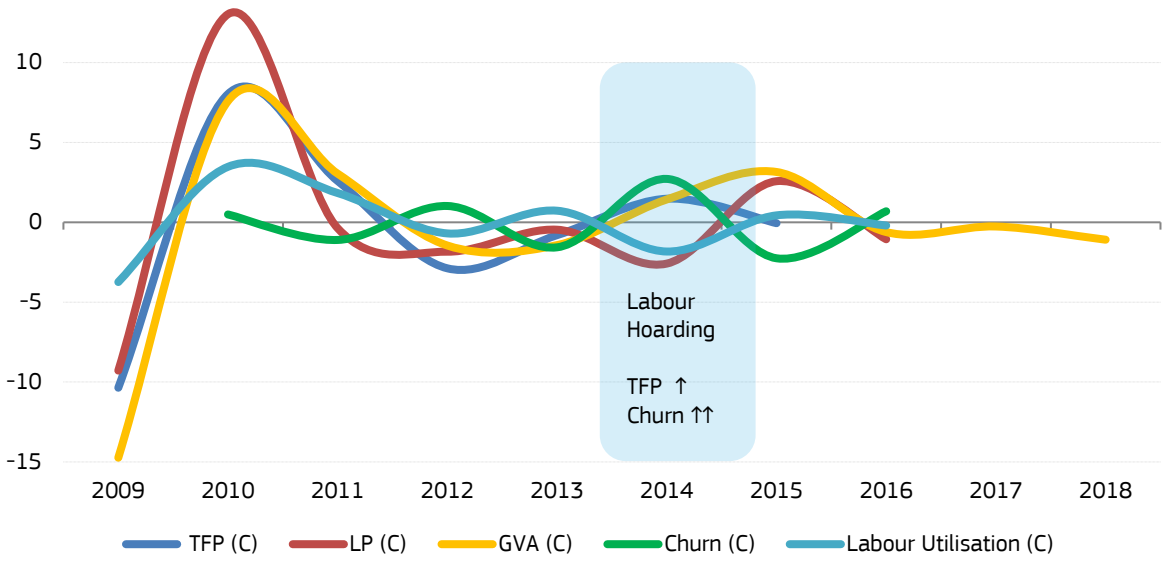
4.3 Business cycle dynamics in a stylised EU12[61]

The purpose of this section is to review asymmetries between labour productivity (LP) and gross value added (GVA) growth during specific years with respect to developments in the role of a) Technology (proxied by total factor productivity - TFP) b) enterprise dynamism (i.e. churn rate); c) labour hoarding (i.e. under-utilisation). Looking at the sample composed by the EU12 countries as defined in the EU KLEMS database, we can observe how substantial changes in the growth rate of enterprise churn and labour utilisation appear during periods when LP Growth is divergent with respect to GVA Growth. That can signal the relevance of such dynamics during periods when changes in LP and GVA are not aligned. Other factors might also be at play which however it does not exclude the importance of those identified so far, particularly given the relative size of the changes across all indicators.

Figure 14 shows the year-over-year HP-filtered growth rates of productivity, gross value added, enterprise dynamism, and labour utilisation indicators for the manufacturing sector in the EU12. For this sector the growth rates of LP and GVA are diverging in 2014, when LP experiences a drop up to negative values while GVA rises steadily until 2015. During the same period, the growth rates of TFP and particularly that of the enterprise churn are both increasing. Labour utilisation (i.e. the ratio between hours worked and number of employees) on the other hand drops substantially, which might signal the presence of labour hoarding in the manufacturing sector during that year. In such a context we notice therefore how GVA appears to follow TFP whereas LP drops at the same time as a steep rise in enterprise dynamism occurs and while a process of labour hoarding is seemingly in place. On this latter point it is worth mentioning, however, how the EU labour market recovery during 2014 might also have played a role in the observed LP drop, since the labour employed would increase more than proportionally with respect to the value added generated by firms that resume their hiring. A resulting effect (more employees and fewer hours worked by each of them) would explain the pattern observed for LP during this period and the later realignment of LP and GVA when the growth rate of labour utilisation is stable and close to zero.

[61] Individual country profiles for France, Germany, Italy, Spain, and Sweden are available as Country factsheets (Annexes A).

Figure 14. EU12 – Manufacturing cycle decomposition (2008-2018).

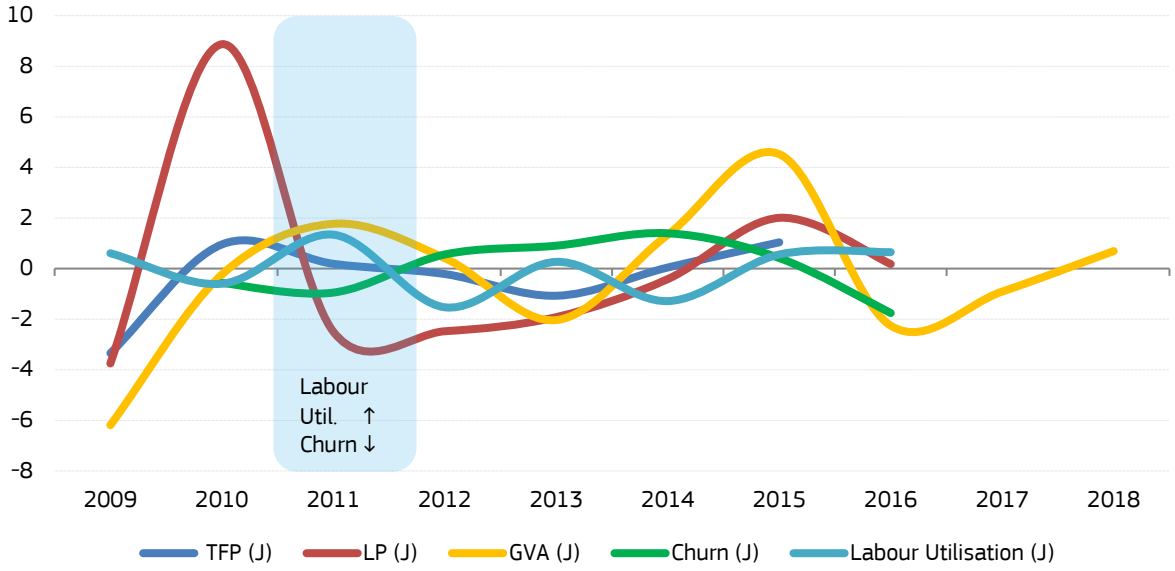


Note: Year-Over-Year Growth (%); EU12 represents the EU member states for which growth accounting could be performed from 2001 onwards, namely: AT, BE, CZ, DK, FI, FR, DE, IT, NL, ES, SE, and UK.; TFP measured as valued added based growth not accounted by labour and capital inputs; LP measured as wage-adjusted labour productivity by average personnel costs; Business Churn computed as the percentage of firm's birth + death rates over all active firms; Labour Utilisation defined as the ratio between hours worked and employees of all active firms in a given year.

Source: EU KLEMS, 2017, and Eurostat – Structural Business Statistics (SBS), Business Demography, Annual National Accounts.

Figure 15 displays the year-over-year HP-filtered growth rates of productivity, gross value added, enterprise dynamism, and labour utilisation indicators for the information and communication sector in the EU12. For this sector the growth rates of LP and GVA are diverging in 2011, when LP experiences a drop up to negative values with respect to 2010 while GVA has risen steadily since 2009. During 2011 we can observe how a steep rise in labour utilisation takes place while the rate of enterprise churn continues to decrease mildly since 2010. It would appear, therefore, how GVA growth is associated to a 'wait and see' labour hoarding which resulted in GVA decreasing faster than the employee's lay-off rate. LP growth starts to revamp from 2012 onwards when the growth rate of enterprise churn moves from negative to positive values and labour appears to hoard once again as in 2010, with a negative growth rate during 2012 for labour utilisation.

Figure 15. EU12 – Information and Communication cycle decomposition (2008-2018).

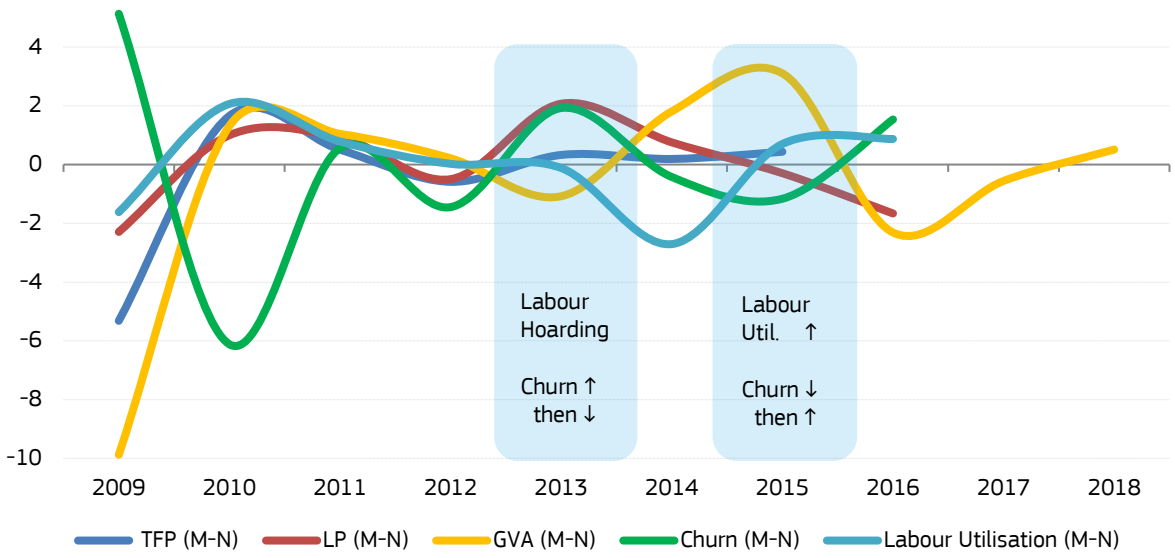


Note: Year-Over-Year Growth (%); EU12 represents the EU member states for which growth accounting could be performed from 2001 onwards, namely: AT, BE, CZ, DK, FI, FR, DE, IT, NL, ES, SE, and UK.; TFP measured as valued added based growth not accounted by labour and capital inputs; LP measured as wage-adjusted labour productivity by average personnel costs; Business Churn computed as the percentage of firm's birth + death rates over all active firms; Labour Utilisation defined as the ratio between hours worked and employees of all active firms in a given year.

Source: EU KLEMS, 2017, and Eurostat – Structural Business Statistics (SBS), Business Demography, Annual National Accounts.

Figure 16 exhibits the year-over-year HP-filtered growth rates of productivity, gross value added, enterprise dynamism, and labour utilisation indicators for the professional services (professional, scientific, technical, administrative and support service activities) sector in the EU12. For this sector the growth rates of LP and GVA are diverging in 2013 – when LP experiences a steep rise while GVA drops to negative values with respect to 2012, and in 2015 – when on the other hand GVA growth experiences its peak while LP growth continues to decrease up to negative values with respect to 2014. During 2013 we can observe signals of labour hoarding and a bell-shape in the growth rate of enterprise churn. During 2015 instead, it appears how labour is being highly utilised and the growth rate of enterprise churn takes on a U-shape. Consequently, it would appear how periods enduring some labour hoarding might be concomitant to increases in LP for the professional services sector while a high labour utilisation rather aligns to higher GVA growth. An increase in the churn rate during 2013 aligns to higher LP growth whereas GVA starts revamping some time afterwards, during 2014.

Figure 16. EU12 – Professional Services cycle decomposition (2008-2018).



Note: Year-Over-Year Growth (%); Professional, Scientific, Technical, Administrative and Support Service Activities; EU12 represents the EU member states for which growth accounting could be performed from 2001 onwards, namely: AT, BE, CZ, DK, FI, FR, DE, IT, NL, ES, SE, and UK.; TFP measured as valued added based growth not accounted by labour and capital inputs; LP measured as wage-adjusted labour productivity by average personnel costs; Business Churn computed as the percentage of firm's birth + death rates over all active firms; Labour Utilisation defined as the ratio between hours worked and employees of all active firms in a given year.

Source: EU KLEMS, 2017, and Eurostat – Structural Business Statistics (SBS), Business Demography, Annual National Accounts.

4.4 Labour utilisation and enterprise dynamism can help revamping productivity

From the perspective of all sectors combined, we could draw how an under-utilisation of labour, possibly signalling the presence of labour hoarding, appears to be beneficial for labour productivity. On the other hand, as one could expect, changes in the growth rate of gross value added appear to be more aligned with changes in the growth rate of total factor productivity rather than of labour productivity. However the productivity paradox makes this conclusion rather questionable, particularly looking at the professional services sector.

A reasonable increase in the rate of enterprise churn is generally associated with higher labour productivity growth, although a too-steep rise in business dynamism with respect to previous periods can be detrimental, and even more so when coupled with high labour utilisation. In the information and communication as well as professional services sectors on the other hand, a rise in labour utilisation appears to help revamping the growth in gross value added. It would therefore seem fair to highlight the possible detrimental role of excessive business dynamism on labour productivity growth and how labour hoarding can be associated to moderating effects in that regard. In the event of a drop in business dynamism, a progressive rise from low to higher labour utilisation takes place at the same time as a revamp in gross value added. Provided changes in the churn rate are not overly high, during periods when demand fails to recover (some) labour hoarding can help labour productivity growth if not protracted for too long.

5 Public expenditure and productivity in business services

5.1 A mixed effect of public expenditure on productivity

Academic literature considers government expenditures as an important determinant of productivity. In this chapter, we estimate effects of government expenditures' structure on productivity growth in business services (private sectors) and industrial sectors. The empirical estimates suggest that productivity growth in business services increases with the government expenditures on economic affairs and declines in military expenditures. These effects show up with a four-year delay. There is also evidence that higher expenditures on social and environmental protection reduce productivity growth in both business services and industrial sectors and productivity growth in industrial sectors increases with expenditures on education; however, these results are less robust. Our additional result is that there is a convergence in productivities across the EU countries: productivity grows faster in countries with a lower productivity level. In business services, this convergence is faster than in industrial sectors.

There is no consensus on the sign of the effect of government expenditures on productivity in the literature; the results depend on the countries under analysis and methods employed. For example, using a VAR model, Linnemann et al. (2016) showed that an increase in government spending leads to a growth in labour productivity. Salotti and Trecroci (2016) reported a negative relation.

Academic literature suggests that productivity depends not only on the size of public sector but also on the structure of government expenditures. The usual result is that productivity increases with government expenditures on investment and infrastructure (Aschauer, 1989, Ramirez, 1998, Ramirez, 2009). Sometimes it is found that productivity is affected by expenditures on health and education (Aschauer, 1989; Hansson and Henrekson, 1994; Smith et al., 2009; Yao, 2019). However, there is no consensus on the sign of these effects.

In contrast to the enumerated works, we analyse the effects of government expenditures on productivity in business services and industrial sectors separately, and the results are rather different. Furthermore, we control for institutional quality, and showed that better institutions (control of corruption and rule of law) increase productivity growth in business services, while effects of institutions on productivity in the industrial sectors are insignificant.

5.2 Methodology and data

First, we assume a production function of a Cobb-Douglass form:

$$Y_{c,t} = A_{c,t} K_{c,t}^{\alpha} H_{c,t}^{\beta} \tag{8}$$

where $\mathrm{Y_{c,t}}$ denotes production output, $\mathrm{K_{c,t}}$- capital input, $\mathrm{H_{c,t}}$- labour input in terms of hours, $\mathrm{A_{c,t}}$- total factor productivity (TFP); c and t denote country- and time-specific indexes. We divide production function (8) by $\mathrm{H_{c,t}}$:

$$y_{c,t} = A_{c,t} k_{c,t}^{\alpha} H_{c,t}^{\alpha+\beta-1} \tag{9}$$

where $\mathrm{k_{c,t} = K_{c,t}/H_{c,t}}$ and $\mathrm{y_{c,t} = Y_{c,t}/H_{c,t}}$; $\mathrm{y_{c,t}}$ can be interpreted as labour productivity. Note that $H_{c,t}^{\alpha+\beta-1}$ remains on the right side of equation (9) because we do not assume constant returns to scale in the production function. Alternatively, division by $\mathrm{H_{c,t}}$ can be omitted. In this case, empirical estimates of all coefficients, we are interested in, remain the same. We take a logarithm of equation (9) and differentiate the result. We obtain:

$$\Delta log y_{c,t} = \Delta a_{c,t} + \alpha \Delta \, log \, k_{c,t} + (\alpha + \beta - 1) \Delta h_{c,t} \tag{10}$$

where $\mathrm{a_{c,t} = \log(A_{c,t})}$ and $\mathrm{h_{c,t} = \log(H_{c,t})}$.

Next, we assume that changes in TFP depend on government expenditures $w_{i,c,t-l}$ taken with a lag l. There are m categories of government expenditures. Furthermore, TFP depends on the difference between labour productivity ($log\ y_{c,t-1}$) in a specific country and the average productivity in the region ($log\ \bar{y}_{c,t-1}$):

$$\Delta a_{c,t} = \mu_{c,t} + \sum_{i=1}^{m} \gamma_i w_{i,c,t-l} + \gamma(log\ y_{c,t-1} - log\ \bar{y}_{c,t-1}) \qquad (11)$$

This last term reflects capital and labour flows between the countries, which bring their experience and practice. It also reflects diffusion of knowledge and technologies. We denote it by ECT, because it is similar to an error correction term. In fact, productivity modelling with error correction models is rather common. See Welfe (2010), Rath and Akram (2017) and Burda and Severgnini (2018), for example. We expect that productivity growth in countries with a relatively low productivity level is higher than in more developed countries due to knowledge diffusion. $\mu_{c,t} = \mu_c + \mu_t$, μ_c is a country-specific fixed effect and μ_t- time fixed effect.

Combining equation (11) and (9), the model becomes:

$$\begin{aligned} \Delta log y_{c,t} \quad &= \mu_{c,t} + \sum_{i=1}^{m} \gamma_i w_{i,c,t-l} + \gamma\left(log\ y_{c,t-1} - log\ \bar{y}_{c,t-1}\right) + \alpha \Delta\ log\ k_{c,t} \\ &+ (\alpha + \beta - 1)\Delta h_{c,t} + \varepsilon_{c,t} \end{aligned} \qquad (12)$$

We used data on productivity, amounts of capital and hours worked in business services and industrial sectors from the EU KLEMS 2017 release. We approximated $\bar{y}_{c,t-1}$ by an average productivity in business services (or in industry) in the Eurozone because the European monetary union data is available for a larger number of periods than the EU data.

Government expenditures are measured in terms of percentage of GDP. They are taken from two sources: OECD and Eurostat. For most countries OECD data is used. However, government expenditures in Bulgaria are taken from the Eurostat, because it is not available in OECD data. In fact, some expenditures of a budget made in one period may be not used completely and return to the budget in the next period. This makes negative expenditures possible. Indeed, data for environment protection contains two negative observations, and taking a logarithm of a negative value is problematic; therefore, we add 0.5 to the variable.

Government expenditures are divided into a number of subcategories (COFOG): General public services, defence, public order and safety, economic affairs, environment protection, housing and community amenities, health, recreation culture and religion, education, social protection. It is important to stress that housing and community amenities include water supply and street lighting. The category of recreation, culture and religion includes expenditures for sport events. The other definitions are rather intuitive.[62]

Furthermore, we control for a tax to GDP ratio, which is received from the World Bank Development Indicators, and three variables, which reflect the quality of institutions: control of corruption, government effectiveness and rule of law. The institutional data comes from the World Bank Worldwide Governance Indicators. Theoretically, all three institutional variables may obtain values between -2.5 and 2.5; higher values correspond to better institutions.

In total, data for 21 EU countries are available[63]. The period under analysis is 1996-2015.

Output in government-provided services, such as education and healthcare, are usually measured by the value of expenses in these services. Labour productivity, disposed on the left side of equation (4), is defined as the output divided by hours worked. Consequently, there can be a trivial direct positive effect of some government expenditures on productivity. In order to exclude this trivial effect, we focus on productivity in the following services: wholesale and retail trade, repair of motor vehicles and motorcycles, transportation and storage, accommodation and food service activities, information and communication, financial and insurance

[62] The exact definitions of COFOG categories of government expenditures can be found on the Eurostat page: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Classification_of_the_functions_of_government_(COFOG)

[63] This includes: BG, CZ, DK, DE, EE, GR, ES, FR, IT, LV, LU, HU, NL, AT, PL, PT, SI, SK, FI, SE, UK.

activities, real estate activities, professional, scientific, technical, administrative and support service activities. Public administration and defence, compulsory social security, education, health and social work are excluded, because these activities are often directly financed by the governments. In industrial sectors, we focus on manufacturing, construction, mining and quarrying, electricity, gas and water supply.

Results based on regressions with time fixed effects are usually interpreted as short-run dependences between the variables. However, we expect that short-run fluctuations in certain categories of government expenditures unlikely have significant influence on productivity, while government policies, which take place for longer periods are more important. In order to address this mismatch we aggregate data into 4-years intervals. After such a procedure, we receive five four-year periods, but differentiation, used in equation (4), results in 4 periods only. In fact, the 4-years intervals are optimal here. As the data for only 20 years is available, a broader 5 years interval would result in 3 periods only, and we would have a problem of insufficient number of degrees of freedom. A lower length of interval is not sufficient to smooth short-run fluctuations. This makes the results less robust, and more dependent on the exact specification of the model.

In this analysis, we address endogeneity issues in two ways. First, government expenditures are included into the model with a four-year lag. Therefore, government expenditures made four years ago may affect productivity growth now, but not viceversa. This allows us to refer to Granger causality (Granger 1969). Furthermore, we employ panel data approach with individual and time-fixed effects. Individual fixed effects solve endogeneity problems, which could arise from time-invariant omitted variables, such as country-specific history, culture, climate, geographic location, etc. (Mundlak, 1978). Time fixed effects control for common structural breaks such as periods of economic crises, technological change, etc.

Breusch-Godfrey test for panel models results in p-values in the range 5.89×10^{6}-3.83×10^{5}, indicating that the residuals of the model are auto-correlated (Breusch, 1987; Godfrey, 1978). Therefore, presenting results we use autocorrelation-robust standard errors of Arellano type (Arellano, 1987). The usage of robust standard errors also accounts for possible heteroscedasticity problems.

5.3 Partial correlations between expenditures and productivity growth

In this section, we first present estimates of the model with all government expenditures used as regressors in order to get a preliminary idea, which parameters shall be considered in more detail. Next, we study a few specific categories of government expenditures deeper.

5.3.1 Empirical results

In Table 7, model (1), we present estimates of equation (4) for business services. Higher defence expenditures are associated with a lower productivity in business services. Such a negative coefficient is not surprising. Academic literature suggests that military expenditures crowd out other components of GDP (Barro and Redlick, 2011). Furthermore, a strong link between military expenditures and shadow economy was found: often agents do not receive direct tangible benefits from military expenditures made by governments and therefore prefer not to pay taxes (Fedotenkov and Schneider 2018). Military spending is usually opaque and provides many possibilities for corruption. Military controlled property, such as land, testing grounds, transport vehicles housing and training centres provide many opportunities for corruption (d'Agostino et al., 2012; Delavallade, 2006; Gupta et al., 2001; Hessami, 2014). Therefore, in model (2) we add control of corruption. Defence expenditures remained negative and highly significant. In models (3) and (4), we control for other measures of the quality of institutions: government effectiveness and rule of law but defence expenditures remained significant with the negative sign.

Table 7. Production function estimates in business services (dependent variable: labour productivity growth).

Variable	(1)	(2)	(3)	(4)
Defence	-0.0483***	-0.0738***	-0.0513***	-0.0512***
	(0.0165)	(0.0204)	(0.0148)	(0.0179)
Economic affairs	0.0364*	0.0524**	0.0452**	0.0378*
	(0.0215)	(0.0198)	(0.0214)	(0.0218)
Education	-0.0036	0.0033	-0.0135	-0.0201
	(0.0527)	(0.0364)	(0.0495)	(0.0395)
Environment protection	-0.1456***	-0.1262***	-0.1370***	-0.1261**
	(0.0485)	(0.0441)	(0.0257)	(0.0489)
Health	-0.0182	-0.0151	-0.0012	-0.0252
	(0.0609)	(0.0587)	(0.0571)	(0.0608)
Housing and community amenities	-0.0011	-0.0023	-0.0018	-0.0022
	(0.0162)	(0.0134)	(0.0160)	(0.0152)
Public order and safety	0.0546	0.0789	0.0698	0.0652
	(0.0527)	(0.0500)	(0.0550)	(0.0507)
General Public Services	-0.0186	-0.0053	-0.0203	-0.0100
	(0.0365)	(0.0318)	(0.0340)	(0.0369)
Recreation, culture and religion	-0.0201	-0.0598**	-0.0386	-0.0432
	(0.0410)	(0.0254)	(0.0417)	(0.0402)
Social protection	-0.0777*	-0.0316	-0.0772*	-0.0632*
	(0.0447)	(0.0293)	(0.0395)	(0.0369)
Tax/GDP	0.0590	0.0258	0.0770	0.0565
	(0.0730)	(0.0574)	(0.0671)	(0.0678)
k (capital-labour ratio)	0.0704	0.0677*	0.0738	0.0600
	(0.0475)	(0.0362)	(0.0466)	(0.0470)
h (logarithm of hours worked)	-0.3121***	-0.3479***	-0.3427***	-0.3152***
	(0.0836)	(0.0612)	(0.0922)	(0.0799)
ECT (last term of equation (12))	-0.5856***	-0.6276**	-0.6403***	-0.7086***
	(0.0895)	(0.0741)	(0.0975)	(0.1269)
Control of corruption		0.0849***		
		(0.0127)		
Government effectiveness			0.0426	
			(0.0268)	
Rule of law				0.0713*
				(0.0447)
R^2	0.8626	0.8949	0.8711	0.86915
Adjusted R^2	0.7128	0.7734	0.7219	0.7179
Observations	77	77	77	77

Note: ***, **, and * denote significance at the 1 %, 5 %, and 10 % levels, respectively. Standard errors are in parentheses.

Furthermore, our analysis reveals that higher expenditures on environment protection and social protection reduce productivity growth. In fact, environment protection includes such subcategories as pollution abatement and protection of biodiversity and landscape, which may restrain economic development. The trade-off between environment protection and productivity growth was intensively studied in academic literature. See Kozluk and Zipperer (2015) for a detailed review of empirical findings, which relate to various measures of environment protection. Social protection may affect productivity via various channels. For example, in the medium run there are general equilibrium effects: better social protection reduces savings and investments to physical and human capital, leading to a decline in productivity. At the same time, social protection provides collective insurance, lower inequality, and, as a consequence, greater political stability, which is an important factor for investment attraction in the long run (Harris, 2002). Therefore, it is possible that a longer lag could reverse the sign of the result. However, we will show later that the result provided in Table 7 for social protection is not robust, and it loses its significance in other specifications.

Our estimates also suggest that productivity growth in business services increases with expenditures on economic affairs. This result is rather intuitive, because this category includes such expenses as investments in transport infrastructure and communication, which are usually supposed to increase economic growth.

Better control of corruption and rule of law increase productivity in business services. Furthermore, the negative error correction term suggests that there is a convergence in productivity in business services in the EU.

Coefficients corresponding to health, education, housing and community amenities, public order and general public services are insignificant in all the models. In fact, due to an aggregation into 4-year intervals, the lag in our model corresponds to 4 years. The effects of these expenditures may be realised later. Furthermore, it is possible that the effect can vary by country.

Table 8. Production function estimates in industrial sectors (dependent variable: labour productivity growth).

Variable	**(1)**	**(2)**	**(3)**	**(4)**
Defence	0.0854 (0.0635)	0.0909 (0.0659)	0.0939 (0.0606)	0.0649 (0.0666)
Economic affairs	0.0533 (0.0695)	0.0494 (0.0655)	0.0380 (0.0656)	0.0663 (0.0741)
Education	0.2759* (0.1569)	0.2837* (0.1627)	0.2675* (0.1482)	0.3288* (0.1737)
Environment protection	-0.2504** (0.1270)	-0.2691** (0.1270)	-0.2447** (0.1099)	-0.2630** (0.1141)
Health	-0.1444 (0.1718)	-0.1436 (0.1740)	-0.1470 (0.1687)	-0.1370 (0.1766)
Housing and community amenities	0.0156 (0.0238)	0.0077 (0.0344)	0.0066 (0.0372)	0.0044 (0.0340)
Public order and safety	-0.1308 (0.1148)	-0.1441 (0.1019)	-0.1438 (0.1152)	-0.1458 (0.0984)
General Public Services	0.0794 (0.1065)	0.0532 (0.1092)	0.0868 (0.1018)	0.0785 (0.1030)
Recreation, culture and religion	-0.1264* (0.0631)	-0.1059 (0.0658)	-0.1083 (0.0751)	-0.1084* (0.0636)
Social protection	-0.2386* (0.1242)	-0.2712* (0.1547)	-0.2477** (0.1208)	-0.2629* (0.1377)
Tax/GDP	0.2808 (0.2520)	0.2767 (0.2506)	0.2990 (0.2432)	0.2485 (0.2530)
k (capital-labour ratio)	0.0623** (0.0287)	0.0623** (0.0287)	0.0690** (0.0287)	0.0647** (0.0281)
h (logarithm of hours worked)	-0.4591*** (0.0960)	-0.4553*** (0.0991)	-0.4375*** (0.0869)	0.4599*** (0.0933)
ECT (last term of equation (12))	-0.2505*** (0.0788)	-0.2434*** (0.0956)	-0.2093** (0.0967)	-0.2031** (0.0891)
Control of corruption		-0.0712 (0.0747)		
Government effectiveness			-0.0478 (0.0736)	
Rule of law				-0.1058 (0.0942)
R^2	0.4712	0.4799	0.4762	0.4864
Adjusted R^2	-0.0434	-0.0546	-0.0621	-0.0414
Observations	74	74	74	74

Note: ***, **, and * denote significance at the 1 %, 5 %, and 10 % levels, respectively. Standard errors are in parentheses.

Table 8 presents estimates for industrial sectors. There are several important differences from business services: economic affairs are positive but insignificant; expenditures for education make a significant positive impact on productivity. Coefficients corresponding to environment and social protection are negative and larger in absolute size than coefficients corresponding to business services. The error correction term is lower in absolute size, indicating that convergence of productivities across countries in business services is faster than in industrial sectors.

In contrast to the regressions for business services, military expenditures are insignificant here. In fact, apart from the negative effects of military expenditures explained above, military expenditures often include goods

produced by industry (weapons, training centres, etc.). We excluded military sector from the productivity data. Nevertheless, production of military goods requires intermediate goods produced by non-military sectors (metals, construction materials, etc.). This increases demand for non-military industrial goods. Consequently, the effects of military expenditures on productivity growth in industrial sectors are not negative as in business services.

There is a convergence in productivities across the EU countries: countries with relatively low productivity increase productivity faster, and convergence in business services is faster than in industrial sectors.

In Table 9, we study a few categories of government expenditures in more detail. We focussed on expenditures for defence, economic affairs and environment protection in the case of labour productivity in business services, and education, environment and social protection expenditures as regards industrial sectors. The 'Other expenditures' variable includes all expenditures which are not specified in the models. In business services, the impact on productivity of expenditures for defence are negative and highly significant. Expenditures on economic affairs preserved a positive coefficient significant at the 5 % level; however, expenditures on environment protection have lost their significance. Nevertheless, the sign of the coefficient remained the same. In industrial sectors, the results are not robust at all. Expenditures for education, environment and social protection lost their significance. Nevertheless, the p-value corresponding to the expenditures on the environment protection is very close to the 10 % significance level (0.1004). Therefore, the impact in business services of public expenditures on defence and economic affairs are rather robust, while our findings are not robust in industrial sectors.

Table 9. Production function estimates in business services and industrial sectors (dependent variable: labour productivity growth).

	Business services			**Industrial sectors**		
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Defence	-0.0839***					
	(0.0223)					
Economic affairs		0.0432**				
		(0.0206)				
Education				0.0047		
				(0.1244)		
Environment protection			-0.0106		-0.0531	
			(0.0255)		(0.0317)	
Social protection						-0.0097
						(0.1340)
Other expenditures	0.0830	-0.1194*	-0.0258	-0.2460	-0.1632	-0.2045
	(0.0562)	(0.0621)	(0.0622)	(0.1533)	(0.1656)	(0.1578)
k (capital-labour ratio)	0.1037***	0.0713***	0.0781***	-0.0304	-0.0448	-0.0270
	(0.0257)	(0.0234)	(0.0265)	(0.0783)	(0.0758)	(0.0806)
h (logarithm of hours worked)	-0.3569***	-0.2781***	-0.3019***	-0.3335***	-0.3617***	-0.3399**
	(0.0659)	(0.0770)	(.0.0813)	(0.1084)	(0.0986)	(0.1078)
ECT	-0.4751***	-0.5139***	-0.4319***	-0.3308***	-0.3268***	-0.3290***
	(0.0755)	(0.0769)	(0.0735)	(0.0545)	(0.0518)	(0.0540)
Control of Corruption	0.0966***	0.0580**	0.0511*	0.0272	0.0313	0.0294
	(0.0253)	(0.0287)	(0.0281)	(0.0615)	(0.0558)	(0.0603)
R^2	0.7883	0.7455	0.7240	0.4646	0.4655	0.4585
Adjusted R^2	0.6503	0.5796	0.5439	0.1666	0.1842	0.1568
Observations	77	77	77	74	74	74

Note: ***, **, and * denote significance at the 1 %, 5 %, and 10 % levels, respectively. Standard errors are in parentheses.

5.3.2 Robustness checks

Table 10 presents results of several additional robustness checks. Models (1) to (3) present robustness checks for labour productivity growth in business services. In model (1), we removed all insignificant expenditures from model (2) estimated in Table 7 whether the coefficients corresponding to remaining expenditures do not change. The results for defence, economic affairs and environment protection remained similar; however, social protection lost its significance. In model (2), we estimated a similar model as (1) but for Western

European countries. Eastern Europe was excluded. In this case, also the coefficient corresponding to environment protection lost its significance; however, the corresponding p-value is close to the 0.1 significance level. In model (3), we used a different functional form for government expenditures. As government expenditures as a percentage of GDP are bounded between 0 % and 100 %, it is logical to use a logit transformation, which is usually used to transform probabilities. The applied transformation is W= $log(w/(100-w))w$ denotes government expenditures as a percentage of GDP. The results are similar to those presented in model (1).

Table 10. Robustness checks on the production function estimates in business services and industrial sectors (dependent variable: labour productivity growth).

	Business services			Industrial sectors		
	All MS	Western MS	Logit	All MS	Western MS	Logit
Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Defence	-0.0600***	-0.0710***	-0.0582***			
	(0.0156)	(0.0235)	(0.0155)			
Economic affairs	0.0403*	0.0483*	0.0382*			
	(0.0226)	(0.0279)	(0.0243)			
Education				0.1620	-0.1143	-0.1486
				(0.1250)	(0.1216)	(0.118)
Environment protection	-0.1061***	-0.0687	-0.1039***	-0.2657***	-0.2155***	-0.1517***
	(0.0241)	(0.0437)	(0.0243)	(0.0892)	(0.0751)	(0.0552)
Social protection	-0.0074	-0.0205	-0.0070	-0.2002*	-0.0726	-0.0273
	(0.0344)	(0.0505)	(0.0287)	(0.1178)	(0.0801)	(0.0717)
k (capital-labour ratio)	0.0708*	0.0956*	0.0701*	0.0333	-0.0713	-0.0759
	(0.0362)	(0.0552)	(0.0355)	(0.0304)	(0.0883)	(0.0721)
h (logarithm of hours worked)	-0.2968***	-0.3441***	-0.2927***	-0.3694***	-0.2981**	-0.3345***
	(0.0602)	(0.0736)	(0.0605)	(0.0883)	(0.1319)	(0.1025)
ECT	-0.6449**	-0.6561***	-0.6467***	-0.2364***	-0.2948**	-0.2825***
	(0.0558)	(0.1142)	(0.0566)	(0.0432)	(0.1308)	(0.0607)
Control of corruption	0.0631***	0.0659***	0.0623***			
	(0.0137)	(0.0154)	(0.0137)			
R^2	0.8788	0.8379	0.8782	0.3610	0.5740	0.5484
Adjusted R^2	0.7800	0.6758	0.7789	-0.0601	0.2136	0.2211
Observations	77	49	77	74	49	74

Note: ***, **, and * denote significance at the 1 %, 5 %, and 10 % levels, respectively. Standard errors are in parentheses.

Model (4) to (6) in Table 10 present similar robustness checks for productivity in industrial sectors. The coefficient corresponding to environment protection remained negative and significant; however, education lost its significance and changed its sign in models (5) and (6). The coefficient corresponding to social protection lost its significance as well, but remained with the same sign. As an additional robustness check (unreported), we controlled for unemployment rate, the results remaining similar. Therefore, we may conclude that findings for military expenditures and economic affairs are robust.

5.4 Counterfactual increase in public expenditures on economic affairs

Table 11 presents some counterfactual results, based on the estimates of model (2) presented in Table 9. It shows how much productivity growth would have increased in 2012-2015 if government expenditures for economic affairs had been increased by 0.1 % of GDP in 2008-2011. We also present 90 % confidence intervals of these estimates. For most countries, such an increase would result in a 0.06 %-0.1 % increase in labour productivity growth in business services.

Table 11. Counterfactual analysis, productivity growth if expenditures on economic affairs are increased by 0.1 % of GDP.

Country	Productivity growth	Country	Productivity growth	Country	Productivity growth
BG	0.0732 % (0.0160-0.1305)	FR	0.0836 % (0.0182-0.1490)	PL	0.0811 % (0.0177-0.1447)
CZ	0.0694 % (0.0151-0.1237)	IT	0.1039 % (0.0226-0.1853)	PT	0.0917 % (0.0200-0.1635)
DK	0.1203 % (0.0262-0.2145)	LV	0.0705 % (0.0154-0.1257)	SI	0.0538 % (0.0117-0.0959)
DE	0.0693 % (0.0276-0.2257)	LU	0.0853 % (0.0186-0.1521)	SK	0.0914 % (0.0199-0.1629)
EE	0.0919 % (0.0200-0.1639)	HU	0.0604 % (0.0132-0.1076)	FI	0.0888 % (0.0194-0.1584)
GR	0.0541 % (0.0118-0.0964)	NL	0.0966 % (0.0210-0.1721)	SE	0.0912 % (0.0212-0.1733)
ES	0.0751 % (0.0164-0.1339)	AT	0.0655 % (0.0143-0.1168)	UK	0.1352 % (0.0294-0.2411)

Note: 90 % confidence intervals of the estimates are in parentheses.

However, this counterfactual analysis shall be treated with caution. First, the models may suffer from omitted time-varying variables, which may bias our estimates. For example, higher government expenditures may correlate with `left' policies, in general. Therefore, the estimated increase in productivity is likely to include the effects of other factors, and the `pure' effect of government expenditures is likely to be lower. Second, our estimates are based on a pool of countries, while `country-specific' dependence between government expenditures and productivity may differ from the `aggregate' estimates.

5.5 Productivity does not increase with every expenditure

Previous literature usually studied contemporaneous links between government expenditures and productivity or used government expenditures with a one-year lag. The usual finding is that expenditures on education make a significant impact on productivity; however, the sign of this impact is disputable (Hansson and Henrekson, 1994; Yao, 2019). In our model, education expenditures obtained a positive and statistically significant coefficient only in the case of productivity growth in industrial sectors, and this effect was not very robust. In general, it seems that even a 4-year lag is insufficient for capturing all the benefits of investments in education. On the contrast, a number of other expenditures showed a significant and robust impact.

We showed that productivity growth in business services increases with the government expenditures on economic affairs and declines with the military expenditures. Furthermore, productivity in business services increases with better institutions, such as control of corruption and the rule of law. Expenditures on environmental protection are associated with lower productivity in business services; however, robustness of this effect is lower. Productivity growth in industrial sectors declines with environmental protection as well, and the decline is more robust than that in business services.

6 Intangibles and productivity in services

6.1 Intangible assets within and outside national accounting

Investment in intangible assets is generally considered to be an important driver of productivity and productivity growth in the modern economy (see e.g. Haskel and Westlake, 2017). Although intangibles can have a somewhat broad definition, by now there seems to be a consensus on a working definition for intangible assets, at least at the macro level.[64] They are classified into three groups: computerised information, innovative property and economic competencies (for details, see e.g. Corrado et al., 2018). Some intangible assets are already included in National Accounts (NA intangibles), namely software, database, R&D, mineral exploration and artistic originals. [65] Others are not included (non-NA intangibles): design and economic competencies which are in turn comprised of brand, organisational capital and training.

Recent studies on multi-country data (Corrado et al., 2018; Thum-Thysen et al., 2017) confirm that at the aggregate economy level, higher investment into intangible capital is associated with higher productivity growth and with faster convergence to the frontier (the US). This type of investment also explains a significant part of the variation in total factor productivity (TFP) across countries. The important role of intangibles in production is also underpinned by some evidences on their complementarity with other assets (Thum-Thysen et al., 2017).

As opposed to these studies which only use aggregate data for intangibles and focus on TFP, we exploit the 1-digit industry-level dimension of the INTAN-Invest database to estimate the importance of intangible investment for labour productivity.[66] A similar approach to ours is applied by Niebel et al. (2017), albeit they construct their own industry-level database which is consistent with the aggregate numbers from a previous release of INTAN-Invest (without industry-level data). Furthermore, their study does not include an analysis of the role of different types of intangibles.

An industry level investigation of the relationship between labour productivity growth and investment sheds light especially on the sectoral (e.g. services vs industry) differences in the impact of intangible investment. In addition, the possible heterogeneity in the impact and the different roles played by different types of intangible assets are explored. The analysis is based on the estimation of a production function, augmented with intangible assets as an input, to investigate the role of intangibles in productivity growth.

The main messages stemming from the analysis are that, one, non-NA intangibles (mainly economic competencies) are important for productivity growth especially in services, and, two, NA intangibles (software and R&D) seem to be more important for industry.

In this paper, we would like to show not just that intangible investment is important for labour productivity growth in general, but also to deliver country-specific assessments of their performance. For that purpose countries are ranked according to two measures. The first measure is the size of the contribution of the growth in intangible capital to productivity growth; the second one is the productivity effect of an additional 1 percentage point increase in intangible investment-to-value added ratio. The logic for including this second measure is to gauge the rate of return[67] of additional investment, rather than actual performance.

According to the rankings, based on the contribution to productivity growth of intangible capital investment, the worst performing countries are Greece, Italy, Germany, Spain and Portugal, while the best countries are the UK, the US, the Netherlands, Sweden and France. According to the productivity impact of additional investment, Greece, Spain and Germany rank highest. By contrast, the Netherlands, Finland, France, Austria and Sweden have exhibit a relatively low rate of return from additional investment.

6.2 Methodology and data

We assume that value added is produced from capital input and labour input with identical factor elasticities across countries, industries and years. Capital input is comprised of different types of capital stocks while

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64 At the firm level, the stock of patents and trademarks are also frequently considered as intangible assets.

65 One important limitation of this classification is that "databases" include only the architecture and not the data itself. This omission is explained mainly by the difficulties in measuring the cost of collection and processing of data (other than the storage and organisation which is captured by the cost of databases).

66 For the details about the database, see Corrado et al., (2016).

67 Rate of return is used here in the sense of return on investment in terms of output and not in terms of profit.

labour input is captured by labour services. We also assume that productivity is affected by an unobserved factor, TFP (total factor productivity) which is time-varying. We assume (following e.g. Niebel at al., 2017) that output is produced according to a Cobb-Douglas production function, as follows:[68]

$$Y_{ist} = A_{ist} K1_{ist}^{\alpha_1} K2_{ist}^{\alpha_2} \dots Km_{ist}^{\alpha_m} H_{ist}^{\beta} \tag{13}$$

where i, s, t denote country, industry and year, respectively, Y is value added, $K1, \dots, Km$ are different types of capital stocks (e.g. ICT capital, NA intangible capital, non-NA intangible capital), and H is labour services. $\alpha_1, \dots, \alpha_m, \beta$ are the factor elasticities. A is TFP. By transforming this equation into logarithmic form [69] and taking first differences, and adding an error term (ω), we obtain:[70]

$$\Delta y_{ist} = \Delta a_{ist} + \alpha_1 \Delta k1_{ist} + \dots + \alpha_m \Delta km_{ist} + \beta \Delta h_{ist} + \omega_{ist} \tag{14}$$

We further decompose the growth of TFP, Δa into country-industry and year specific fixed effects, plus a white noise error term:

$$\Delta a_{ist} = \lambda_{is} + \delta_t + \varepsilon_{ist} \tag{15}$$

Now, this means that log(TFP) is determined by a country-industry specific stochastic trend (random walk with drift) component plus a year-specific common component. We allow for correlation between the fixed effects and production factors.

We consider three specifications and their respective estimation methods. For the first and second case, we assume that the error term of the TFP process, ε is not correlated contemporaneously with production factors. This means that production factors can react immediately to aggregate shocks (captured by the time fixed effects δ_t) but not to idiosyncratic country and/or industry specific shocks. Systematic differences across countries and industries are captured by the time-invariant fixed effects λ_{is}.

In the first case, we also assume that country-industry fixed effects can be decomposed into country and industry fixed effects: $\lambda_{is} = \mu_i + \nu_s$. In the second case we do not make this last assumption. The first and second case can be estimated by the fixed effect estimator. In the first case, it is simply a LSDV (least-squares dummy variables) estimator with three sets of dummies for countries, industries and years. In the second case it is more convenient to implement it by subtracting the time-average from all variables over country-industry pairs (this is automatically done by the FE estimator with country-industry identifiers for cross-section).

In the third case we allow for the error term in the TFP equation, ε to be correlated contemporaneously with production factors. We also assume that this error term to be AR(1). In this case the equation to be estimated is the following:

$$\Delta y_{ist} = \alpha_1 \Delta k1_{ist} + \dots + \alpha_m \Delta km_{ist} + \beta \Delta h_{ist} + \lambda_{is} + \delta_t + u_{ist} \tag{16}$$

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68 More complex production functions are challenging to estimate considering the relatively large number of inputs that we use.

69 Lowercase roman letters represent variables in logarithms.

70 Taking first differences is not self-evident. In fact, firm-level production function estimators use the level form as starting point. In contrast to firm-level data, macro data is much more persistent. This persistence is eliminated by taking first differences. As a robustness check, we estimated the production function by the Arellano-Bover/Blundell-Bond system GMM estimator starting from the level form. We got results where the lagged dependent variable had a coefficient close to 1. This also points to the necessity of first-differentiating the equation.

where $u_{ist} = \varepsilon_{ist} + \omega_{ist}$ and $\varepsilon_{ist} = \rho\varepsilon_{ist-1} + \zeta_{ist}$.

These relaxations of the assumptions mean that the FE estimator is biased mainly because of both simultaneity between the production factors and output and because production factors can react to the lagged value of the error term u which in turn, can be correlated with its contemporaneous value due to the AR(1) structure. In this case, a usually applied estimator for macro data is the Arellano-Bover or Blundell-Bond system GMM estimator.[71] We estimate the following equation:

$$\Delta y_{ist} = \gamma\Delta y_{ist-1} + \alpha_1\Delta k1_{ist} + \cdots + \alpha_m\Delta km_{ist} + \beta\Delta h_{ist} + \lambda_{is} + \delta_t + \nu_{ist} \qquad (17)$$

We should note that while the third case is the most general, the estimation method was originally developed for so-called "large N, small T" panel datasets. As we only have a small number of cross sections (11 countries × 10 industries), the results might be subject to small sample bias.

We take annual growth of real value added from the EU KLEMS dataset for the period 1995-2015.[72]

Intangible investment is taken (NA and non-NA categories, too) from INTAN-Invest.[73] We focus on the following industries only: C, D-E, F (manufacturing, energy, water etc., construction), which we refer to as the industry sector; and G, H, I, J (trade, transportation, accommodation, information), M-N (professional and administrative activities), R, S (entertainment and other services), which we refer to as the service sector. We omit A, B (agriculture and mining) as they are especially prone to outliers and considered as special. We also omit K (finance) because the measurement of value added is considered to be problematic and L (real estate) because of similar reasons and because of the lack of data for it in INTAN-Invest. We also omit non-market industries such as O, P and Q (public administration, education and healthcare).

Value added is adjusted to include non-NA intangible investment, also from INTAN-Invest, to be consistent between NA and non-NA intangibles. This adjustment is simply an addition of investment of non-accounted intangibles to value added to ensure the identity of the production and use side of the economy.[74]

All of our results refer to this adjusted measure of value added and consequently productivity.

Data for tangible capital by asset type is from EU KLEMS. NA intangible capital by asset type is also from EU KLEMS with the exception of Greece, Ireland, Belgium and Portugal. Non-NA intangible capital is calculated from the real intangible investment series from INTAN-Invest, and in the case of Greece, Ireland, Belgium and Portugal, NA intangible capital is also calculated from INTAN-Invest.[75]

We use PIM (Perpetual Inventory Method) for the calculation of the real intangible capital stock.[76] The formula is the following:

$$K_t = K_{t-1}(1-\delta) + I_t \qquad (18)$$

where K is capital, δ is depreciation rate, and I is real investment. For depreciation rates, we borrow the values for the different types of intangible assets from Corrado et al. (2018). To start the calculation, we need

[71] We use only lags 2 to 4 of the endogenous variables as instruments, i.e. of all the variables on the left and right hand side of equation (1), to avoid proliferation of instruments. For details of the methodology of the system GMM estimator, see Arellano and Bover (1995); Blundell and Bond (2000).

[72] For some countries data are available as far back in time as 1970, but for most countries it starts in 1995.

[73] These data cover all EU-15 countries, years (1995-2015) and NACE 1-digit industries. Data are in chain linked volumes, base year=2010.

[74] For purchased non-NA intangibles, production of these assets are already taken into account as the value added of the seller. In the National Accounts, this value is deducted as costs from the buyers' value added. We just undo this deduction. For own-account non-NA intangibles, as training and own-account organisational capital, these are not accounted as production in National Accounts. By adding the value of the investment of these assets, we acknowledge the value that is created and immediately invested.

[75] For these four countries we only use this data for simulation but not for estimation as detailed tangible capital data is not available.

[76] For the remainder of the section, capital is always defined in real terms, so we do not reiterate this term.

an initial value, K_{1995}., For this, as in Niebel et al. (2017), we assume that in the starting year, the value of intangible capital for all assets is in its steady state. This means that the level of investment in 1995 is assumed to sustain the growth of capital at a level which is equal to the long-run average growth of value added.[77] From this assumption we can calculate the capital stock in 1995: $K_{1995} = I_{1995}/(\delta + g)$, where g is the long-run growth rate of value added.[78]

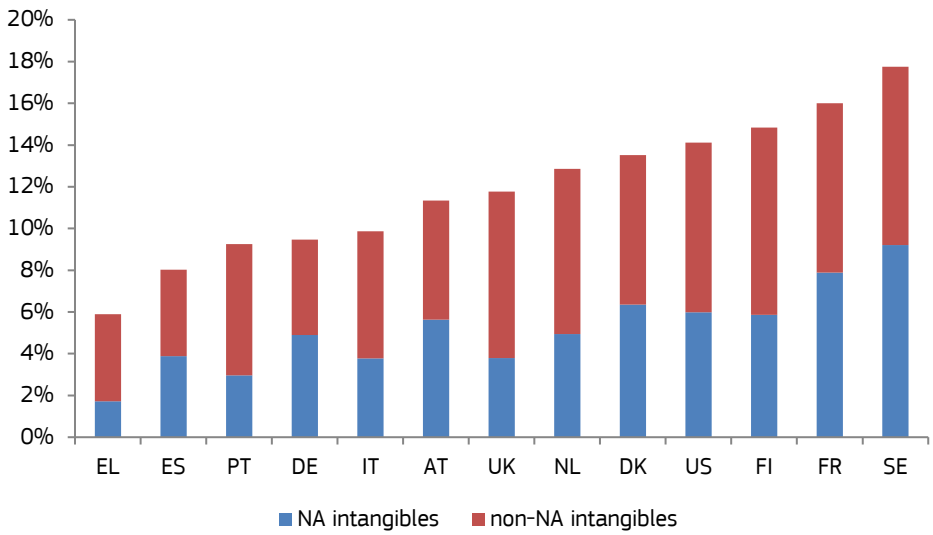
After we have constructed the data for tangible and intangible capital stocks by asset type following this procedure, we group these assets into the following groups. For tangible assets: ICT: computers and telecommunication equipment; Machinery: transport equipment and other machinery; Constructions: other constructions (excluding dwellings). For intangible assets: NA intangibles: Software, database, R&D, mineral exploration and artistic originals; non-NA intangibles: design, brand, organisational capital, training.[79] For these groups, we simply add up the capital stocks of its constituent elements thus estimating the ICT, Machinery, Constructions, NA intangibles and non-NA intangibles capital stocks.

Instead of using capital services, we decided to use capital stocks, but we handle several asset types separately from each other.[80] This reduces the necessity to use capital services.

For labour input we use labour services from EU KLEMS. Labour services is an index of labour input where the composition of the labour is taken into account.[81]

Before presenting the econometric results, the graphs below show some important descriptive statistics of the data. Ireland and Belgium are excluded because of obvious outliers in their data.[82]

Figure 17. Investment-to-value added ratio in 2015 (calculated from current price data).



Source: Intan-Invest.

77 Long-run growth rate is defined as the 10-year average growth of value added around 1995, i.e. average growth over 1990-1999.

78 Note that small measurement errors in the estimated capital stock in 1995 affect only a couple of years after 1995 as the effect of initial value decays very quickly with high depreciation rates.

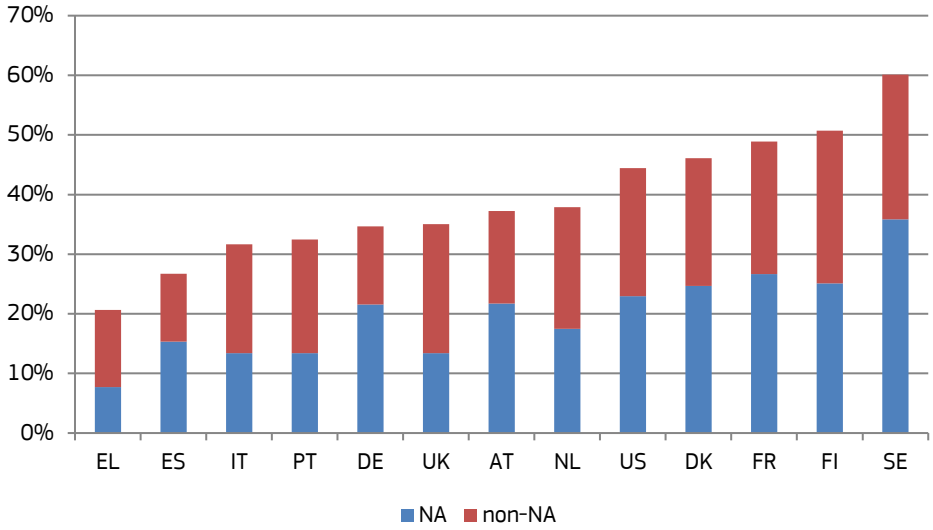
79 The last three form the so-called "economic competencies".

80 Especially constructions, which are marked by a very low depreciation rate.

81 In practice, the growth of labour services is calculated as a weighted average of growth in hours of different segments of the labour force (according to age, gender, education). The weights are the shares of the segments in labour compensation.

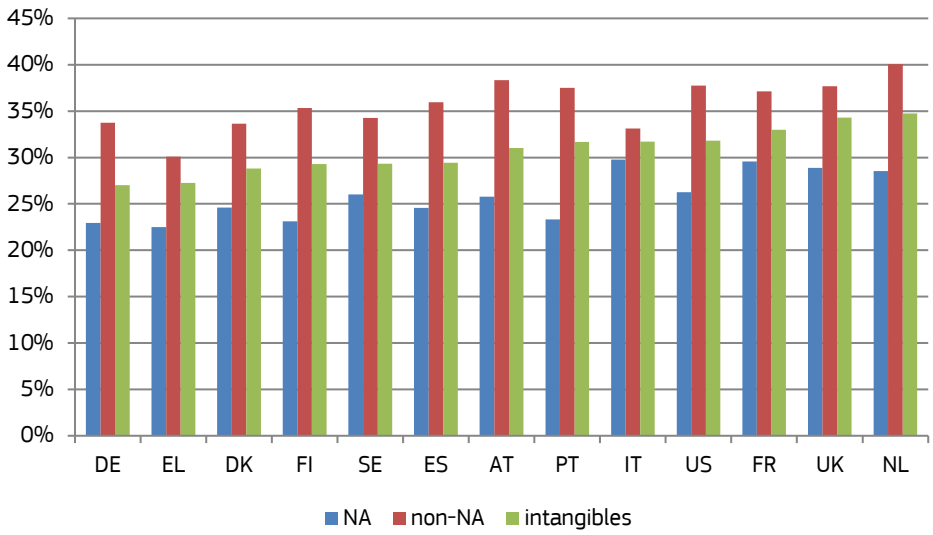
82 In case of Ireland, the investment in R&D is suspiciously large. In case of Belgium, the deflator of mineral extraction and artistic originals can be considered as an outlier.

Figure 18. Capital-to-value added ratio in 2015.



Source: Own calculation based on Intan-Invest.

Figure 19. Investment-to-capital ratio in 2015.



Source: Own calculation based on Intan-Invest.

The figures show that Greece, Spain, Germany, Italy and Portugal exhibit the lowest levels for intangible investment and capital as a share of value added. Concerning the investment-to-capital ratio, however, the lowest values are found for Denmark, Sweden and Finland, in addition to Greece and Germany. The investment-to-capital ratio (sometimes called as the investment rate) is considered to be important because it is the main determinant of the growth rate of capital.

6.3 Results of the production function estimation

We estimated the production function (13) according to equation (17) via the fixed effect estimator and system GMM, as described in section 6.2. The main result in all specifications (see Table 12) is that non-NA intangibles (design and economic competencies) are important for services but not important for the industry.

NA intangibles (software and R&D) are more important for industry than for services.[83] For example, for the baseline estimation (columns 8 and 9), coefficients are 0.006 and 0.131 for NA and non-NA intangibles in services, respectively, while in industry, they are 0.053 (NA intangibles) and -0.009 (non-NA intangibles). The coefficient of NA intangibles in services and non-NA intangibles in industry are not significant at standard levels of significance. If we interpret these results in the context of the original production function (13), it means that a (ceteris paribus) 10 % increase in NA intangible capital will result in an increase of productivity by 0.06 % in services, a negligible impact, and by 0.53 % in industry, a low, but economically significant number. A 10 % increase in non-NA intangible capital will increase productivity by 1.31 % in services, a considerable impact. In industry, we regard the impact as zero, because the coefficient is statistically insignificant and negative.

For tangible capital, ICT capital is statistically significant only in services, while in industry only Machinery is significant. In any case, from the estimated coefficients it seems that the importance of tangible capital in production is relatively low; this is in-line with the results of Niebel et al. (2017). Summing up the coefficients of the production function, it is far less than one, suggesting that the constant returns to scale property of the production function is not satisfied.

All of our estimates suggest a much larger impact of non-NA intangibles than of NA intangibles on aggregate productivity. This is due to the fact that the service sector has a larger share in the economy, and NA intangibles are comparatively less relevant in the service sector. Furthermore, the impact of NA intangibles in industry is not as high as the impact of non-NA intangibles in services.

Table 12. Estimated coefficients of the production function (dependent variable: Δlog(value added))

	Fixed effect						System GMM		
	All	**Serv**	**Ind**	**All**	**Serv**	**Ind**	**All**	**Serv**	**Ind**
Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
Δlog(ICT capital)	0.0142**	0.0329***	0.00581	0.00986*	0.0233**	0.00346	0.0134*	0.0214*	0.00290
	(0.00577)	(0.00927)	(0.00861)	(0.00591)	(0.00965)	(0.00877)	(0.00752)	(0.0129)	(0.00788)
Δlog(machinery capital)	-0.00620	-0.0172	0.0476	-0.00144	-0.0184	0.0782	-0.00786	-0.0423	0.115**
	(0.0189)	(0.0194)	(0.0461)	(0.0208)	(0.0209)	(0.0509)	(0.0318)	(0.0288)	(0.0528)
Δlog(NA intangible capital)	0.0263**	0.0167	0.0572**	0.0197	0.0104	0.0509	0.0192	0.00604	0.0534*
	(0.0131)	(0.0138)	(0.0291)	(0.0143)	(0.0149)	(0.0315)	(0.0200)	(0.0192)	(0.0304)
Δlog(non-NA intangible capital)	0.160***	0.201***	0.0551	0.142***	0.192***	0.0300	0.0847**	0.131***	-0.00948
	(0.0278)	(0.0292)	(0.0634)	(0.0295)	(0.0306)	(0.0677)	(0.0408)	(0.0384)	(0.0704)
Δlog(labour services)	0.363***	0.265***	0.494***	0.362***	0.262***	0.482***	0.479***	0.310***	0.511***
	(0.0261)	(0.0300)	(0.0503)	(0.0268)	(0.0304)	(0.0520)	(0.0431)	(0.0437)	(0.0536)
Country FE	yes	yes	yes	no	no	no	no	no	no
Sector FE	yes	yes	yes	no	no	no	no	no	no
Country-sector FE	no	no	no	yes	yes	yes	yes	yes	yes
Year	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	2,040	1,416	624	2,040	1,416	624	1,962	1,362	600
Number of country-sectors				108	75	33	108	75	33

Note: 'Serv' and 'Ind' indicate the services and the industry sub-sample, respectively. We do not report the coefficient of the lagged dependent variable in case of the system GMM estimation. It was not significant and very small for the whole sample and for the industry, while significant but very small for services.
***, **, and * denote significance at the 1 %, 5 %, and 10 % levels, respectively. Standard errors are in parentheses.

6.4 Benchmarking countries according to their intangible investments

It follows from the results above that intangible investment-to-value added is not the best measure for ranking countries if we want to take into account the productivity impact of that investment. We found that the impact of non-NA intangibles on productivity is higher in services (in fact, it was practically zero in the industry). Even in the industry, the impact of NA intangibles is lower than the impact of non-NA intangibles in

[83] We find the same results when we apply a simple approach for linking productivity growth to intangible investment as a robustness check (see Annex B3).

services. Furthermore, the service sector has higher shares in both value added and employment than the industry, which means that productivity growth of the service sector is more important for aggregate productivity growth. This shows that the impact of intangible investment on productivity is dependent on its distribution across asset-types and sectors and non-NA intangibles in general have a higher impact on aggregate productivity growth. Because production functions explain growth of productivity (or value added) by growth of capital and not by investment-to-value added, the impact is also non-linear in investment. This stems from the fact that the same amount of investment means a higher percentage increase in capital from a lower level of capital than from a higher level of capital. All these considerations imply that investment-to-value added is not a very meaningful metric to gauge the impact of intangible investment levels on productivity.

We chose two measures to present the intangible investment performance across countries. The first is the contribution of intangible capital growth to productivity growth. This is computed as the estimated coefficients of both types of intangible capital multiplied by the respective actual values of the growth of capital.[84] We want to emphasize that we use the same estimated coefficients for each country, thus differences are not stemming from different factor elasticities as we assume homogeneity across countries.[85] Still, the heterogeneity of the contributions across countries stems from different sources. First, it comes from the different growth rates of intangible capital across countries. Second, it comes from the different distributions of intangibles investment between assets and sectors. Finally, it comes from the different economic structure of countries, i.e. the different sector weights.

Our second measure is the additional productivity growth as a consequence of an additional 1 % of value added invested into intangibles (0.5 % into NA intangibles, 0.5 % into non-NA intangibles, in all sectors). This calculation is based on the econometric estimates in last section.

The second measure is more about estimating the rate of return than about actual performance. However, again, we do not assume different factor elasticities across countries. This measure simply shows that countries with low level of capital (compared to value added and with a certain distribution across sectors) could benefit more from higher investment into intangibles. The intuition is that countries with high intangible capital-to-value added ratio have little to gain from increasing intangible capital by the same fraction of value added, because for them it means a lower percentage growth in intangible capital.

To better understand how the contribution of intangible investment to aggregate productivity growth depends on NA and non-NA intangible investment in different sectors, we show the contribution both in services and in industry (Figure 20 and Figure 21). We can see what the regression results already showed. For the ranking according to the contribution in the business economy, ranking in services is more important, and as a consequence non-NA intangibles are more important drivers of aggregate productivity growth.

According to the aggregate productivity contribution of intangible capital growth (Figure 22), the worst performing countries are Greece, Italy, Germany, Spain and Portugal, while the best countries are the UK, the US, the Netherlands, Sweden and France. According to the productivity impact of additional investment (Figure 24), Greece, Spain and Germany stand the highest chance to benefit from investing more into intangibles. By contrast, the Netherlands, Finland, France, Austria and Sweden have relatively low productivity returns from additional investments into intangibles.

[84] It means that the interpretation of the contribution is the difference in productivity growth compared to the counterfactual of zero growth of intangible capital.

[85] Low level of investment rate of certain assets in certain countries could be explained by low rate of return on these assets in those countries. Without country-heterogeneity in the production function, we cannot check this hypothesis.

Figure 20: Contribution of intangible capital growth to productivity growth in services, 2015.

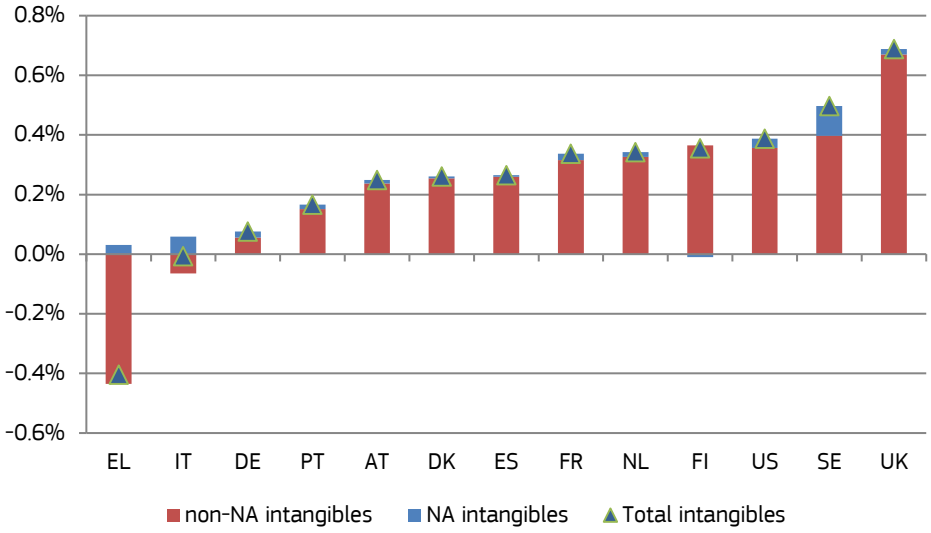


Figure 21: Contribution of intangible capital growth to productivity growth in industry, 2015.

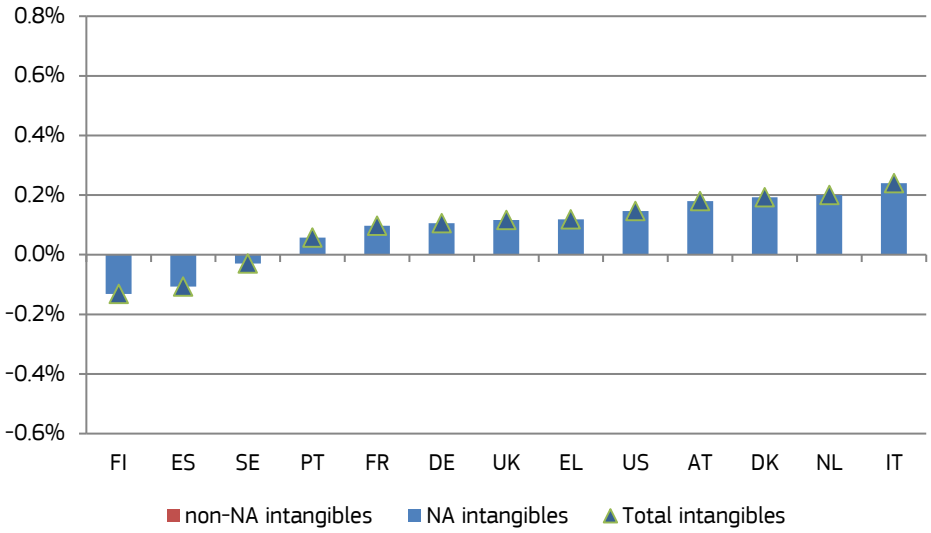
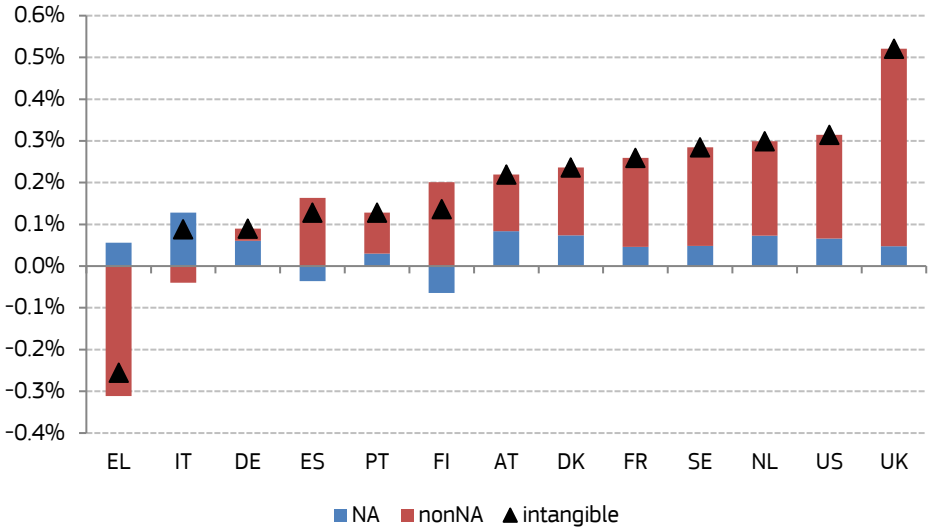
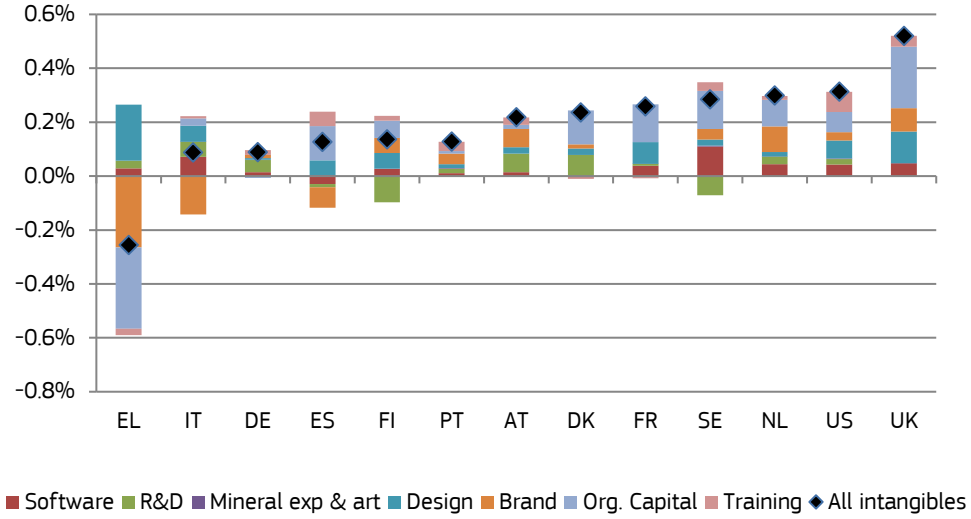


Figure 22. Contribution of intangible capital growth to productivity growth in the business economy, 2015.



Source: Own calculation based on Intan-Invest.

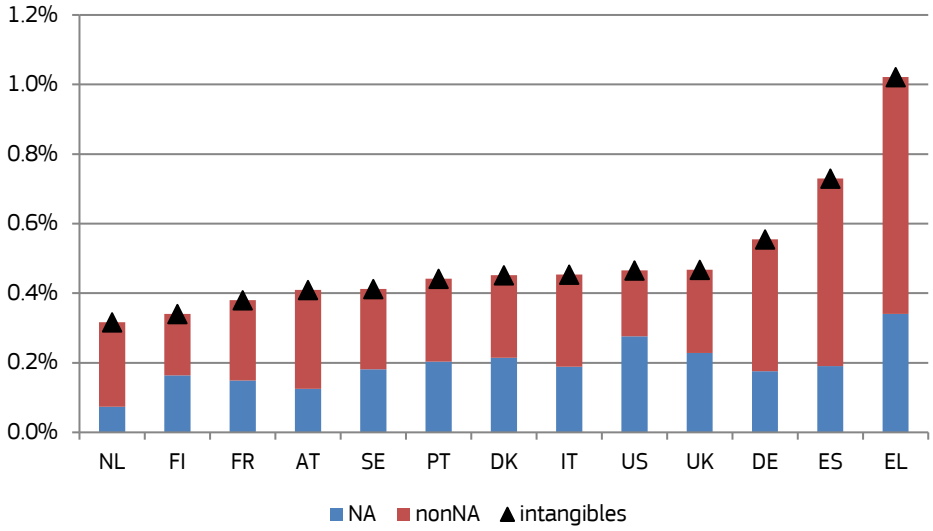
Figure 23. Contribution of intangible capital growth to productivity growth in 2015, by asset.



Note: The sum of the contributions from all intangible assets is sometimes different from the total contribution from intangibles. This is because log-differencing is only an approximation of percentage change.

Source: Own calculation based on Intan-Invest.

Figure 24. Productivity effect of an additional 1 percentage point increase in intangible investment-to-value added, 2015.



Source: Own calculation based on Intan-Invest.

6.5 Non-National Accounts intangibles have a strong impact on productivity

The main findings of this study are that intangible investment is an important driver of labour productivity growth. The relationship between intangible investment and productivity growth is heterogeneous in terms of asset type and sector. National Accounts intangibles are important for the industry, while non-National Accounts intangibles are important for the service sector.

From a policy perspective, improving productivity by increasing intangible investment requires the knowledge of the drivers and potential obstacles to intangible investment. There is existing evidence in the literature that drivers of intangible investment are different from the ones affecting tangible investment. Corrado et al. (2018) applies a pooled cross-country regression to show that intangible investment relative to tangible investment is correlated with employment regulation (negatively), government funded R&D (positively) and relative prices (negatively). Thum-Thysen et al. (2017) use the accelerator model (with a country fixed-effect extension) on country-level data to show that the intangible investment rate is much more affected by human capital and employment regulation than tangible investment, and less sensitive to the aggregate demand and to the long-term interest rate. Further research should focus on shedding light on the causal drivers of intangible investment.

7 Business demography, firm size and productivity

7.1 Firm demography and productivity growth

Business demography, more specifically the economy-wide or the industry-level entry and exit rate of firms are indicators of business dynamism.[86] Entry and exit is a margin of adjustment with a potentially large impact on productivity growth (see Foster et al., 2001; Haltiwanger et al., 2013, 2017; and Decker et al., 2014, for the US; Brandt et al., 2012, for Chinese manufacturing; Asturias et al., 2017, for China and Korea). When new, innovative firms with high growth potential enter the market in large numbers, the economy's aggregate productivity improves both in levels and growth rates. Conversely, if many low productivity firms exit the market that improves aggregate productivity by facilitating the flow of resources. Low levels of entry rates might be a sign of weak entrepreneurship in an economy, which in turn could be due to many factors. Regulations that constitute barriers to entry are considered the most important of them (see e.g. Brandt, 2004), but also lack of finance for new firms and crowding out effects of monopolistic incumbents are also among the possible reasons. The reasons behind low exit rates are usually very similar to the causes of low entry rates as the main reason of the exit of firms is that more viable firms crowd them out from the market. Also, since many entrant firms eventually fail, a higher number of entrants means a higher number of exiting firms. Therefore entry rates and exit rates are usually positively correlated.

In this section we analyse the development of entry rates between 2008 and 2017 using the Firm Demography database within Structural Business Statistics (SBS) of Eurostat. Previous literature often focused on the manufacturing sector, while we focus on the entry rates in the service sector.[87] Furthermore, we use the latest release of SBS data, thus complementing earlier studies based on previous vintages of SBS, or studies that used other sources of data, e.g. firm-level databases. SBS has the advantage that entry and exit is well-measured, only active firms are included, and merger and acquisition activities are filtered out.

In the following, we document a widespread decline in entry rates across EU countries in the service sector. At the same time, entry rates in manufacturing did not significantly decrease. This finding is different from the experiences in the US where entry rates declined both in manufacturing and in services (see Gourio et al., 2014). Also, we show the link between productivity growth and entry and exit rates using SBS data. According to our results, aggregate productivity growth increases with higher entry rates of larger-than-micro firms. We do not find a significant impact of exit rates, and no impact at all of micro firms' entry or exit rates. These findings are also in-line with the fact that decline in both productivity growth and entry rate is more pronounced in services than in manufacturing in the EU.

Later, using the CompNet database that reports the terms of the FHK decomposition of aggregate productivity growth (see Foster et al. 2006), we highlight the importance of net entry contribution[88] in productivity growth, and its pattern by country.

7.1.1 Descriptive analysis of the entry rate

On entry rate, we mean the share of new firms in the population of active firms. In the SBS database this is called birth rate. First, we look at the development of entry rates in the largest economies of the EU (Figure 25).

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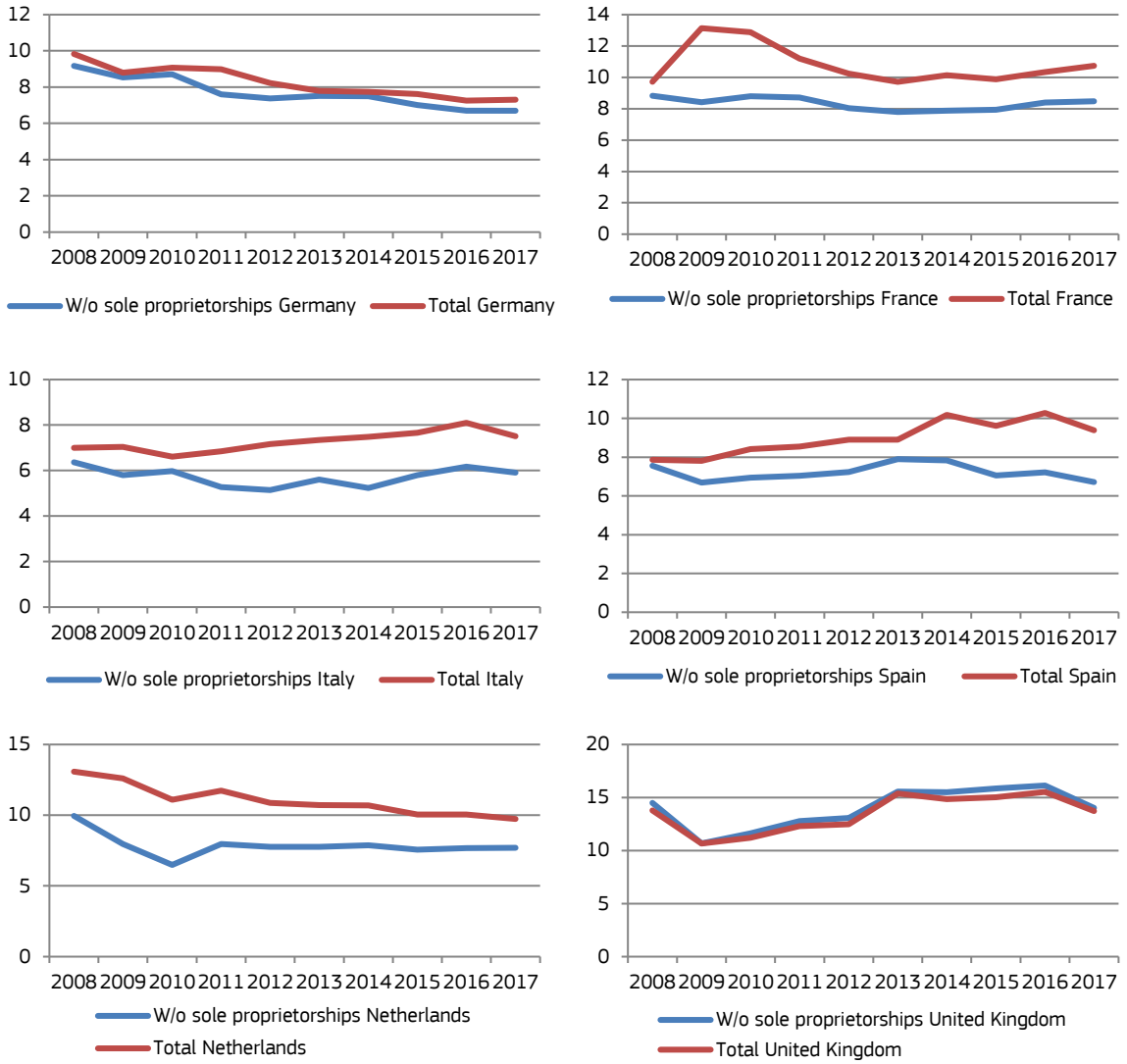
86 Beyond entry and exit, survival rates and the age distribution of firms is also considered as part of business demography.

87 We do not analyse exit rates in the descriptive analysis of business dynamism in the first part of this sub-chapter, only later when we investigate the relationship between productivity growth and firm demography. The reason is that comparable data are available only from 2008. We can observe a decline in exit rates between 2008 and 2017, but it is difficult to say whether exit rates are unusually low in 2017 or it is only a natural decline after a big jump in exit rates in 2008. For entry, in contrast to exit, we can expect lower, not higher rates in 2008 due to the crisis. That is the main reason why we think that observing declining entry rates is an interesting finding and a sensible subject of analysis despite our sample is also restricted to the period of 2008-2017.

88 Net entry contribution is the impact on productivity from entry and exit combined. Unfortunately, due to data limitations, the individual contributions from the two flows cannot be computed.

Figure 25. Entry rate for business services (industries G-N), 2008-2017 for the largest economies (percentage of active population of firms).



Source: SBS (Eurostat).

From the six largest economies of the EU, Germany and the Netherlands show a significant decline in entry rate in the service sector as a whole. It is important to distinguish between so called sole proprietorships and other types of firms. Sole proprietorship is a special legal form of the firm when the firm is owned and run by one entrepreneur and there is no legal distinction between the owner and the business entity. Sole proprietorships are usually very small firms (0-1 employees) and there is not much potential for high growth and improvement in productivity, also the comparability of them across countries is limited in SBS because of thresholds in some countries for data reporting. Thus it is better to exclude them from the analysis. As illustrated in Figure 25, this decision has significant consequences for the results: for the six largest economies, the entry rate of the total population of firms and the entry rate of the population of firms without sole proprietorships diverge substantially in the cases of France, Italy and Spain. Especially at the latter two countries we can see that the entry rate of the total population increased significantly and permanently in the aftermath of the crisis compared to the entry rate of firms without sole proprietorships. A possible explanation is that in these countries some former employees turned into entrepreneurs instead of going into unemployment or inactivity, or in some cases this is a pure statistical phenomenon caused by changing tax incentives for sole proprietorships.[89]

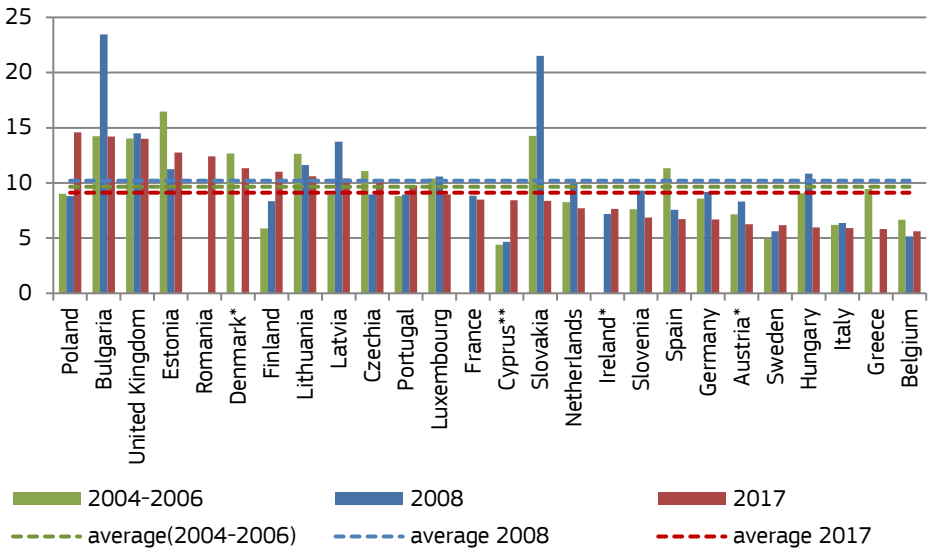
[89] E.g. in case of Italy, the change of labour law created a tax incentive for firms to turn employees to sole proprietors.

From now on, we only report results excluding sole proprietorships.

To investigate which country shows a decline in entry rate we show a graph with entry rates in 2008 and in 2017 (or latest available data) for the business services sector (G-N). To make our results more robust, we show also the entry rates for the average of 2004-2006 (there are several countries where the numbers are not available for all three years). This number should be used carefully, as before 2008, – for most of the countries, – entry rates are available only from an older version of the database using the previous NACE classification (rev1.1 instead of rev2). After an assessment of indirect evidence for comparability, we concluded that merging the two databases is only reliable for the service sector while it is not for the manufacturing sector.[90] We can observe a decline in 2017 compared to both the 2004-2006 average and 2008 for the following countries (Figure 26): Lithuania, Slovakia, Luxembourg, Netherlands, Spain, Slovenia, Germany, Austria, and Hungary and Italy. Compared to only 2008, we can add Bulgaria, the United Kingdom, Latvia and France to the list. Furthermore, to see the robustness of the results in terms of choosing 2017 as the end of period, we compared entry rates of the average of 2004-2006 versus the average of 2014-2017 in the service sector (Figure 27). A decline occurred in entry rate in two thirds of the countries for which we have data for both periods.

These results suggest a widespread decline in entry rates in the service sector among EU countries. Also, it seems that there is a downward trend not just a jump in entry rates in services which suggests further potential deterioration in business dynamism (Figure 28). Also, this decline is characteristic to the service sector while we observe an upward trend in manufacturing.

Figure 26. Entry rate in services (without sole proprietorships) in 2004-2006 (avg.), 2008 and 2017 (%).



Note: Averages are unweighted. Data before 2008 are calculated from NACE rev1.1 classification. * denotes data from 2016 instead of 2017; ** denotes data from 2015 instead of 2017.

Source: SBS (Eurostat).

[90] For 2004-2007, number of births of firms is available for many countries for both NACE classifications while the number of active firms is not. So we can compare only the number of births but not the birth rate (entry rate). For manufacturing, we found significant deviation, while for the service sector as a whole, the deviation was more minor for most of the countries.

Figure 27. Entry rate in services (without sole proprietorships) in 2004-2006 and 2014-2017, and the difference between the two periods (per cent and percentage points, respectively).

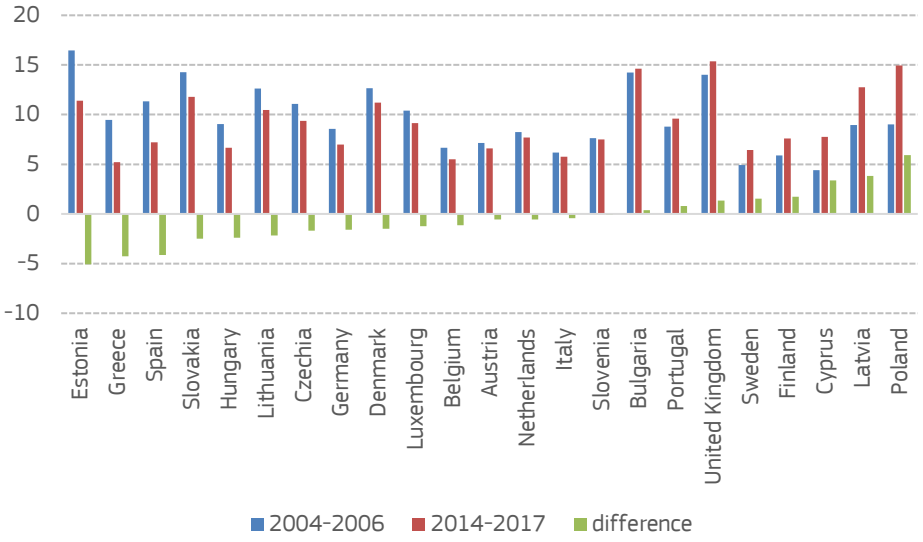
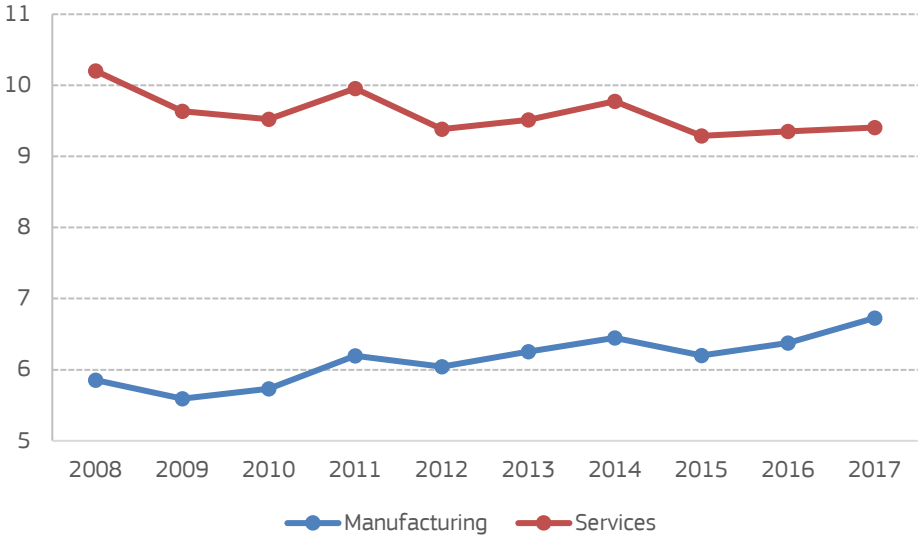


Figure 28. Average entry rate in manufacturing and in the service sector across EU countries (%).



For some countries, there is evidence that this decline is part of a longer downward trend.[91]

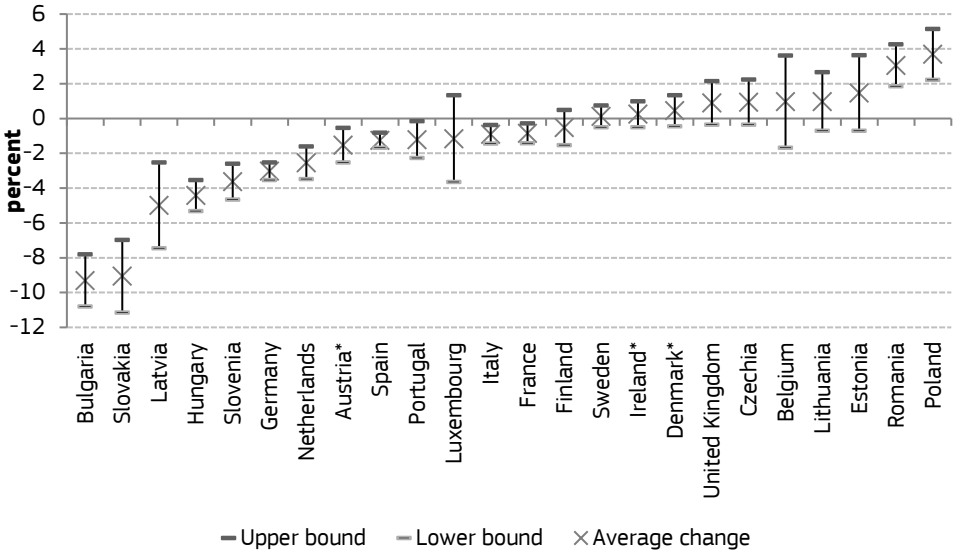
For the observed decline in business dynamism, several potential explanations were offered in the literature. The traditional explanation starts from the importance of regulatory barriers to entry. Among regulatory measures, licences and permit system and the length of bankruptcy procedure seems to be important for entry (Brandt, 2004). Furthermore, credit constraints could deter firms from market entry (Aghion et al., 2007). Market congestion generated by zombie firms can also create barriers to entry (McGowan et al., 2017). Another strand of the literature emphasises the role of market structure. Theoretically, rising market power may reduce business dynamism. The recent literature tries to explain the trends of increasing market power, lower labour income share, declining business dynamism and lower productivity growth in a unified framework (Akcigit and Ates, 2019; De Ridder, 2019; Aghion et al., 2019; Liu et al., 2019). However, most of the evidences show that market power increased in the US but not in the EU (Gutiérrez and Philippon, 2019).

[91] For the US, see Akcigit and Ates (2019); for Belgium, see Bijnens and Konings (2018); for other advanced economies, see Criscuolo et al. (2014).

Thus, it is unlikely, that increased market power would be the driver behind the decline in European business dynamism.

As entry rates can be volatile and may increase or decrease also randomly, it is important to show that the observed decline is intrinsic to the country analysed. One way to do that is to exploit the 2-digit industry level data for entry rates, and to test whether the decline was significant across service industries within a country. Thus we test whether the average change across industries was significantly different from zero. Figure 29 shows the 95 % confidence interval of the average change for each country. If the whole interval is below zero then we can say that the decline was statistically significant. According to this test, significant decline between 2008 and 2017 took place in Bulgaria, Slovakia, Latvia, Hungary, Slovenia, Germany, Netherlands, Austria, Spain, Portugal, Italy and France.[92] The results change only slightly if we compare 2008 to the average of 2014-2017.[93]

Figure 29. Average change in entry rates in the service sector between 2008 and 2017 and its 95 % confidence interval (calculated over 2-digit industries, percentage points).



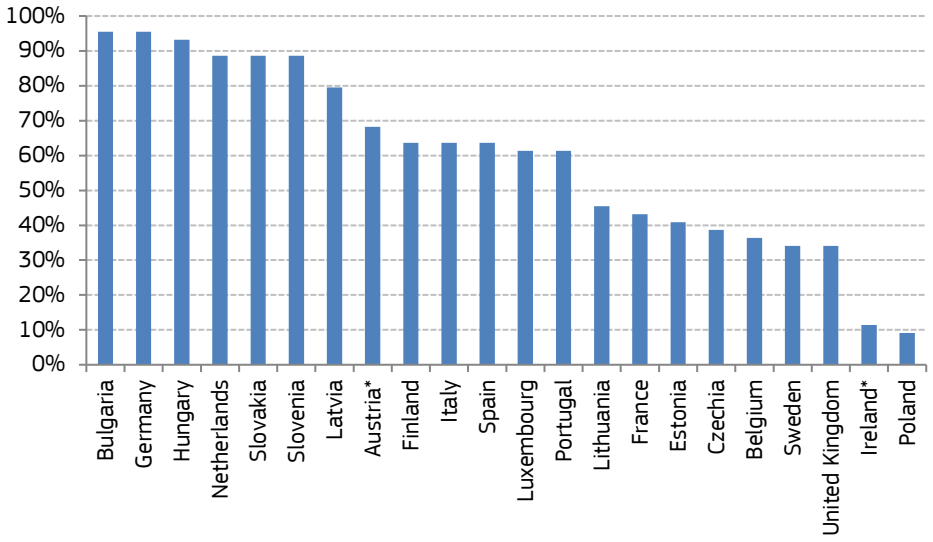
Source: Own calculation based on SBS (Eurostat).

In addition, we can look at how the decline in entry rates was widespread within countries, across service industries. Figure 30 shows the share of industries with a decline between 2008 and 2017. We can see that the majority of the EU countries have a share higher than 50 %.

92 For Portugal, at the level of the whole service sector, there was no decline. The difference is because of weighted vs non-weighted average entry rates.

93 For the sake of robustness, it would be better to compare 2004-2006 to 2014-2017, however, as we already noted, we cannot go before 2008 with the analysis at the 2-digit industry level due to the change of industry classification.

Figure 30. Share of 2-digit services with a decline in entry-rate between 2008 and 2017, by country.



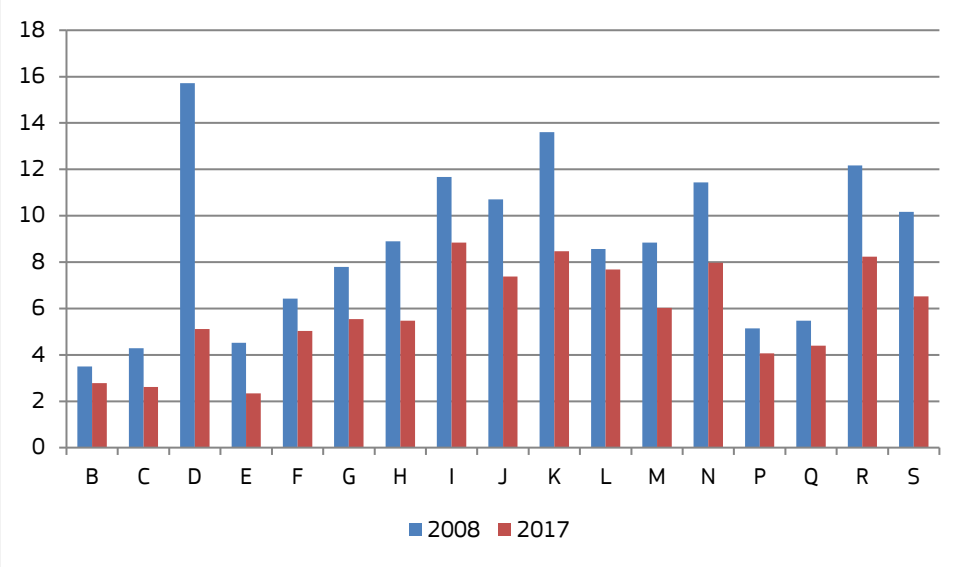
Source: SBS (Eurostat).

Box 2. Country example: Germany

We show more detailed results for Germany in this box, as Germany is one of the countries where the decline in entry rates proved to be quite broad across service industries (see Figure 30).

First, we analyse the decrease of entry rates at the 1-digit industry level. We find that the decline was larger in most of the service industries (with the exception of the real estate sector, (L) than in manufacturing (C). The biggest drop was in the energy sector (D), but the entry rate was extremely high there in 2008.

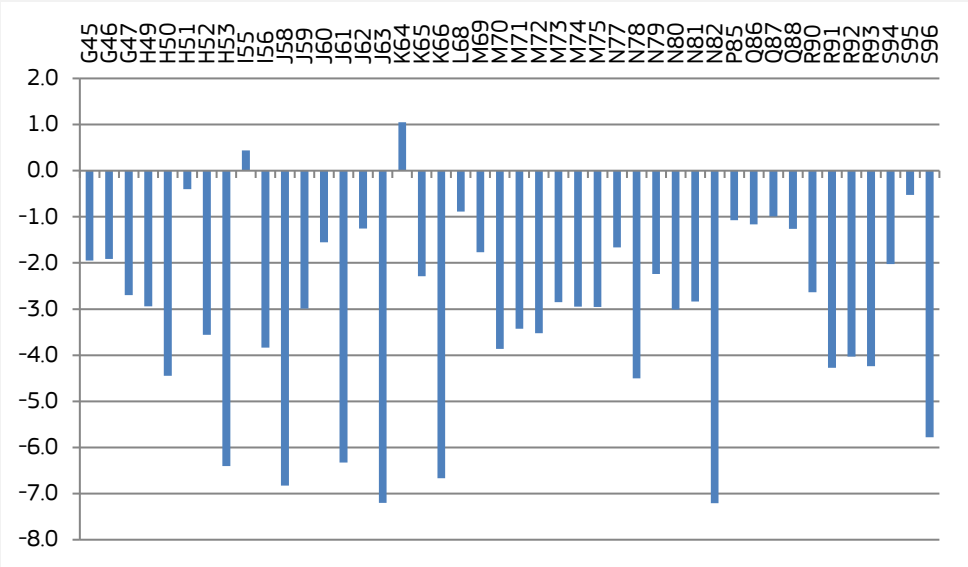
Figure 31. Entry rates in Germany, 2008 and 2017, 1-digit industries (%).



Source: SBS (Eurostat).

Within the service sector, we observe a widespread decline in entry rate at the 2-digit industry level services, as well (Figure 32). In fact, there are only 2 industries with an increase in the entry rate, and the decrease is really considerable in many industries.

Figure 32. Change in entry rates between 2008 and 2017, Germany, 2-digit service industries (percentage points).



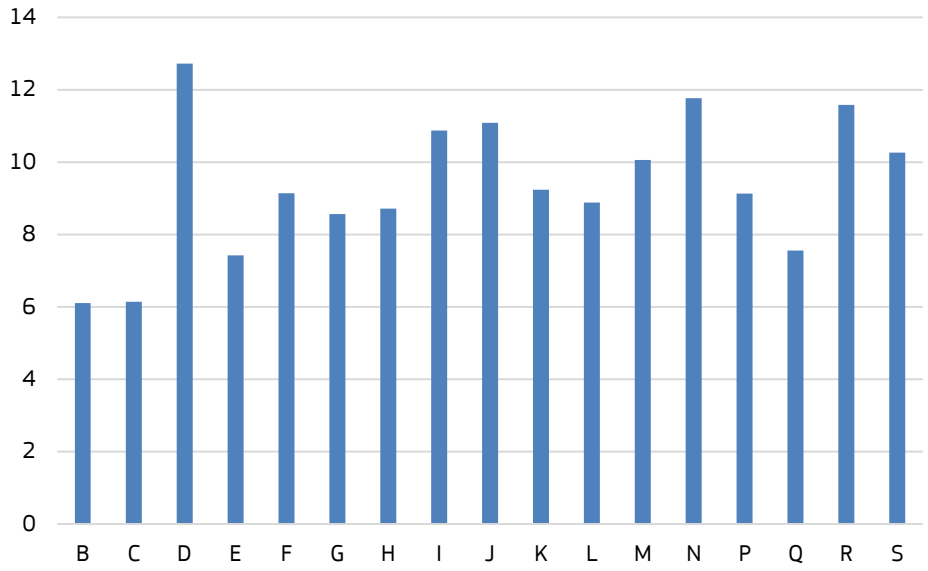
Source: SBS (Eurostat).

The reason behind this widespread, large and statistically significant decline of entry rates in the German service sector is not clear. Coupled with the fact that the level of the entry rate was already among the lower half of EU countries, this finding seems to be especially worrying for business dynamism in Germany.

We can compare entry rates between different sectors using the EU's unweighted average across the period of 2008-2017. Entry rates of services are generally higher than in manufacturing (Figure 33) while the

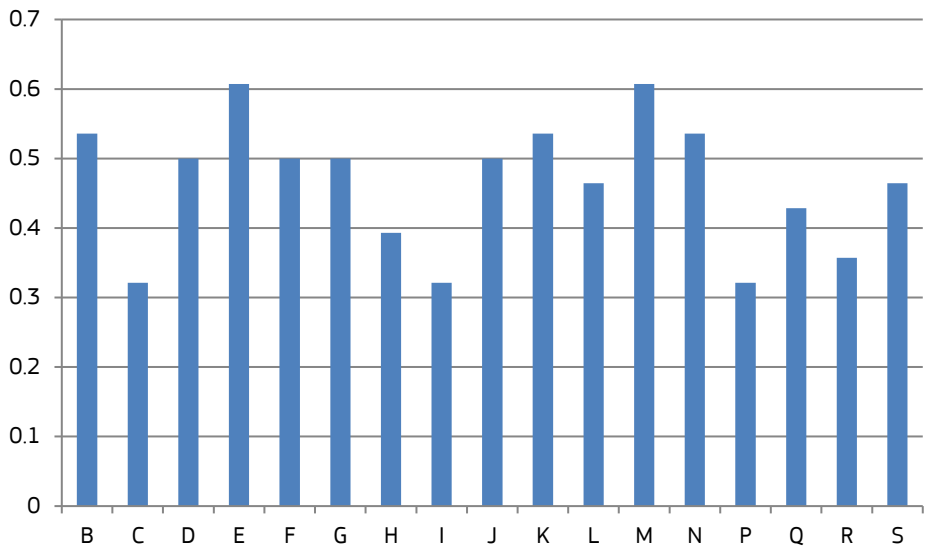
decline is less characteristic to manufacturing and accommodation/restaurants (Figure 34). Based on the average changes we can also state that manufacturing is less affected by the decline in entry rates (Figure 35).

Figure 33. Average birth rate across countries and years in 1-digit industries (2008-2017, %).



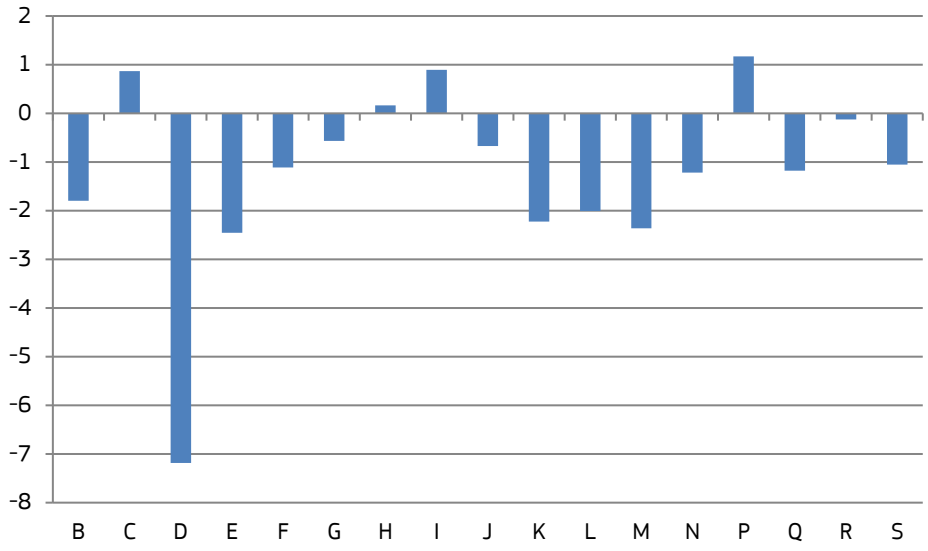
Source: SBS (Eurostat).

Figure 34. Share of countries where the entry rate decreased between 2008 and 2017, by 1-digit industries.



Source: SBS (Eurostat).

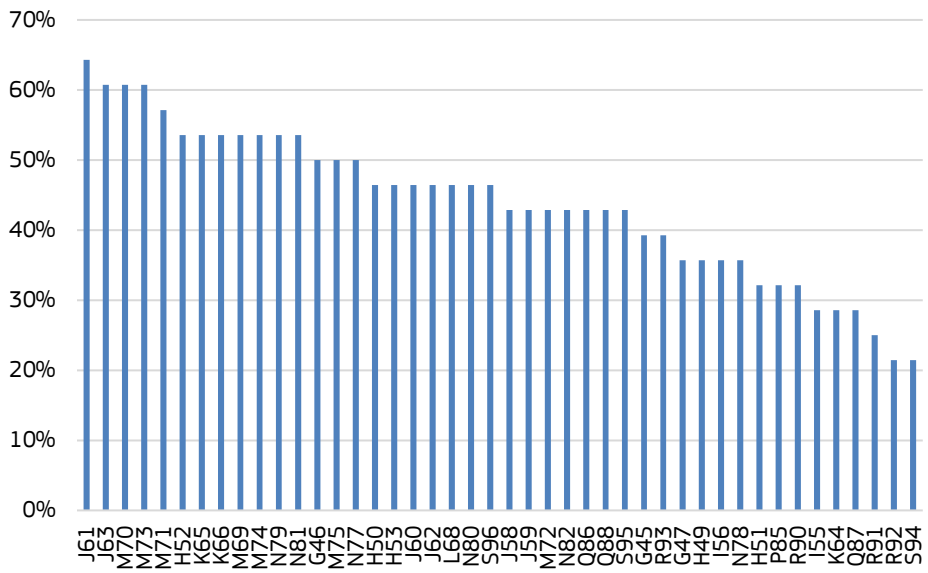
Figure 35. Average change in entry rates between 2008-2017 (percentage points).



Source: SBS (Eurostat).

Then, the question is whether the observed decline in many countries is country-specific or industry-specific. If we analyse entry rates of different industries within the service sector, we find that the decline in entry rates is not widespread across service industries. This is indicated by the relatively low number of industries where more than half of the EU countries showed a decline (Figure 36).

Figure 36. Share of countries within 2-digit service industries where the entry rate decreased between 2008 and 2017.



Source: SBS (Eurostat).

To show more evidence that the observed decline is country-specific rather than industry-specific, we run regressions that explain the decline in country-industry pairs with country dummies only, and with 2-digit industry dummies only for services. Then we compare the explanatory power of the regressions. First, we ran

OLS regressions, then probit regressions. Both type of regressions showed (R^2 and Pseudo-R^2, respectively) that country dummies explain a lot more of the variation in entry rate declines than industry dummies.[94]

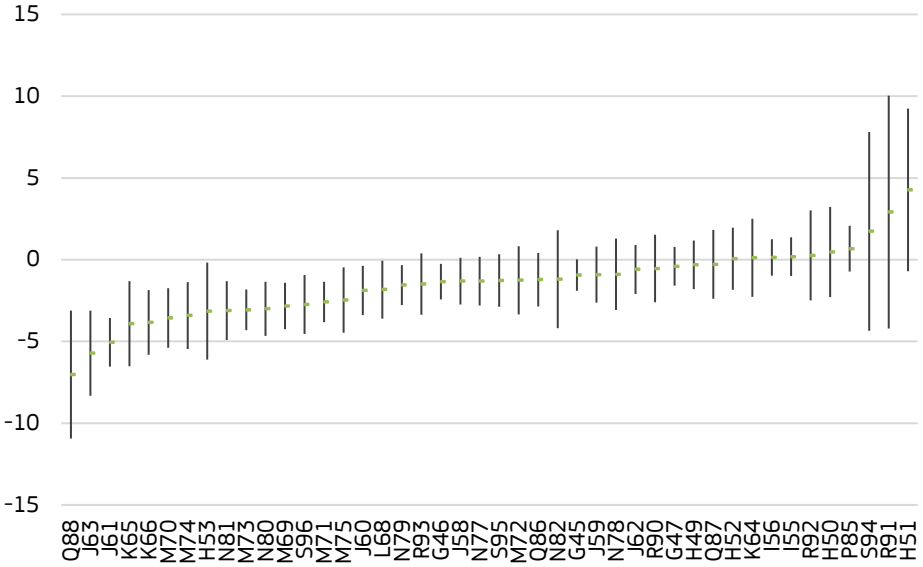
Table 13. Explanatory power of country or industry dummies for the decline in services between 2008 and 2017 (dependent variable: decline between 2008 and 2017).

	Country dummies only	Industry dummies only
R^2 (OLS)	0.4893	0.0467
Pseudo-R^2 (Probit)	0.2175	0.0349

Note: The dependent variable is a binary variable which takes: 1 for a strictly negative change between 2008 and 2017; and 0 for a positive change.

Furthermore, we can observe that the average size of the change of the entry rates is significantly negative in many services. This is driven by the steep declines observed in some countries.

Figure 37. Average change in entry rates between 2008 and 2017 in 2-digit services and its 95 % confidence interval (calculated over countries), percentage points.



Source: Own calculation based on SBS (Eurostat).

7.1.2 Linking productivity growth and firm demography

We follow Anderton et al. (2018) to explain productivity growth by entry and exit rates, but with some differences. First, we use the period of 2008-2016 instead of 2000-2014.[95] The reason is that the data before 2008 are available only in NACE rev1.1 from SBS, and according to our analysis, linking NACE rev2 data to rev1.1 is not reliable for all sectors (see footnote 90). Not linking the two datasets has also the advantage that we can use 2-digit industry level data instead of 1-digit level. We use labour productivity growth as our dependent variable instead of TFP growth. Labour productivity is an observable measure of productivity in contrast to TFP, with a direct relevance to economic growth and welfare. Using macro-level data, it is not easy to measure TFP convincingly well.[96] In contrast to Anderton at al. (2018), we estimate the effect of entry and exit jointly as they are correlated,[97] while they estimated the effects by separate

[94] This cannot be explained by the number of regressors, as there are more industries than countries in the sample.

[95] We cannot use the entry and exit rates for 2017 in this analysis, as we use lagged entry and exit rates, and 2-digit industry level productivity data from National Accounts are not yet available for 2018 for most of the EU countries (at the time of the writing of this report).

[96] Anderton et al. (2018) use a very simple approach of calculating the Solow residual with a fixed input share of 1/3 and 2/3 of capital and labour, respectively.

[97] We also checked the estimation separately, and got very similar coefficients as in the joint estimation. We do not report these results.

regressions.[98] Finally, instead of controlling for lagged GDP growth, in one specification of the regression, we control for country-year fixed-effect which is more general.

The estimated baseline equation that links productivity growth and firm demography is the following:

$$\Delta\, log(labprod_{cst}) = \beta_1 birthrate_{cst-1} + \beta_2 deathrate_{cst-1} + \delta_c + \mu_s + \lambda_t + u_{cst} \qquad (19)$$

where c is country, s is industry, t is year, the left hand side variable is labour productivity growth (in log) while the right hand side variables are lagged birth rate (entry rate) and death rate (exit rate) and country, industry and time fixed-effects. Entry and exit rate are lagged to alleviate the problem of endogeneity.[99] In another variant of the equation, we include country-year fixed-effect instead of separate country and year fixed effects, to control for the effects of country-specific trends on labour productivity growth.

Following Anderton et al. (2018), we estimate the equation for firms with fewer than 10 employees (micro firms) and for firms with at least 10 employees (larger than micro firms), separately.[100] As the legal status dimension is not available jointly with the size information in the SBS-Firm Demography database, we could not filter out sole proprietorships from the data. This affects only the results for micro firms as sole proprietorships are very small firms.

We applied a simple outlier filtering procedure, where we winsorize extreme changes in labour productivity and extremely high entry or exit rates. For labour productivity growth we set values to 20 and -20 % that are higher or lower than 20 and -20, respectively (very close to a 5th, 95th percentile threshold). For entry rate and exit rate, we chose the threshold at 40 % and 30 %, respectively (very close to the 99th percentile of all firms).

Table 14. Estimates of the impact of entry and exit rate on productivity growth.

	<10 employees				>=10 employees			
	All sectors		Services		All sectors		Services	
Variable	**Baseline**	**Country× Year FE**	**Baseline**	**Country× Year FE**	**Baseline**	**Country× Year FE**	**Baseline**	**Country× Year FE**
Birth(t-1)	0.03	0.00	0.07**	0.05	0.28***	0.30***	0.24**	0.26***
Death(t-1)	0.06	0.07	0.02	0.03	-0.07	-0.09	-0.17	-0.16
Year FE	yes	yes	yes	yes	yes	yes	yes	yes
Country FE	yes	yes	yes	yes	yes	yes	yes	yes
Industry FE	yes	yes	yes	yes	yes	yes	yes	yes
Country × Year FE	no	yes	no	yes	no	yes	no	yes
Wooldridge serial correlation test p-value	0.0947	0.2094	0.5873	0.7668	0.1301	0.2784	0.5174	0.7821
Observations	6,287	6,287	4,082	4,082	6,277	6,277	4,076	4,076

Note: *** and ** denote significance at the 1 % and 5 %, respectively.

According to our results (see Table 14), entry increases productivity growth, but only for larger than micro firms. This effect is also statistically significant. We did not get significant results for exit.[101] For micro firms,

98 They also estimated the effect of the churn rate which is the sum of the entry and exit rate. In this sense, that estimation is a joint estimation of the effect of entry and exit but with the constraint that the coefficients are the same.

99 We use only one lag which means that we measure the short-term impact on productivity growth. As the length of the time dimension of the data is a limitation against using several lags, we cannot exclude the possibility of longer-term effects.

100 We could not split the sample at a larger firm size, as 10 employees is the largest threshold in the Firm Demography database. However, we should note, that as firms at entry are usually small, analysing the entry rate for larger firms does not have an added value. This is, of course, not true for the exit rate.

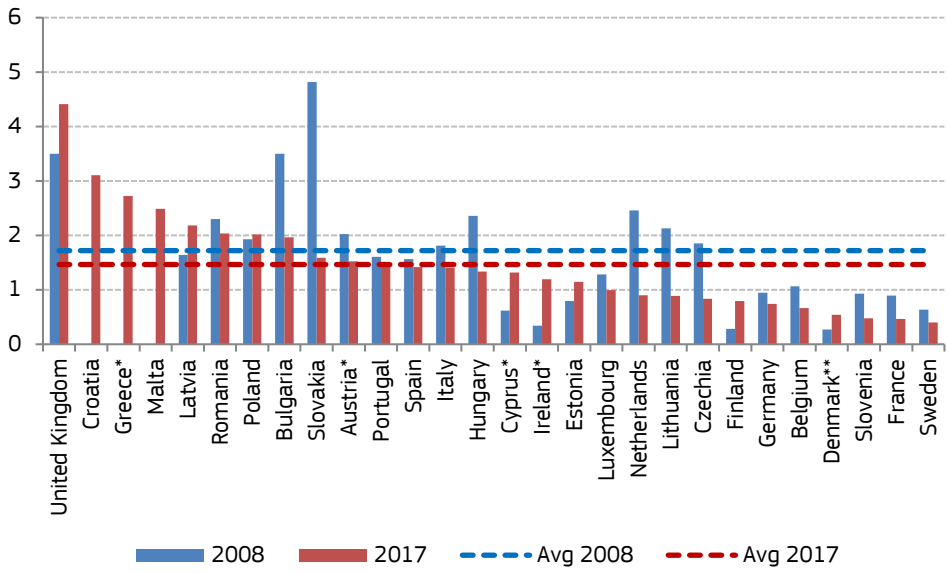
101 This is a result that differs from the one of Anderton et al. (2018). They find significant and large positive effect from the exit rate on larger-than-micro firms.

we got small (and mostly insignificant) effects from entry and exit. We got similar results for service industries as for all industries.[102].

According to the estimated coefficient from the specification that we consider the best (including country-year fixed effect), a 1 percentage point increase in the entry rate in the larger-than-micro segment increases labour productivity growth next year by 0.26 percentage points in the service sector.

As our results indicate the importance of entry rate for the larger-than-micro firms, we analysed the development of entry rates in this segment, too (Figure 38). We find that entry rates declined for many countries between 2008 and 2017 in this segment of the economy as well.[103]

Figure 38. Entry rates in services for larger than micro firms (i.e. with at least 10 employees), 2008 and 2017 (%).



Source: SBS (Eurostat).

Based on these numbers and our estimates of the marginal effect of entry on productivity, it is possible to calculate the impact of the decline. According to this calculation, the decline in entry rates in many countries was not so large in the larger-than-micro firm sector to reduce productivity growth by much since 2008. However, knowing that many countries could experience this decline for a longer time (see Criscuolo et al., 2014) then the impact on productivity growth can be larger. Also, the potential to improve productivity growth is substantial for some countries if we consider the distance to the average in terms of entry rates.

7.1.3 Productivity decomposition with the net entry rate

The size of the impact of entry and exit rates on aggregate productivity also depends on the productivity of entrant and exiting firms. SBS does not include this information. In the following we use the CompNet database to assess the importance of entry and exit in productivity growth. CompNet is a so-called micro-aggregated database which means that using firm level data, some moments of the firm level distributions are reported, e.g. the percentiles of employment, value added, and productivity. They also report the results from various productivity decompositions, like Olley-Pakes and FHK (Foster et al. 2006). We use the latest, 6th vintage of the database.[104]

---

102 We tested for serial correlation in the residual as this could bias the coefficients of the explanatory variables. Based on the Wooldridge serial correlation test for panel regressions, there is no statistical evidence for serial correlation. Generally, it is claimed that serial correlation may bias the estimates of the standard errors only. In our case, where reverse causality is a potential issue, it may also bias the estimates of the coefficients.

103 The trailing positions of Scandinavian countries can come as a surprise. In fact, an OECD study links that to some regulatory barriers, like licence and permits, and length of bankruptcy procedure (Brandt, 2004).

104 For a detailed description, see the user guide of this vintage, CompNet, 2018.

We use the FHK decomposition to uncover the entry-exit effect on productivity growth. The structure of this decomposition is based on the following identity (see Foster et al. 2006):

$$\begin{aligned}\Delta y_{st} &= \Sigma_{i\in C}\theta_{i,t-k}\Delta\omega_{it} + \Sigma_{i\in C}\left(\omega_{i,t-k} - y_{s,t-k}\right)\Delta\theta_{it} + \Sigma_{i\in C}\Delta\theta_{it}\Delta\omega_{it} \\ &+ \Sigma_{i\in N}\theta_{it}\left(\omega_{it} - y_{s,t-k}\right) - \Sigma_{i\in X}\theta_{i,t-k}\left(\omega_{i,t-k} - y_{s,t-k}\right)\end{aligned} \tag{20}$$

where s is the 2-digit industry, t is the year, y is aggregate labour productivity, θ is employment share of the firm within the industry and ω is log-labour productivity of the firm. k is the time-window over which the change in productivity is analysed, i.e. Δ means a change from t to $t-k$. C denotes the set of continuing firms (firms that do not enter or exit from the market), N is the set of entrant firms, X are the exiting firms.

We have an unbalanced panel dataset where the time period is 2001-2016, and the country coverage includes 14 EU countries.[105] The period 2007-2015 includes data for most (13) countries.

In CompNet, only the growth of productivity over one-year is decomposed (i.e. $k = 1$), and they report only the within, between and covariance terms (the first, second and third terms on the right hand side of the equation). Since there are data for the left hand side variable, we can calculate the net entry contribution (the sum of the fourth and fifth term) as a residual.

We should be aware, however, of the fact that aggregate labour productivity growth on the left hand side of the equation is not the same as in National Accounts. There are a number of reasons why. First, the definition of (log) aggregate labour productivity is somewhat different: it is the log of the geometric average of firm level productivity in case of CompNet, i.e. it is an employment share weighted sum of log-labour productivity in contrast to the usual definition where it is equivalent to the weighted sum of non-logarithmic labour productivity. The reason is that aggregate productivity growth can be decomposed more easily in the former case. Furthermore, in case of CompNet, the weights are the two-year averages of employment shares. It is not possible to calculate this for firms that do not exist for two consecutive years, so they are excluded from the calculation of aggregate productivity. This also has the consequence that entry and exit are also somewhat different from the usual definition. The entry term for year t does not capture the effect of new firms in t, but new firms in $t-1$ that also survive until t. These are the firms that are included in y_{st} but not included in y_{st-1}. The exit term includes firms that exist in $t-1$ and $t-2$ but exit in t. Then these firms are included in y_{st-1}, but not in y_{st}. These differences from the usual definition suggest a larger-than-usual contribution of the net entry term as entrant firms are older (and because of that, more productive) when we evaluate their productivity impact.[106]

Beside definitional differences, aggregate labour productivity calculated from firm level data can be different from National Accounts because there they may use (additionally or exclusively) different sources of data, they may clean the data differently (e.g. outlier treatment) or they may include sole proprietors (CompNet excludes them).

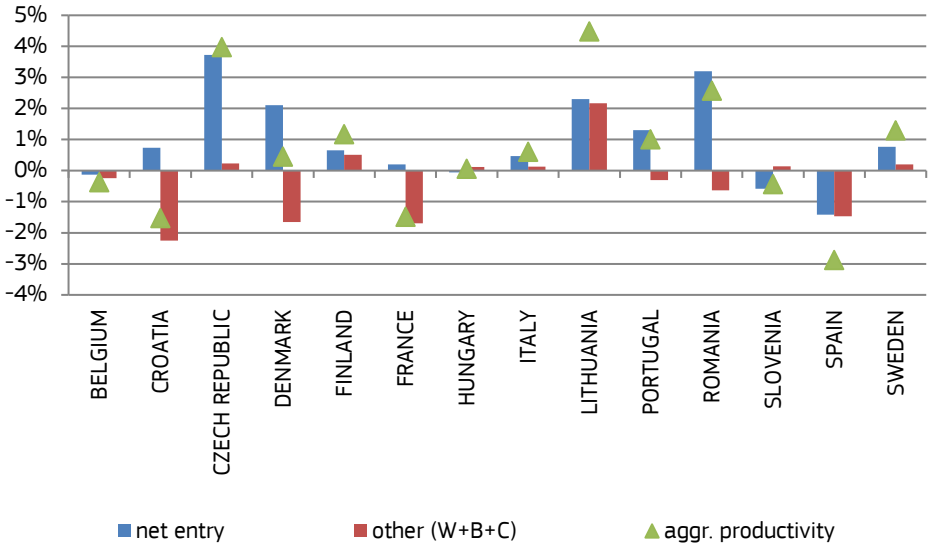
With these limitations in mind, we show the average net entry contribution over the sample period by country for the service sector as a whole (Figure 39), where we aggregated 2-digit industry level decomposition results by using nominal value added share as industry weights.[107] According to the results net entry contribution is quite substantial relative to aggregate productivity growth for several countries.

[105] We need the full sample of firms, thus we have Belgium, Croatia, Czechia, Denmark, Finland, France, Hungary, Italy, Lithuania, Portugal, Romania, Slovenia, Spain and Sweden in the sample.

[106] Exiting firms also have somewhat higher productivity on average because we exclude firms that enter in $t-1$ and exit in t which are probably the lowest productivity firms. But this is only a subset of exiting firms and their weight is probably quite small, so we expect that this effect is dominated by the effect of entrant firms.

[107] Specifically, we used the 2-year average of nominal value added share as weights.

Figure 39. Contribution of net entry and the other terms in the FHK decomposition (averaged over time and aggregated to the level of the whole service sector from 2-digit industries).



Note: W: within, B: between, C: covariance term in the FHK decomposition.

Source: Own calculation based on CompNet.

It would be useful to show the importance of net entry at the level of 2-digit services. However, there are many cases where aggregate productivity growth is negative (as we could see it even at the level of the whole service sector, Figure 39). In those cases it is not clear what is the quantitative measure of "importance" of net entry, as the percentage share has no meaning then. In the following, we look at the explanatory power of net entry for aggregate productivity growth across 2-digit services. We find that net entry is an important driver of productivity growth in the economy and even more important in the service sector. To show that we run regressions with the net entry contribution or with the other three terms combined (within, between and covariance added up) as explanatory variables for aggregate productivity growth in services.[108] We found that net entry has a much higher explanatory power across countries, years and sectors (Table 15).

Table 15. Explanatory power of the within, between, covariance terms combined and net entry (from the FHK decomposition) for productivity growth in 2-digit services (R^2 from OLS regressions).

Control variable	Other (W+B+C)	Net entry	Difference
No control variables	0.27	0.70	0.42
Country × Sector FE	0.33	0.73	0.40
Country × Year FE	0.32	0.74	0.43
Sector × Year FE	0.36	0.76	0.40
Time-averages	0.18	0.60	0.42

Note: W: within, B: between, C: covariance term in the FHK decomposition; diff is the difference in the explanatory power (in terms of R2) between net entry and the other terms combined.

We also found that the net entry term is quite volatile from one year to another, so it is also a question how net entry explains long-term growth in productivity. For answering that question we took the average of productivity growth and of the terms of the decomposition over time. Then we run a regression explaining average productivity growth by the average net entry contribution and by the other terms. We found that net entry is still more important to explain productivity growth in the service sector than other terms (also in Table 15).

[108] We dropped extreme observations where the productivity contribution from net entry or from the other terms (combined) exceeded 100 log-points in absolute terms (i.e. it was larger than 1 or smaller than -1).

7.1.4 Declining business dynamism as a drag to productivity growth

In this chapter, we documented a widespread decline in business dynamism in the service sector, specifically in entry rates since 2008 among EU member states based on SBS data. This finding is in line with existing evidence that several advanced economies already experienced a long-term decline in business dynamism well before the crisis (see e.g. Criscuolo et al., 2014). We showed that the decline since 2008 was statistically significant within several countries. The observed decline is more country specific than industry specific. A statistically significant decline in entry rates occurred between 2008 and 2017 in Bulgaria, Slovakia, Latvia, Hungary, Slovenia, Germany, Netherlands, Austria, Spain, Portugal, Italy and France.

Declining business dynamism may be a drag on productivity growth. Indeed, according to our results based on SBS data, a higher entry rate improves productivity growth. Using another data source, CompNet, we complemented this result with the finding that net entry contribution is an important driver of productivity growth.

Until now, the reasons behind the deterioration in business dynamism are not clear. The traditional approach emphasises the role of barriers and costs to entry. Financial constraints could also contribute to declining entry rates. On the other hand, recent theories that link the decline in business dynamism to increasing market power are unlikely to be relevant in Europe. This is because most of the evidences show that in the EU – as opposed to the US – markets became more rather than less competitive in the relevant period.

7.2 Firm size distribution and sectoral labour productivity

7.2.1 Exploiting the positive relation between size and labour productivity

Differences in productivity are an important explanatory factor for differences in living standards across countries (Restuccia and Rogerson, 2017). In turn, these differences might arise due to not only a genuine divergence in aggregate production efficiency or in the allocation of resources, but also to different economic structures, both in sectoral terms and across production units (Bartelsman and Doms, 2000).

Heterogeneous productivity across different types of firms finds its theoretical foundation in the industry model built in Melitz (2003), and has been empirically documented in recent years owing to the increased availability of firm-level data (ECB, 2017).

In this chapter we focus on the role of a country's firm size in conditioning aggregate and sectoral labour productivity, both in levels and in growth rates. Sectoral differences aside (Berlingieri et al., 2018), there is an overall positive relation between firm size and labour productivity (Table 16). For EU Members States, we develop a decomposition analysis that splits sectoral productivity differences relative to the benchmark of the EU aggregate into differences in the firm size distribution and differences in the productivity level within each firm size class.

Table 16. Distribution of firm size classes by average labour productivity[109]

		Firm Size Class (persons employed)				
		0-9	10-19	20-49	50-249	≥250
Firm Size Class ranked by average Labour Productivity	Highest	9%	4%	8%	27%	52%
	2nd	4%	8%	19%	53%	16%
	3rd	4%	14%	61%	12%	9%
	4th	6%	65%	9%	8%	12%
	Lowest	77%	9%	3%	1%	10%

Source: Own calculation based on SBS data (2016 or latest) for five firm size classes in eight NACE sections and 24 Member States.

[109] The ranking on the left corresponds to the order of the five existing firm size classes by average labour productivity within each sector-country pair; e.g. 77% of the observations for firms employing less than 10 workers correspond to the size class recording the lowest productivity level within a given sector-country pair.

7.2.2 How to decompose the productivity gap relative to the EU average

We use business demographic variables provided by the Structural Business Statistics (SBS) from Eurostat[110], which covers NACE Rev. 2 'business economy' activities from sections B to N (excluding K) and division S95[111]. The SBS includes data by firm size class given by the number of persons employed[112] in the following ranges: 0-1, 2-9, 10-19, 20-49, 50-249 and 250 or more[113].

The apparent labour productivity for a country 'c'-sector 's' pair is given by the ratio of value added (VA) and the number of persons employed (EMP):

$$LP_{c,s} = \frac{VA_{c,s}}{EMP_{c,s}} \tag{21}$$

Value added is measured in purchasing power parity-adjusted euros using GDP-based price levels referred to the EU-28 aggregate provided by Eurostat[114].

Now we introduce the firm size dimension (size class indexed by 'i') and we rewrite aggregate productivity as follows:

$$LP_{c,s} = \frac{VA_{c,s}}{EMP_{c,s}} = \frac{\sum_i VA_{c,s,i}}{EMP_{c,s}} = \sum_i \frac{VA_{c,s,i}}{EMP_{c,s}} = \sum_i \frac{EMP_{c,s,i}}{EMP_{c,s}} \times \frac{VA_{c,s,i}}{EMP_{c,s,i}} = \sum_i \alpha_{c,s,i} \times LP_{c,s,i} \tag{22}$$

where:

$\alpha_{c,s,i} = employment\ share\ of\ firm\ size\ class\ i\ in\ sector\ s\ of\ country\ c$

$LP_{c,s,i} = labour\ productivity\ of\ firm\ size\ class\ i\ in\ sector\ s\ of\ country\ c$

With this framework we can decompose the difference in the productivity level for a given sector between a Member State and the EU aggregate into differences in the firm size distribution (*size distribution effect*) and differences in the productivity level within the corresponding firm size classes (*size class productivity effect*):

$$\begin{aligned} LP_{c,s} - LP_{EU,s} &= \sum_i \alpha_{c,s,i} \times LP_{c,s,i} - \sum_i \alpha_{EU,s,i} \times LP_{EU,s,i} \\ &= \sum_i \left(\alpha_{c,s,i} - \alpha_{EU,s,i}\right) \times \left(\frac{LP_{c,s,i} + LP_{EU,s,i}}{2}\right) [size\ distribution\ effect] \\ &+ \sum_i \left(LP_{c,s,i} - LP_{EU,s,i}\right) \times \left(\frac{\alpha_{c,s,i} + \alpha_{EU,s,i}}{2}\right) [size\ class\ productivity\ effect] \end{aligned} \tag{23}$$

For instance, if employment in a country was more concentrated in larger firms compared with the EU aggregate, given that larger firms are associated on average with higher productivity, the *size distribution*

110 http://ec.europa.eu/eurostat/web/structural-business-statistics

111 A detailed structure and description of NACE Rev. 2 is available at: https://ec.europa.eu/eurostat/web/products-manuals-and-guidelines/-/KS-RA-07-015

112 Number of persons employed is defined as the total number of persons who work in the observation unit (inclusive of working proprietors, partners working regularly in the unit and unpaid family workers), as well as persons who work outside the unit who belong to it and are paid by it (e.g. sales representatives, delivery personnel, repair and maintenance teams). It excludes manpower supplied to the unit by other enterprises, persons carrying out repair and maintenance work in the enquiry unit on behalf of other enterprises, as well as those on compulsory military service.

113 Data for the two smallest classes are provided in aggregate terms under the '0-9' range for industry activities (sections B to E) and construction (F).

114 https://ec.europa.eu/eurostat/web/purchasing-power-parities/data/database

effect would be positive. However, at the same time, if average productivity for larger firms in this country was lower than peers in the EU aggregate, the *size class productivity effect* would be negative.

Finally, in order to provide an overall picture, we aggregate results at country level. A third component is then added to account for differences in the weight of sectors and the fact that productivity is higher in certain sectors than others. We refer to this component as the *sectoral composition effect*. Accordingly, for the aggregate productivity level we can split the difference with respect to the EU benchmark as follows:

$$\begin{aligned} LP_c - LP_{EU} &= \sum_j \beta_{c,s} \times LP_{c,s} - \sum_j \beta_{EU,s} \times LP_{EU,s} \\ &= \sum_j \left(\beta_{c,s} - \beta_{EU,s}\right) \times \left(\frac{LP_{c,s} + LP_{EU,s}}{2}\right) \; [sectoral\ composition\ effect] \\ &+ \sum_j \left(LP_{c,s} - LP_{EU,s}\right) \times \left(\frac{\beta_{c,s} + \beta_{EU,s}}{2}\right) \end{aligned} \tag{24}$$

where:

$\beta_{c,s} = employment\ share\ of\ sector\ s\ in\ country\ c$

The aggregate sectoral productivity difference is then given by the weighted sum of the size distribution effect and the size class productivity effect across all sectors in the economy.

An analogous decomposition can be carried out for dynamics at country level, using then lagged values for the corresponding country 'c' in equations (23) and (24) instead of those of the EU benchmark.

There are a number of caveats that need to be considered when using this methodology.

First, using the same purchasing power adjustment for all economic activities within one country might introduce some distortions. Duarte and Restuccia (2017) shows that both the expenditure share and the relative price of services with respect to those of manufacturing products rises with economic development. Hence, in the presence of strong income divergences across EU Member States, aggregate and sectoral differences in price levels might differ significantly[115]. Unfortunately, purchasing power parities are not available in Eurostat at the sectoral level but only for final expenditure items.

Second, data availability is limited for smaller countries due to confidentiality restrictions, and, what is more relevant, across the board at a more granular level for recent years. The lack of coverage for many NACE divisions and groups doesn't allow exploiting heterogeneity and composition effects, what could then generate some biases when analysing productivity at section and aggregate level.

And third, firms with zero persons employed are included in the SBS sample and their value added is reported in the smallest firm class. The interpretation of labour productivity would then be difficult in those economic activities where these firms have a significant weight.

7.2.3 Size distribution effects play a significant role only in a few countries

In this section we make an attempt to synthetize the role of the different factors in shaping country productivity levels as described in the methodology. Unfortunately, the limited coverage restricts our exercise to the use of a number of aggregate sections, namely manufacturing (section C), trade (G), transport (H), accommodation and food services (I), ICT services (J), professional activities (M) and support service activities (N)[116].

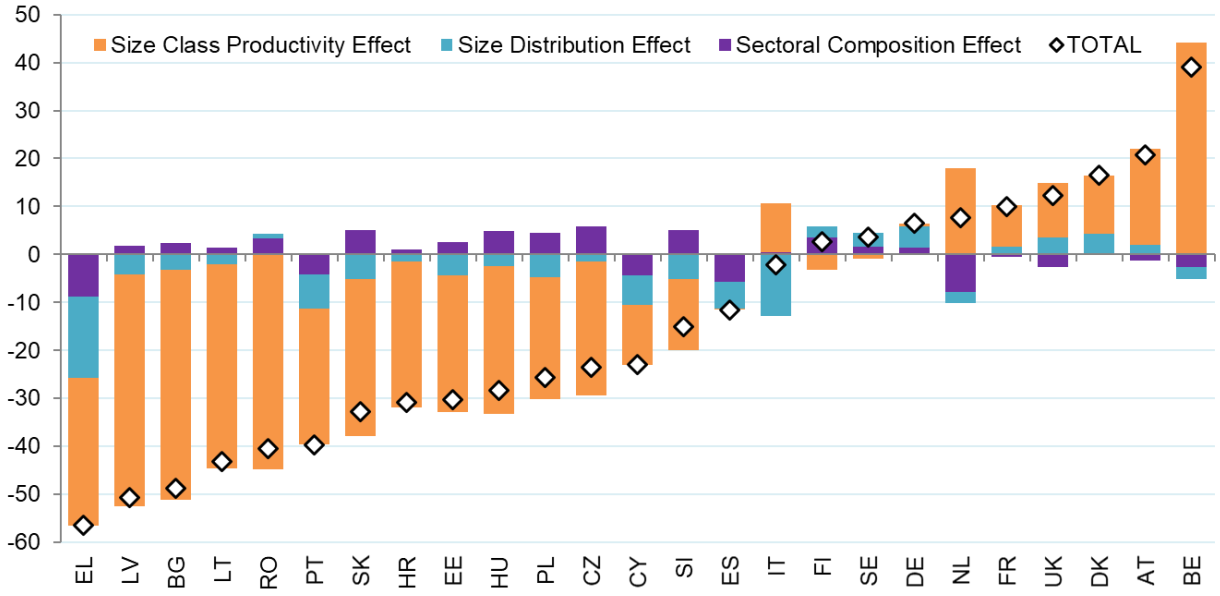
Accordingly, Figure 40 shows the decomposition of the difference in labour productivity between individual Member States and the EU28 into sectoral composition effects, size distribution effects and size class

[115] This effect would be even more exacerbated when considering relative prices of different service activities, which show heterogeneous income elasticities (Duarte and Restuccia, 2017).

[116] These NACE sections represented in 2016 around 60% of EU28 total value added and employment, excluding B (mining), D&E (utilities) and L (real estate) due to SBS data limitations and not having information for A (primary sector), K (financial activities) and O to Q (non-market services such as public administration, education and health).

productivity effects. Luxembourg and Malta are excluded due to insufficient data availability and Ireland because of comparability concerns[117].

Figure 40. Decomposition of the percentage difference in total labour productivity relative to the EU28 aggregate.



Note: NACE sections considered are C, F, G, H, I, J, M and N. Value added figures have been adjusted by GDP-based purchasing power parity. IE, LU and MT not included.

Source: Own calculation based on SBS data (2016 or latest).

In general terms, country differences in productivity levels for each firm size class play by large the most important role and mainly explain the divergence across Member States. The strongest negative deviation from the benchmark is found for those countries that joined the EU after 2004, as well as for Greece and Portugal, whereas on the contrary Belgium, Austria and the Netherlands show the most pronounced positive deviation. In turn, these 'pure' productivity effects would be negligible for the case of Spain, Sweden and Germany.

The sectoral composition effect – i.e. differences in sectoral employment shares – seems to be operating in the opposite direction, although with a much more limited impact. Eastern EU countries benefit from their specialization in manufacturing, which usually records productivity levels above the whole economy average; a similar situation is observed for ICT services in Finland. On the contrary, the sectoral distribution has a negative effect for productivity in Greece, the Netherlands and Spain, for which manufacturing employment shares are low and specialization falls on activities with lower productivity levels (trade, accommodation and food services or support service activities).

Finally, the size distribution effect only plays a limited role in explaining aggregate productivity differences. However, for a few countries, having a firm distribution tilted to less productive firms – in principle those with a smaller size – seem to be significantly detrimental for the whole economy. This is particularly the case of Greece, for which it accounts for almost a third of the productivity difference with respect to the EU benchmark, and Italy, where it more than offsets the positive contribution from the 'pure' productivity effects. It's also worth highlighting the case of Spain, in which the size distribution effects and the sectoral composition effects explain fifty-fifty the productivity gap.

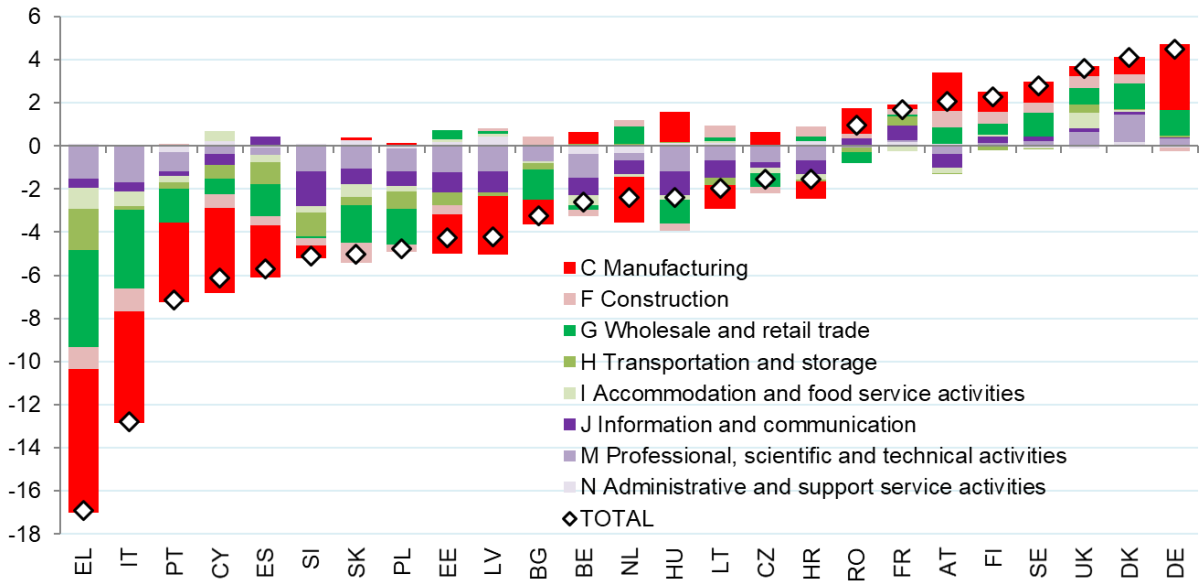
On a sectoral basis, contributions to size distribution effects are on average above their employment share in the case of manufacturing (C), ICT services (J) and professional activities (M), whereas the opposite happens for support service activities (N), accommodation and food services (I) and sections related to logistics (G&H).

[117] The Irish Central Statistics Office (CSO) changed in 2016 the accounting rules for intellectual property and that had a significant impact on value added figures starting in 2015.

This would be a first hint on the economic activities where firm size plays a larger role defining productivity and confirm findings in recent studies[118].

Sectoral contributions seem to move in the same direction within most countries, particularly for those with larger overall contributions (Figure 41). Nevertheless, there are some noticeable exceptions, such as those observed for Member States involved in central European value chains; e.g. Austria, Czech Republic and Hungary show positive size distribution effects in the manufacturing sector but negative in business services (J, M and N NACE sections).

Figure 41. Sectoral decomposition of the percentage difference in total labour productivity relative to the EU28 aggregate due to size distribution effects.



Note: NACE sections considered are C, F, G, H, I, J, M and N,. Value added figures have been adjusted by GDP-based purchasing power parity. IE, LU and MT not included.

Source: Own calculation based on SBS data (2016 or latest).

Recent dynamics

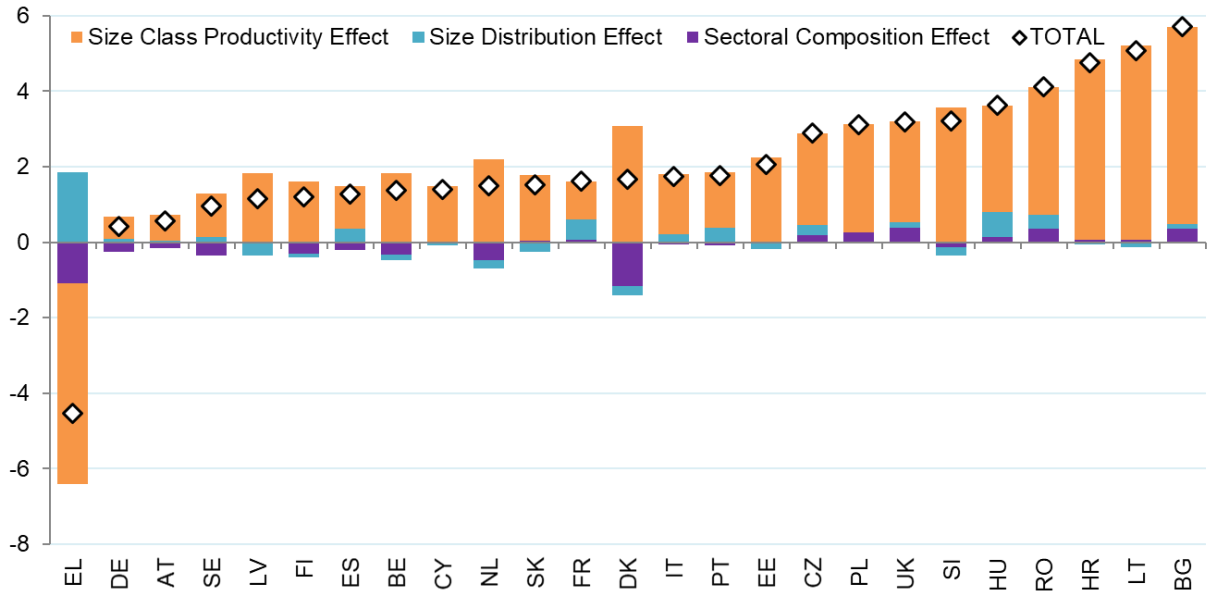
Analogously to the decomposition with respect to the EU benchmark, in this subsection we present the overall picture for recent dynamics at country level. Data limitations commented beforehand hold – and are even exacerbated – for time series analysis, so we keep the degree of disaggregation at NACE section level.

Labour productivity increased in recent years (2012-2017) across all countries, most notably in those Member States with lower levels compared with the EU benchmark (Figure 42). These developments show a convergence process that was mainly driven by the increase of productivity levels across firm size classes, supported also in some cases – and to a much lower extent – by a sectoral shift to economic activities with higher productivity levels (e.g. in Bulgaria and Romania). Greece was the only exception by recording a significant decline in labour productivity over the sample period.

Overall, changes in the firm size distribution played a limited role shaping productivity growth, although they had a positive contribution in those countries previously identified for which size distribution has a detrimental effect, namely Greece, Spain, Portugal and Italy. In policy terms, it might be worth investigating whether such a declining share of employment in smaller firms is associated with the aftermath of the crises (i.e. being less resilient than bigger firms) or/and the result of structural reforms supporting a higher size of enterprises.

[118] For instance, Berlingieri et al. (2018) shows that "in contrast to manufacturing, the size premium is much weaker in the service sector".

Figure 42. Decomposition of the percentage change in total labour productivity, annual average between 2012 and 2017.



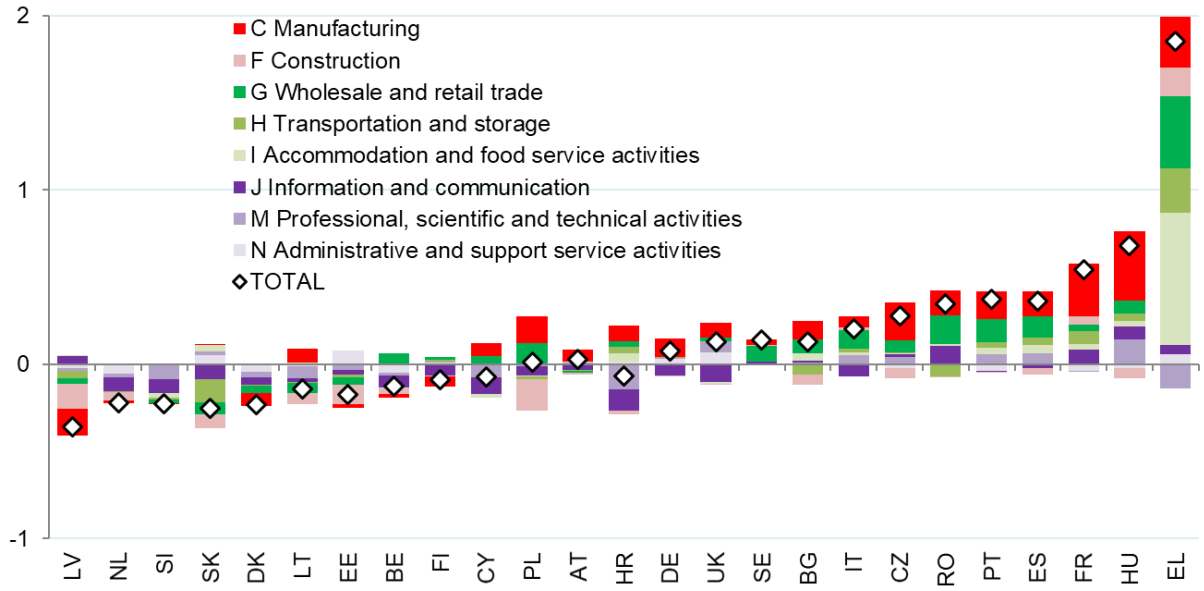
Note: NACE sections considered are C, F, G, H, I, J, M and N. Value added figures have been adjusted by GDP-based purchasing power parity. IE, LU and MT not included. 2012-2016 change for DK, FI, IT, HR, UK.

Source: Own calculation based on SBS data.

Figure 43 decomposes the size distribution effect in Figure 42 by sector. On average, this factor had a positive contribution to productivity growth in manufacturing (C), retail trade (G) and accommodation and food services (I), while negative for construction (F) and ICT services (J), showing then different sectoral patterns following the crises.

On a country basis, within those recording a significant shift of employment towards larger firms, developments were particularly driven by accommodation and food services in Greece, while in other countries, manufacturing (e.g. in Hungary) and trade (e.g. in Portugal and Spain) played a relatively more important role.

Figure 43. Sectoral decomposition of the percentage change in total labour productivity due to size distribution effects, annual average between 2012 and 2017.



Note: NACE sections considered are C, F, G, H, I, J, M and N,. Value added figures have been adjusted by GDP-based purchasing power parity. IE, LU and MT not included. 2012-2016 change for DK, FI, IT, HR, UK.

Source: Own calculation based on SBS data.

7.2.4 A more granular approach show a strong country component

The overall picture presented in the previous section provides a useful starting point for analysis, although heterogeneity at a more disaggregated sectoral level is expected and calls for caution when extracting policy insights. Accordingly, and despite the limited data coverage, we present in this section results for the decomposition analysis of sectoral productivity relative to the EU benchmark at NACE division level (2 digits) and also at group level (3 digits) for service activities in subsection 4.1.

Table 17 shows the percentage difference in labour productivity relative to the EU28 by sections and divisions for which there is disaggregated information by size class.

The first thing to be noted is that the colour scale (red for productivity below the benchmark, green for above) helps to identify a very strong country component, meaning that for most economic activities productivity departs from the benchmark in the same direction and with a similar degree of intensity. This would suggest an important role for overall institutional factors, such as educational attainment or the technological absorption capacity.

Among those Member States with a more extensive coverage, this would be the negative case of Bulgaria and Romania, as well as the positive one for Belgium and Austria. The picture is less conclusive for countries that on average show productivity levels around the EU28 aggregate. For instance, among the largest Member States, Germany, Italy and Spain present a positive productivity difference for most manufacturing divisions, whereas the opposite happens for construction and a number of service activities.

The latter relates to a second interesting feature, which should be taken with caution due to data limitations and is in any case beyond the scope of analysis of this chapter. According to the mean absolute deviation for NACE sections, the dispersion of productivity levels across countries seems to be larger for industrial activities and construction. One possible explanation could be their higher capital intensity and hence a more significant impact of existing obstacles for economies of scale (such as financial frictions). On the other hand, among services, professional activities show higher productivity dispersion, which in this case could be potentially related to regulation heterogeneity.

Table 17. Percentage difference in labour productivity relative to the EU28 aggregate by NACE section and division.

NACE Group	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IT	LT	LV	NL	PL	PT	RO	SE	SI	SK	UK
B Mining and quarrying	34%		-46%		-43%	-18%			11%	-24%	-7%	-24%	-44%		26%	-47%			-17%	-42%		46%			111%
B05 Mining of coal and lignite									68%			90%		-38%											
B06 Extraction of crude petroleum and natural gas						-55%																			
B07 Mining of metal ores																									
B08 Other mining and quarrying					-7%	13%	69%					17%		-21%					-20%			21%			65%
B09 Mining support service activities		-31%						-90%		7%									-23%		-47%				-16%
C Manufacturing	27%	63%	57%	-42%	-29%	17%	32%	-43%	-35%	0%	5%	7%	-44%	-21%	0%	-49%	-58%	40%	-29%	42%	-55%	10%	-24%	-36%	6%
C10 Manufacture of food products	13%	56%	-53%	-28%	-30%	-11%	25%	-31%	-37%	12%	3%	6%	-39%	-29%	19%	-37%	-52%	72%	-14%	-36%	-67%	1%	-22%	-45%	34%
C11 Manufacture of beverages	88%	68%	-54%		-10%	-11%			-24%	5%	1%	45%	-26%	-49%	20%	-32%	-56%		19%	-25%	-23%	13%		-43%	
C12 Manufacture of tobacco products			-77%						-9%																
C13 Manufacture of textiles	48%	48%	-45%	-45%	-18%	30%		-32%		5%	4%	16%	-39%	-62%	33%	-41%		64%	-28%	-26%	-43%	23%	25%		13%
C14 Manufacture of wearing apparel			-43%	-28%	-28%	135%	173%	-19%	-29%	41%	59%	72%	-22%	-39%	85%	-28%	-52%		-25%	-18%	-33%		-2%	-33%	93%
C15 Manufacture of leather and related products	68%	5%	-65%		-29%	30%		-38%	-46%	-7%		114%	-60%	-28%	56%	-60%			-28%	-37%	-56%			-33%	43%
C16 Manufacture of wood and of products of wood and cork, except furniture; manufa	85%	85%	-56%	-33%	-28%	36%	40%	9%	-65%	8%	32%	30%	-37%	-39%	5%	-39%	-12%		-19%	-10%	-40%	39%		-9%	29%
C17 Manufacture of paper and paper products		26%	-57%	-50%	-24%	-2%	-6%		-29%	13%	66%	-15%		-31%	7%	-35%	-55%	14%	-4%	42%	-48%	21%	-31%	2%	0%
C18 Printing and reproduction of recorded media	57%	30%	-36%	-28%	-27%	8%	10%			-7%	0%	4%	-25%	-42%	10%			22%	-11%	-22%		8%		-40%	9%
C19 Manufacture of coke and refined petroleum products		78%							169%						-25%				35%						94%
C20 Manufacture of chemicals and chemical products	57%	48%	-48%	-59%	-46%	0%	16%		-41%	-8%	-1%	-7%	-65%	26%	-5%	-9%		64%	-31%	-27%	-67%	-15%	-43%	-54%	-13%
C21 Manufacture of basic pharmaceutical products and pharmaceutical preparations	-32%	91%	-76%		-69%	-14%	17%		-57%	23%		29%	-41%	-33%	-14%					-52%	-59%	49%			-42%
C22 Manufacture of rubber and plastic products	26%	64%	-51%	-33%	-4%	11%	22%		-12%	24%	16%	11%	-44%	-10%	25%		-52%	46%	-15%	12%	-21%	-3%	-12%	1%	4%
C23 Manufacture of other non-metallic mineral products	28%	47%	26%		-17%	17%	31%		-29%	15%	10%	10%	-16%	-10%	6%	-44%	-25%	37%	-10%	-29%	-27%	10%	-10%	-23%	19%
C24 Manufacture of basic metals	43%	59%	5%		-32%	3%	-12%		-29%	26%	14%	-3%	-58%	-11%	8%			42%	-6%	-9%	-46%	5%	-8%	-13%	-14%
C25 Manufacture of fabricated metal products, except machinery and equipment	49%	37%	-39%		-27%	17%	9%	-28%	-29%	3%	-5%	15%	-26%	-35%	12%	-41%		41%	-20%	-32%	-53%	7%	-13%	-40%	7%
C26 Manufacture of computer, electronic and optical products	33%	57%	-40%		-35%	20%	35%	-52%		-16%	7%	15%	-20%	-15%	-6%		29%	88%	-43%	-37%	-53%	9%	-26%	-31%	9%
C27 Manufacture of electrical equipment	41%	29%	-49%		-34%	21%	23%	-33%	-39%	9%	12%	6%	-31%	-36%	11%	-50%	-47%	56%	-24%	-30%	-42%	5%	-22%	-44%	3%
C28 Manufacture of machinery and equipment n.e.c.	16%	44%	-58%		-42%	7%	1%			-9%	-13%	-3%	-48%	-22%	8%	-51%	-63%	38%	-43%	-35%	-44%	0%	-27%	-41%	1%
C29 Manufacture of motor vehicles, trailers and semi-trailers	13%	-17%	-73%	-61%	-14%	39%	-29%	-49%		-8%	-42%	-9%		-5%	-12%	-60%		6%	-28%	-50%	-53%	-9%	-34%	-27%	12%
C30 Manufacture of other transport equipment		45%	-67%		-40%	16%	-24%	-48%	-63%	-2%	-30%	27%	-83%	-41%	-1%			-23%	-35%	-50%	-61%	-14%	-50%		-10%
C31 Manufacture of furniture	44%	48%	-53%	-20%	-18%	48%	85%	-18%	-54%	-3%	-17%	27%	-31%	-39%	40%	-28%	-50%	37%	-15%	-33%	-47%	41%		-20%	19%
C32 Other manufacturing	12%	28%	-27%	-54%	-41%	5%		-48%	-75%	29%	-27%	13%	-56%	-40%	-15%	-58%			-45%	-49%	-58%	17%	-20%	-54%	14%
C33 Repair and installation of machinery and equipment	38%	46%	-45%	-19%	-19%	21%	16%	29%	-53%	-3%	-1%	22%	-30%	-35%	-6%	-36%		15%	-26%	-20%	-51%	-9%	-16%	-39%	27%
D Electricity, gas, steam and air conditioning supply	-3%	61%	-37%	-12%	24%		61%	2%	-10%	195%	18%	-20%	-30%	-19%	55%		-41%		-8%	140%	-52%	1%	-38%	-1%	8%
E Water supply; sewerage, waste management and remediation activities	26%		-65%	33%	-44%		109%		-18%	-7%	44%	-16%	-48%	-57%	7%	-50%		39%	-23%	-16%	-62%	-10%		-56%	55%
E36 Water collection, treatment and supply			-74%	12%	-42%					6%	104%	-14%	-46%	-67%	59%	-51%			-30%	-17%	-67%				
E37 Sewerage		200%		99%			177%			53%		-32%	-48%		-44%	-75%	-73%		-43%	-36%		-42%		-81%	
E38 Waste collection, treatment and disposal activities; materials recovery	35%	62%	-53%		-41%				-42%	-1%	17%	-9%	-48%	-43%	11%	-46%		66%	-20%	-27%	-57%		-26%		11%
E39 Remediation activities and other waste management services								-53%		-15%		-15%	-33%	-52%	-23%				-38%	-79%		-76%		-30%	
F Construction	24%	13%	-52%	-23%	-41%	-1%	16%	-29%	-60%	-12%	5%	9%	-35%	-51%	-13%	-49%	-60%	31%	-37%	-49%	-47%	3%	-40%	-55%	61%
F41 Construction of buildings	42%	14%	-60%	-9%	-50%	32%	31%		-80%	-24%	-11%	49%	-48%		-22%	-55%	-67%	25%	-39%	-62%	-48%	-7%		-57%	97%
F42 Civil engineering	35%	26%	-52%	-26%	-16%	8%	33%	-25%	11%	25%	13%	-3%	-21%	-48%	32%	-41%	-51%	33%	-32%	-37%	-62%	5%	-32%		39%
F43 Specialised construction activities	18%	12%	-52%	-30%	-37%	-4%	15%		-77%	-13%	12%	10%	-42%		-13%	-52%	-53%	31%	-42%	-44%	-43%	9%	-28%		40%
G Wholesale and retail trade; repair of motor vehicles and motorcycles	23%	56%	-46%	-26%	-20%	13%	11%	-19%	-56%	-8%	5%	16%	-23%	-31%	-1%	-37%	-42%	17%	-25%	-32%	-23%	16%	4%	-34%	2%
G45 Wholesale and retail trade and repair of motor vehicles and motorcycles	26%	66%	-55%	-46%	-28%	10%	9%	-20%	-72%	-14%	-3%	1%	-32%	-46%	-13%		-58%	9%	-38%	-42%	-35%	8%		-34%	29%
G46 Wholesale trade, except of motor vehicles and motorcycles	22%	55%	-36%	-37%	-30%	22%	22%		-45%	-16%	0%	9%	-32%	-27%	-5%	-32%	-37%	38%	-26%	-35%	-30%	3%		-47%	-1%
G47 Retail trade, except of motor vehicles and motorcycles	22%	37%	-54%	-5%	-14%	5%	-14%		-64%	0%	15%	29%	-10%	-32%	5%	-39%	-40%	-15%	-22%	2%	-14%	22%	29%	-19%	9%
H Transportation and storage	34%	42%	-45%	-2%	-27%	-14%	28%	-19%	-24%	19%	-7%	15%	-21%	-28%	12%	-37%	-39%	35%	-33%	6%	-45%	-13%	5%	-24%	16%
H49 Land transport and transport via pipelines	32%	36%	-40%		-16%	-3%	28%		-63%	8%	4%	7%	-11%	-38%	25%	-31%	-44%	31%	-28%	-24%	-39%	-3%	-1%	0%	28%
H50 Water transport		343%			-70%	27%			-24%	0%	-36%	197%			-21%					-26%		-56%			78%
H51 Air transport		11%		-39%		-51%	-5%			-4%					-7%	-55%				4%		-24%			-12%
H52 Warehousing and support activities for transportation	-76%	41%	-36%	-2%	-22%	-19%	-36%	-1%	-4%	40%	-19%	38%	-27%	-27%	-2%	-28%	-36%	47%	-31%	64%	-41%	-16%		-43%	-4%
H53 Postal and courier activities		61%	-55%	-20%		-20%	-34%			-12%		15%			14%					28%	-46%	-4%			26%
I Accommodation and food service activities	28%	23%	-46%	33%	-28%	-18%	-11%	-24%	-67%	2%	18%	49%	28%	-40%	3%	-44%	-49%	-5%	-15%	-17%	-31%	15%	6%	-46%	1%
I55 Accommodation	16%		-33%	14%	-16%	-22%	2%	-29%	-28%	38%	7%	25%		-18%	26%	-30%	-46%	-2%	-9%	-10%	-34%	-4%	2%		-8%
I56 Food and beverage service activities	19%	30%	-59%	22%	-33%	-17%	-11%	-25%	-93%	-10%	29%	64%		-48%	-3%	-47%	-49%	-2%	-25%	-22%	-32%	23%	2%	-48%	7%
J Information and communication	-6%	20%	-41%	5%	-17%	2%	-16%	-40%	-42%	-9%	-11%	-1%	-27%	-38%	-1%	-46%	-55%	0%	-26%	-20%	-34%	-21%	-34%	-31%	12%
J58 Publishing activities	-12%	5%	-70%	-18%	-18%	-17%	-27%		-73%	-30%	-28%	-2%	-56%	-41%	1%	-66%		1%	-36%	-36%	-41%	-23%			11%
J59 Motion picture, video and television programme production, sound recording and			-57%		-42%	-7%			-78%	-18%	-46%	3%	-28%	-74%	17%				5%		-52%				25%
J60 Programming and broadcasting activities			-56%	-75%		46%			-55%	-36%		5%	-63%	-55%	3%			-21%	9%	-12%	-44%		-84%		42%
J61 Telecommunications	7%	26%	-56%		-7%	29%	-17%		-34%	34%	-14%	-8%	-14%	-11%	26%	-37%	-46%	25%	-16%	15%	-47%	-16%			-10%
J62 Computer programming, consultancy and related activities	-2%	10%	-27%		-22%	7%	0%	-30%	-52%	-22%	0%	-4%	-38%	-39%	-5%	-45%	-51%	3%	-36%	-40%	-25%	-10%		-31%	10%
J63 Information service activities	7%	48%	-43%	-40%	6%	3%	-10%	-34%	-68%	-20%		-2%	-36%	-49%	-34%				-28%	-32%	-51%		-42%	-31%	130%
L Real estate activities	79%			-54%	-13%	51%	51%	-4%		-35%	55%	13%	-27%	-53%	-37%			112%	-53%		-40%	66%			-27%
M Professional, scientific and technical activities	7%	28%	-48%	-15%	-36%	2%	24%	-41%	-75%	-19%	-14%	13%	-40%	-50%	-16%	-54%	-63%	1%	-41%	-50%	-42%	-1%	-34%	-42%	18%
M69 Legal and accounting activities	10%	25%	-62%	-6%	-39%	-2%	21%	-47%	-76%	26%	-7%	34%		-49%	-14%	-53%	-65%	9%	-47%	-55%	-43%	9%	-35%	-45%	28%
M70 Activities of head offices; management consultancy activities	27%	35%	-41%	-13%	-12%	-8%	2%	-22%	-66%	18%	-19%	11%		-52%	7%	-40%		9%	-30%	-41%	-38%	0%		-38%	-14%
M71 Architectural and engineering activities; technical testing and analysis	6%	8%		-43%	-36%	11%	28%	-38%	-82%	-16%	-6%	9%	-28%	-50%	-23%		-59%	6%	-49%	-51%	-45%	-1%			19%
M72 Scientific research and development	3%	50%	-10%		-27%	-14%	134%		-74%	-29%		-23%	-30%	-38%		-54%	-61%	-25%		-57%	-44%	43%	-30%	-50%	44%
M73 Advertising and market research	-27%	-4%	-44%			-22%		-47%	-56%	-26%	-28%	7%	-26%	-42%	-15%	-49%	-57%	-16%	-13%	-37%	-35%			-35%	96%
M74 Other professional, scientific and technical activities	-27%	-30%	-31%	-39%	-41%	62%	-2%		-78%	-13%	-24%		-53%	-64%	-14%	-67%		-28%	-49%	-53%					28%
M75 Veterinary activities	-11%		-71%	-33%	-35%	-6%	10%	-38%	-92%	-47%	52%	56%	-17%	-57%		-76%	-77%	21%		-44%			11%	-68%	15%
N Administrative and support service activities	35%	26%	-55%	-24%	-35%	-14%	13%	-27%	-50%	-22%	-13%	-2%	-35%	-36%	-9%	-34%	-53%	-24%	-26%	-55%	-47%	-11%	-33%	-38%	37%
N77 Rental and leasing activities	84%	57%	-63%	-73%		-1%	-4%	-45%		40%	-33%	-21%	-67%	-20%	-9%	-55%	-75%	-9%	-49%	-39%	-34%	-32%	-68%	-61%	-5%
N78 Employment activities	38%	28%	-39%		-43%	-12%	1%	-20%	-40%	-9%	-14%	15%	-39%	-36%	12%	-29%		-46%	-19%	-46%	-33%	-12%	-12%	-41%	92%
N79 Travel agency, tour operator reservation service and related activities	-28%	-14%	-64%	-36%		-1%	-22%		-59%	-20%	-39%	-25%	-42%		-41%	-60%	-67%	68%	-52%	-48%	-66%	-19%	-44%	-43%	138%
N80 Security and investigation activities	2%	80%	-61%			2%			-48%	22%	22%	23%	-37%	-36%	27%	-40%	-56%	44%	-12%	-24%	-57%	68%	-8%	-33%	31%
N81 Services to buildings and landscape activities	29%	14%	-56%		-5%	-16%	27%	-37%	-50%	-13%	28%	3%	-27%	-42%	-7%	-25%	-56%	10%	-21%	-55%	-41%	28%	-20%	-25%	18%
N82 Office administrative, office support and other business support activities	19%	34%	-36%	-41%	-25%	-5%	15%	-31%	-36%	-35%	1%	13%		-42%	-11%	-38%		5%	-23%	-69%	-37%	-48%	-41%	-44%	52%
S95 Repair of computers and personal and household goods	35%	27%		-41%	-4%	21%	42%	-42%		-10%	15%	12%	27%	-42%	-15%		-72%		-36%	-45%		34%			50%

Scale (%): <-25% -15% -5% 5% 15% >+25%

Note: Value added figures have been adjusted by GDP-based purchasing power parity.

Source: Own calculation based on SBS data (2016 or latest).

Now, in Table 18 we turn our attention to the contribution of the size distribution effect in explaining differences in sectoral productivity levels relative to the EU benchmark. In general terms, we observe that this effect is rather moderate, with a majority of sections and divisions within the range between -5 and +5 percentage points.

However, the role of firm size distributions turns out to be important for a number of Member States, as already seen in the previous section. This would be the case of Greece, Italy and, to a lesser extent, Portugal and Spain, which show firm distributions tilted to size classes with lower productivity levels, whereas the opposite happens for instance in Austria, Germany or Denmark. In general, this seems to be more of a country feature, rather than driven by some specific industry, suggesting again the relevance of institutional factors (explored in the last section).

Table 18. Percentage points contribution of the size distribution effect on the difference in labour productivity relative to the EU28 aggregate by NACE section and division.

NACE Group	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IT	LT	LV	NL	PL	PT	RO	SE	SI	SK	UK
B Mining and quarrying	-35.8		2.0		1.2	-1.0			1.0	-13.1	-5.3	-7.0	-1.7		-4.8	-12.5			5.3	-25.8		3.8			-5.2
B05 Mining of coal and lignite									11.9			9.1		-21.7											
B06 Extraction of crude petroleum and natural gas						-21.3																			
B07 Mining of metal ores																									
B08 Other mining and quarrying					7.3	1.4	-2.1					0.0		-10.2					4.4			-10.7			20.2
B09 Mining support service activities		135.6						107.0		15.8									-0.2		-4.2				34.3
C Manufacturing	5.9	2.1	-3.3	-16.9	1.6	9.6	3.0	-5.6	-28.2	-9.6	3.1	0.9	-2.4	4.1	-16.2	-3.7	-9.6	-9.3	0.4	-12.5	3.3	3.5	-1.5	0.3	1.9
C10 Manufacture of food products	-3.1	-3.1	-10.1	-4.6	1.6	4.3	10.6	0.8	-16.5	-3.2	6.1	-7.5	3.3	0.1	-28.1	7.8	-0.1	0.3	6.8	-11.6	-0.7	4.1	-3.9	-3.4	15.7
C11 Manufacture of beverages	-3.3	9.4	-3.2		-8.5	-0.5			-13.1	-18.9	11.0	-5.5	2.4	-22.3	-17.0	-2.2	-1.0		7.5	-17.0	5.3	14.8		-12.5	
C12 Manufacture of tobacco products			-2.7						-4.0																
C13 Manufacture of textiles	3.3	5.6	6.2	-25.7	8.0	6.8		5.2		-9.5	-9.1	-6.3	-0.7	-0.4	-11.0	5.6		-5.9	0.4	2.4	5.9	-2.5	-0.8		0.5
C14 Manufacture of wearing apparel			4.3	-24.3	-11.0	17.2	4.8	0.7	-25.7	-10.2	0.0	-2.0	11.0	2.3	-21.0	3.8	-4.1		-8.1	-2.9	4.5		-3.3	-0.9	1.0
C15 Manufacture of leather and related products	4.9	-19.2	0.5		-0.3	2.3		-16.5	-26.8	-11.0		30.8	12.2	18.6	-22.7	-20.2			-0.7	-2.6	5.0			22.8	-0.8
C16 Manufacture of wood and of products of wood and cork, except furniture; manufa	18.9	4.6	-4.4	-29.1	-13.4	6.5	12.9	14.0	-30.5	-12.6	18.5	-1.7	5.7	-5.7	-27.2	2.6	10.8		6.2	-2.4	6.6	10.7		-21.2	-2.8
C17 Manufacture of paper and paper products		4.5	-11.4	-31.8	-5.1	7.1	1.2		-14.7	-10.9	22.8	-1.4		1.9	-12.6	-1.7	-34.1	-4.8	-6.0	-10.0	-9.0	17.7	2.9	7.2	0.1
C18 Printing and reproduction of recorded media	10.7	-6.3	3.4	-16.8	0.4	4.4	-0.3			-11.9	4.5	-5.3	3.4	1.0	-8.5			-0.9	3.8	-5.9		1.0		-1.4	1.4
C19 Manufacture of coke and refined petroleum products		1.6							14.5						-17.1				-1.1						-16.9
C20 Manufacture of chemicals and chemical products	2.8	0.9	-10.7	-38.0	-1.3	7.5	0.3		-11.2	-11.8	0.3	2.4	-3.8	-5.4	-9.0	0.6		1.5	0.4	-21.8	-2.0	-1.8	0.4	-1.5	-4.2
C21 Manufacture of basic pharmaceutical products and pharmaceutical preparations	1.4	8.7	-0.3		-1.3	1.9	5.0		-3.2	-3.5		1.1	3.5	2.5	-1.7					-10.0	-4.2	-0.5			-1.8
C22 Manufacture of rubber and plastic products	3.0	-0.4	-3.0	-17.3	5.1	4.2	-2.4		-9.7	-4.5	-6.0	1.0	-6.9	2.7	-9.3		-21.1	-4.9	0.9	-11.9	0.0	-5.1	-4.2	6.5	-1.0
C23 Manufacture of other non-metallic mineral products	4.6	4.1	-2.6		5.8	3.0	7.8		-27.6	-9.3	4.2	4.1	-11.0	2.6	-15.6	-4.9	-2.0	0.2	3.8	-7.3	0.8	7.8	0.9	-2.1	4.4
C24 Manufacture of basic metals	7.5	2.6	-2.3		2.1	1.9	-2.9		-5.1	-3.4	8.0	0.1	-4.9	1.8	-4.6			-1.5	-0.9	-18.2	1.0	2.4	0.2	3.4	-1.0
C25 Manufacture of fabricated metal products, except machinery and equipment	11.1	-1.4	7.8		-0.1	5.6	1.0	-0.7	-22.0	-7.8	-1.7	1.4	2.2	-2.0	-9.1	0.1		-3.8	2.3	-6.2	3.9	-6.0	-1.1	-10.2	-0.6
C26 Manufacture of computer, electronic and optical products	1.5	1.1	-0.2		0.6	2.3	-0.9	2.4		-8.7	1.4	3.1	-4.0	7.8	-4.0		0.7	-11.4	-0.3	1.2	2.1	-3.8	-2.7	-2.5	-8.0
C27 Manufacture of electrical equipment	5.9	-1.6	-0.2		-1.4	4.2	-9.3	-0.9	-16.3	-1.4	-1.8	1.0	-6.7	2.1	-9.7	-0.6	-0.7	-11.7	1.6	-1.2	1.5	-1.9	3.6	0.8	-3.3
C28 Manufacture of machinery and equipment n.e.c.	2.8	-1.5	-0.1		0.2	5.2	0.3			-9.1	2.0	-1.1	-3.8	3.2	-7.6	-3.5	-5.0	-12.4	-1.7	-5.0	2.3	1.6	-4.3	2.7	-1.8
C29 Manufacture of motor vehicles, trailers and semi-trailers	-3.0	-1.2	1.2	-48.1	1.7	4.6	-24.7	-9.4		-3.1	-8.2	-1.7		1.5	-3.5	-1.9		-15.7	-0.3	-3.8	-6.7	-0.6	-2.3	1.0	-9.5
C30 Manufacture of other transport equipment		1.6	-1.4		-1.0	3.1	-11.0	-45.5	-6.3	-1.9	-4.3	6.9	-3.6	-9.2	-4.5			-8.6	-3.0	-16.8	-1.7	-0.6	-46.8		1.8
C31 Manufacture of furniture	-7.2	-9.0	-0.7	-19.3	-3.2	3.0	6.5	2.4	-26.1	-14.2	-2.1	-4.0	1.9	-1.5	-12.0	8.1	-0.7	-14.0	5.6	-3.0	4.5	2.8		6.5	0.8
C32 Other manufacturing	3.6	-8.6	5.3	-41.2	6.0	5.5		-21.1	-43.8	-16.0	-23.3	-6.9	-32.5	13.4	-13.1	2.5			-3.9	-6.1	-2.0	0.4	5.9	-7.4	0.5
C33 Repair and installation of machinery and equipment	9.0	7.1	1.3	-5.9	0.2	7.8	-2.5	-1.2	-8.9	0.5	4.1	0.9	1.1	-5.5	-16.3	3.9		1.9	-2.7	-3.2	3.0	-2.0	0.2	-2.0	5.0
D Electricity, gas, steam and air conditioning supply	2.7	-19.2	-1.8	-3.4	-0.9		17.0	-2.9	-8.5	0.0	1.2	-1.3	0.0	-4.5	2.4		-0.5		0.1	10.1	-3.8	-7.7	3.0	-5.0	-0.1
E Water supply; sewerage, waste management and remediation activities	0.0		1.7	-1.7	-1.5		17.5		-16.1	1.5	-9.8	1.1	-4.7	0.8	-0.3	-5.5		0.4	-6.5	0.5	1.9	-1.0		1.0	9.2
E36 Water collection, treatment and supply			2.4	-9.7	0.6					-1.8	24.0	4.5	-6.6	3.3	0.8	-8.7			-9.0	-2.8	3.6				
E37 Sewerage		-45.9		-4.6			7.3			-24.9		3.1	-27.2		-5.1	-31.6	-35.2		-5.0	-24.2		-29.0		-31.0	
E38 Waste collection, treatment and disposal activities; materials recovery	0.0	2.7	0.1		-4.1				-11.6	1.2	-1.2	-0.7	0.9	-2.2	-0.1	-1.1		-3.4	-3.1	-0.2	0.0		1.1		0.5
E39 Remediation activities and other waste management services								-25.2		2.4		6.8	6.6	1.0	-7.9				0.9	-29.5		-3.9		-8.7	
F Construction	8.7	-3.2	4.9	-9.9	-3.3	-1.8	4.9	-4.5	-14.8	-4.9	5.4	2.8	5.1	-4.6	-12.6	5.9	1.4	3.8	-4.0	0.9	2.7	4.8	-4.2	-10.9	7.7
F41 Construction of buildings	12.5	-0.6	-4.5	-14.3	-3.8	-2.4	8.5		-7.5	-16.0	2.9	18.8	0.5		-12.9	1.0	-2.9	-2.4	-3.1	-5.1	-4.0	13.9		-9.9	23.8
F42 Civil engineering	0.7	-3.3	-0.8	-11.5	1.6	-3.1	-1.1	-3.4	-12.9	1.2	0.3	0.4	4.0	-2.2	-2.5	1.3	-3.0	2.3	-5.7	0.7	-0.2	2.0	-11.8		3.6
F43 Specialised construction activities	6.8	-2.7	3.3	-6.5	-8.3	0.1	6.0		-15.7	-0.1	8.4	1.5	-2.9		-10.5	4.8	-3.4	6.2	-7.7	1.2	5.3	5.0	-4.9		2.0
G Wholesale and retail trade; repair of motor vehicles and motorcycles	3.6	-0.9	-6.3	-3.2	-3.2	6.0	5.3	2.0	-19.1	-6.7	2.5	0.3	1.2	-5.5	-17.7	0.7	0.6	3.7	-7.5	-7.5	-2.4	5.5	-0.4	-8.5	3.6
G45 Wholesale and retail trade and repair of motor vehicles and motorcycles	7.3	-2.7	-8.8	-18.4	-4.4	6.6	5.0	-10.9	-32.3	-10.4	6.9	-0.4	-8.2	-8.4	-35.8		-17.8	-0.1	-19.2	-10.6	-2.3	6.0		-11.1	16.6
G46 Wholesale trade, except of motor vehicles and motorcycles	2.3	-1.6	-1.1	-4.3	-5.2	6.2	3.8		-17.8	-4.4	0.4	4.1	-4.3	-2.6	-18.0	-1.5	-3.5	2.8	-5.8	-11.3	-1.2	3.7		-10.5	2.3
G47 Retail trade, except of motor vehicles and motorcycles	4.1	-2.6	-16.1	-5.7	-2.1	3.7	4.7		-20.9	-7.4	4.7	-2.1	6.4	-9.4	-17.8	1.3	1.3	2.5	-7.9	-8.1	-7.8	5.1	8.9	-8.0	10.5
H Transportation and storage	-0.5	1.0	-3.7	-8.0	-0.1	0.9	0.5	-6.7	-22.6	-12.9	-2.2	4.9	-1.0	0.2	-1.7	-3.0	-1.5	1.2	-8.6	-3.8	-2.5	-0.4	-13.0	-4.9	4.7
H49 Land transport and transport via pipelines	1.3	4.8	-4.8		2.7	-0.7	1.1		-24.7	-16.9	-8.0	7.5	2.0	1.5	-4.6	2.5	1.4	5.2	-10.0	-3.4	-1.5	-0.5	-10.2	-4.8	10.8
H50 Water transport		113.4			-4.9	16.1			0.4	-2.4	-6.6	-8.3			-8.8					7.5		-8.0			-4.5
H51 Air transport		11.1		-2.5		-8.8	8.3			-2.7					9.6	21.3				-5.7		6.6			-1.6
H52 Warehousing and support activities for transportation	-0.5	0.4	1.6	-4.0	0.3	-1.7	-1.7	-6.7	-6.1	-4.4	0.0	1.1	-5.7	-0.2	-6.1	-8.3	-1.0	-2.0	-1.7	-1.6	0.4	-0.6		-2.8	1.3
H53 Postal and courier activities		-1.8	-0.2	-7.3		1.2	-1.0			-3.0		3.3			3.1					0.9	0.0	0.0			-0.1
I Accommodation and food service activities	-5.6	-13.7	-1.7	7.1	-7.8	-0.5	3.2	3.4	-14.0	-6.3	3.1	-6.6	-5.7	-6.2	-15.5	3.4	3.8	-3.3	-10.3	-6.7	-0.4	-2.1	-8.6	-19.4	15.5
I55 Accommodation	-5.5		2.0	2.2	-3.7	-2.7	-0.7	2.8	-7.3	6.8	4.8	-5.9		1.3	-15.8	-7.1	-0.7	2.7	-11.0	-5.0	-1.4	-0.1	2.8		4.8
I56 Food and beverage service activities	-7.2	-13.8	-5.6	-0.2	-7.4	-1.3	2.8	0.1	-15.4	-6.4	3.5	-4.2		-7.2	-10.7	4.3	4.4	-4.3	-8.9	-5.9	-1.6	-2.1	-13.1	-12.0	18.1
J Information and communication	-7.4	-8.7	0.3	-5.6	-3.3	0.7	0.8	-9.4	-5.8	5.0	2.7	6.9	-7.5	-12.2	-5.1	-10.2	-10.0	-7.0	-7.9	-3.1	3.8	1.9	-18.8	-8.1	1.4
J58 Publishing activities	-2.9	-1.1	-7.6	-16.0	-13.5	1.8	0.1		-11.3	-10.1	3.6	-1.6	-6.8	-13.3	-6.3	-27.1		1.8	-6.0	-14.5	-6.9	-1.6			4.4
J59 Motion picture, video and television programme production, sound recording and			-1.3		-13.4	-1.5			0.1	0.8	2.1	0.9	-15.3	-20.7	0.1				-24.1		-6.9				0.5
J60 Programming and broadcasting activities			-11.1	-46.8		-8.2			-6.0	0.0		8.2	-3.9	-25.6	-23.3	-38.2		5.5	4.3	-3.0	-0.5		-63.6		-0.5
J61 Telecommunications	2.3	-0.3	-1.8		-7.5	1.3	1.2		-4.4	-14.3	-3.3	2.9	-1.2	-2.7	1.5	-7.2	-15.9	1.6	-14.2	-0.1	-2.6	0.9			0.1
J62 Computer programming, consultancy and related activities	-8.3	-9.5	1.1		0.0	1.4	-1.4	-9.6	-9.8	7.9	4.0	6.1	-21.9	-6.6	1.5	-5.3	-9.6	-3.8	-8.0	-1.3	3.8	3.4		-2.9	-5.7
J63 Information service activities	9.8	-10.6	4.5	-17.3	17.3	9.6	-1.3	-27.2	-37.0	4.2		5.9	-3.2	-16.2	-24.7				4.0	13.1	5.5		-31.1	-19.3	49.0
L Real estate activities	0.9			-15.5	-1.3	-2.8	-0.2	-3.5		-13.0	0.1	4.1	-1.3	-0.2	-19.2			16.8	1.2		-0.6	-6.6			6.2
M Professional, scientific and technical activities	-3.5	-9.1	-7.9	-3.1	-6.9	3.0	11.3	-12.7	-12.7	-3.2	0.8	0.8	-6.5	-10.2	-15.7	-6.6	-11.3	-2.5	-10.3	-8.6	-0.4	2.0	-10.3	-9.5	4.7
M69 Legal and accounting activities	-3.6	-9.3	-13.6	9.0	-11.1	1.1	18.8	-16.8	-22.6	-10.4	3.5	-0.2		-10.6	-18.5	-3.5	-10.7	5.6	-7.9	-17.3	-10.1	6.3	-21.7	-6.3	13.3
M70 Activities of head offices; management consultancy activities	6.5	-8.3	3.9	7.5	-0.8	0.0	4.1	1.3	-2.6	2.5	-3.5	-0.8		-2.0	-1.5	-0.2		-13.1	-4.9	-0.5	0.5	2.7		-2.2	-12.8
M71 Architectural and engineering activities; technical testing and analysis	-7.1	-5.3		-26.9	-2.9	2.8	15.4	-12.9	-13.7	0.5	5.9	4.2	-6.8	-10.1	-25.7		-14.0	3.8	-12.5	-12.1	-0.4	5.5			4.6
M72 Scientific research and development	-13.5	2.3	-4.2		0.0	5.9	18.7		-10.9	-5.5		-4.9	-23.0	-6.0		-41.0	-45.4	0.7		-10.9	-2.3	-8.6	-31.6	-35.6	12.3
M73 Advertising and market research	-4.0	-12.3	-2.6			2.2		-12.5	-3.3	-2.2	-9.5	3.7	-2.1	-19.5	-1.5	-15.8	-17.8	-13.2	-15.0	-12.9	-1.0			-28.4	17.2
M74 Other professional, scientific and technical activities	-12.7	-18.9	6.0	-25.6	-14.1	18.9	15.2		10.9	12.6	-7.8		-11.9	-6.0	-8.7	-15.6		-4.2	-8.5	-12.5					1.3
M75 Veterinary activities	-8.7		-9.6	-10.5	-8.9	-2.0	1.9	-11.9	-20.4	-8.1	3.7	-5.7	6.6	-10.4		-16.9	-10.6	8.1		-8.2			2.4	-16.1	-3.8
N Administrative and support service activities	1.2	-3.6	0.3	3.9	-0.8	-0.7	2.4	2.6	1.5	-0.8	0.6	1.8	3.4	2.1	0.5	2.1	6.4	-3.0	-2.0	-3.0	-0.3	-0.7	1.2	4.1	-1.3
N77 Rental and leasing activities	6.8	-1.8	-17.7	-18.9		-3.4	-0.9	-14.4		-4.7	1.7	-3.2	-21.7	-14.0	-19.6	-23.7	-17.8	2.2	-10.9	-9.4	-14.6	-1.4	-26.8	-19.1	8.0
N78 Employment activities	-0.9	-5.8	1.2		-2.6	-2.7	0.4	2.6	-3.8	-3.5	0.9	3.8	-3.0	-3.5	-14.3	4.7		-1.7	-1.9	-6.8	0.8	1.5	-0.8	-1.2	-2.2
N79 Travel agency, tour operator reservation service and related activities	1.7	-0.5	-16.7	-9.5		1.0	-1.1		-2.7	-0.1	-7.5	-0.1	-12.4		-10.8	-16.2	-19.9	23.6	-14.5	-5.0	-2.2	3.3	-13.1	-32.4	0.5
N80 Security and investigation activities	0.7	0.2	-0.5			-1.3			-0.5	4.1	1.0	0.0	0.2	-5.1	-1.9	0.8	-1.9	0.2	-1.2	2.9	-2.1	-3.5	-0.9	-2.3	0.6
N81 Services to buildings and landscape activities	0.2	0.1	3.0		-0.5	-0.1	0.5	-0.1	-1.1	0.3	0.6	1.2	4.1	-1.0	0.0	0.1	0.9	1.2	-1.8	-2.5	1.2	0.9	0.6	-2.1	1.8
N82 Office administrative, office support and other business support activities	3.5	0.1	2.3	-8.5	1.5	1.0	1.0	2.1	-2.3	-0.5	3.9	1.1		-2.0	1.3	0.8		1.5	-3.4	-17.9	4.5	-8.7	-31.5	-4.4	-0.8
S95 Repair of computers and personal and household goods	-3.9	-7.1		-31.6	12.9	3.2	-2.7	-22.6		-4.0	-7.6	0.7	-9.8	-14.0	-20.9		-28.8		-8.1	-14.3		12.4			8.9

Scale (percentage points): <-25 | -15 | -5 | 5 | 15 | >+25

Note: Value added figures have been adjusted by GDP-based purchasing power parity.

Source: Own calculation based on SBS data (2016 or latest).

Service activities

In this subsection we provide a further disaggregation for the service NACE sections. As already mentioned, data coverage is very limited, particularly for small- and medium-size countries, as well as within transport (H) and ICT services (J); only the trade section (G) has an overall acceptable group representativeness.

Table 19 shows the percentage differences in labour productivity relative to the EU28 by NACE group, while Table 20 presents the contribution of the firm size distribution effect in explaining those differences. In addition, Box 3 contains an example on how the analysis works at the most granular level available.

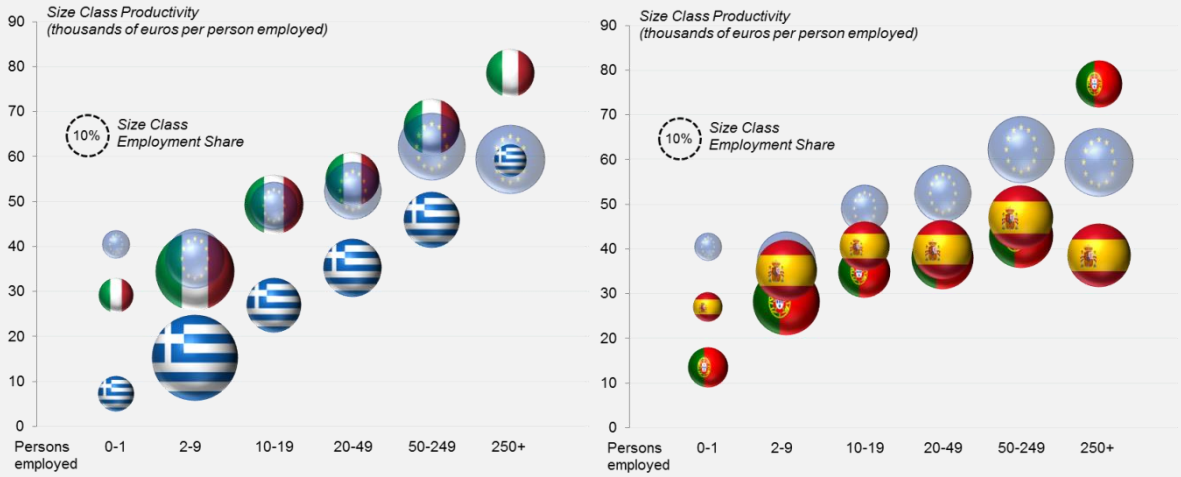
Box 3. An example for an individual NACE group

We have picked up one group that is sufficiently covered in the SBS dataset, narrowly defined in terms of business activity, and also non-negligible in terms of employment. Our choice has been 'G463 - Wholesale of food, beverages and tobacco', for which we focus on a few countries suggested throughout the report to have significant negative size distribution effects, namely Greece, Italy, Portugal and Spain.

Figure 44 shows the labour productivity and employment share by size class for these four countries compared with the EU28 aggregate.

First, we confirm a positive correlation of size and productivity, particularly strong and progressive for Greece and Italy. Second, size class productivity is lower than the EU benchmark except for the case of Italy and larger firms in Greece and Portugal. And third, firm size distributions are tilted towards smaller firms in all cases, particularly in Greece and Italy, where up to 60 % of the employment in this group corresponds to firms with less than 20 persons employed, compared with a third for the EU28 aggregate.

Figure 44. Labour productivity and employment share by size class for group 'G463 - Wholesale of food, beverages and tobacco'.

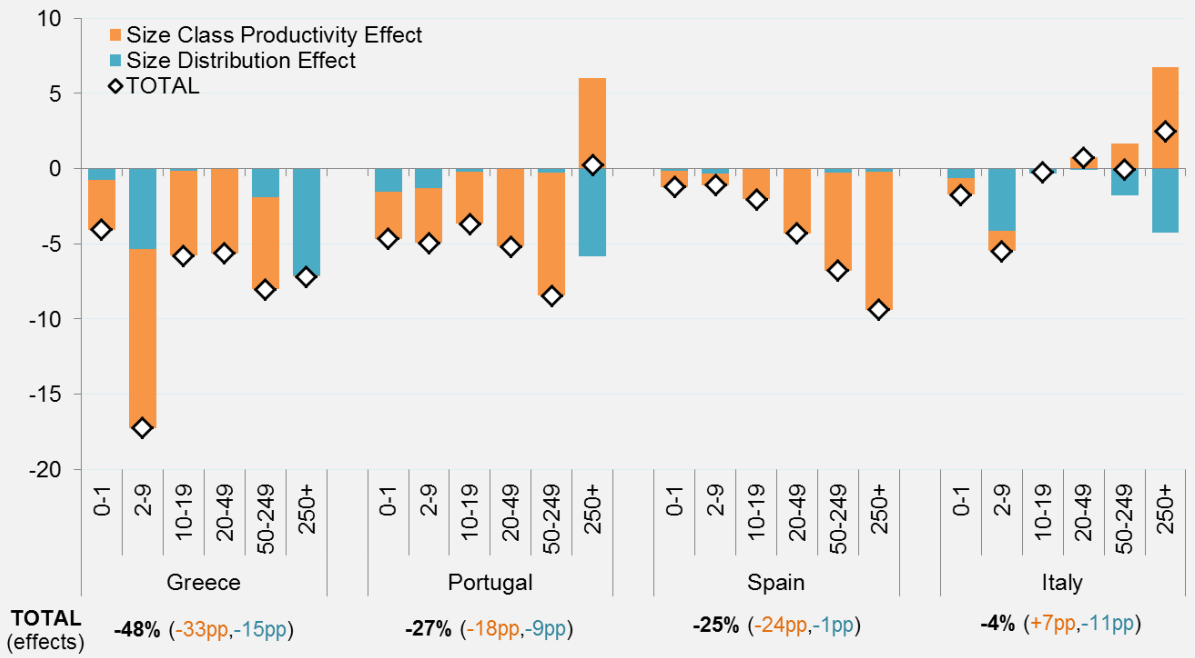


Note: Value added figures have been adjusted by GDP-based purchasing power parity. Total employment accounts for 354k people in Spain (or 11 % of total employment in section 'G – Trade'), 196k in Italy (6 %), 59k in Greece (11 %) and 54k in Portugal (7 %).

Source: Own calculation based on SBS for 2016.

The assessment is confirmed on a more detailed basis. Figure 45 shows the contribution of each firm size class to the overall labour productivity difference between each selected Member State and the EU28 aggregate, differentiating between the productivity and the distribution effects. Labour productivity in 'G463' is almost 50 % lower in Greece and close to 30 % below the EU benchmark in Portugal, a third of which could be explained by size distribution effects in both cases (namely, a lower share of firms with 250 or more persons employed and a higher share of those with less than 10). And for Italy, the detrimental firm size distribution more than offsets levels of size class productivity around or even above those for the EU28 aggregate. Finally, the 25 % negative difference in Spain, with a firm size distribution that is similar to the benchmark, would be fully explained by lower productivity across all size classes, particularly for medium and large firms.

Figure 45. Decomposition of the percentage difference in labour productivity relative to the EU28 for group 'G463 - Wholesale of food, beverages and tobacco', contribution by type of effect and firm size class.



Source: Own calculation based on SBS data for 2016.
Note: Value added figures have been adjusted by GDP-based purchasing power parity.

Table 19. Percentage difference in labour productivity relative to the EU28 aggregate by NACE group of sections G to N (excluding K) and division S95.

NACE Group	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IT	LT	LV	NL	PL	PT	RO	SE	SI	SK	UK
G451 Sale of motor vehicles	8%	30%				-7%	-9%		-52%	-7%	-9%	-18%		-48%	6%	-41%	-31%	-21%	-29%	-33%		-5%		-22%	37%
G452 Maintenance and repair of motor vehicles						24%			-82%		-17%	29%	-51%			-61%					-50%	17%	-15%	-43%	30%
G453 Sale of motor vehicle parts and accessories			-56%	-35%		21%		-5%	-64%		-1%	8%		-35%			-52%	40%	-6%		-31%	20%		-30%	-3%
G454 Sale, maintenance and repair of motorcycles and related parts and accessories	84%	15%		-51%		2%		-21%	-77%	-18%	-4%	17%	-10%	-59%	-30%	-68%				-51%		-7%			49%
G461 Wholesale on a fee or contract basis			-18%			63%	72%	-21%	-33%			27%	-22%	-23%	-8%				-23%	-66%			-19%	-41%	56%
G462 Wholesale of agricultural raw materials and live animals	-8%					3%			-56%			23%	-16%	-7%	3%	1%	-13%	24%	-32%	-40%	40%		-12%	-5%	14%
G463 Wholesale of food, beverages and tobacco	44%	42%	-55%			26%	36%		-48%	-25%	45%	16%	-34%	-40%	-4%	-22%	-45%	79%	-18%	-27%	-29%	11%	-4%	-37%	7%
G464 Wholesale of household goods	15%	66%	-37%			9%	22%	-36%	-43%	-13%	-19%	18%	-23%	-20%	2%	-43%	-44%	28%	-22%	-33%	-34%	-7%		-21%	-13%
G465 Wholesale of information and communication equipment	9%	18%	-38%	-60%		7%	-2%	-17%	-43%	-25%		1%	-37%	-31%	-12%		-36%	10%	-23%			-23%	-30%	-30%	-5%
G466 Wholesale of other machinery, equipment and supplies	7%	36%		-56%		6%	-10%	-31%	-51%	-16%	-17%	-5%		-5%			-40%	7%	-27%	-36%		-8%		-25%	-14%
G467 Other specialised wholesale	28%	64%	-40%	-15%		23%	15%	-1%		-4%	13%	3%	-22%	-29%	3%	-32%	-25%	44%	-29%	-24%	-34%	4%	-5%	-20%	-10%
G469 Non-specialised wholesale trade			26%			77%			-36%		25%	-1%	-37%	-4%	30%		-47%		1%		-13%	3%		-33%	44%
G471 Retail sale in non-specialised stores	21%	53%	-57%			-4%	-33%	-30%	-44%	22%	14%	28%	-9%	-23%	36%	-45%	-43%	-31%	-20%	-14%	-32%	20%	12%	-15%	6%
G472 Retail sale of food, beverages and tobacco in specialised stores	39%	44%	-70%	27%		-10%			-88%	-11%		90%	-25%	-30%		-44%	-49%	13%	-21%	-35%					20%
G473 Retail sale of automotive fuel in specialised stores	-14%								-60%		-31%	28%	-15%			-23%		-5%	-19%	-36%				-1%	212%
G474 Retail sale of information and communication equipment in specialised stores	4%		-46%	-18%		19%				-14%		6%	-38%	-39%	-14%	-36%			-26%		-30%	-4%		-18%	90%
G475 Retail sale of other household equipment in specialised stores	22%	33%	-43%			18%	15%	-10%	-80%	-25%	8%	40%	9%	-40%	-15%	-32%	-31%	-5%	-18%	-32%	16%	16%	15%	-14%	-7%
G476 Retail sale of cultural and recreation goods in specialised stores	40%	22%	-44%			-1%	3%			-5%	8%	43%	-33%	-29%	-13%		-42%	-2%	-12%	-30%	7%	14%	26%	-19%	-15%
G477 Retail sale of other goods in specialised stores	15%	27%	-59%			-4%	-7%	-25%	-69%	-2%	8%	46%	-6%	-37%	3%	-37%	-45%	-7%	-26%	-22%	-8%	24%	16%	-20%	0%
G478 Retail sale via stalls and markets	21%	91%	-59%	36%			230%		-108%		44%	17%		-54%	9%	-50%	-61%			-64%			15%		
G479 Retail trade not in stores, stalls or markets	11%		-56%	-55%		-52%	0%		-91%	12%	6%	-47%			29%		-59%	-22%	-33%	-59%	-1%	4%		-42%	
H491 Passenger rail transport, interurban																									
H492 Freight rail transport						-9%					344%														
H493 Other passenger land transport	22%		-56%			-11%	5%		-84%				-23%	-51%			-50%		-34%		-50%	-7%			72%
H494 Freight transport by road and removal services	37%	53%	-30%			11%	52%	-25%	-44%	9%	22%	12%	-8%	-9%	16%	-24%			-27%	-8%	-34%	15%	8%	-19%	18%
H495 Transport via pipeline																									
H501 Sea and coastal passenger water transport									-20%					-28%								-60%	-84%	-52%	
H502 Sea and coastal freight water transport									-37%		-19%	-116%		-50%	13%			31%				-51%			
H503 Inland passenger water transport						1%							-62%				-79%								
H504 Inland freight water transport						17%								-61%	-54%										
H511 Passenger air transport				-50%		-56%									-6%										
H512 Freight air transport and space transport	-15%					-20%									-11%										
H521 Warehousing and storage		56%	-36%			-4%	74%		-28%	65%		18%		20%	50%		-38%	130%	-20%			15%		-46%	-40%
H522 Support activities for transportation		43%	-41%			-24%	28%		-8%	41%		45%		-35%	-10%		-40%	32%	-34%			-22%		-40%	41%
H531 Postal activities under universal service obligation				-7%																					
H532 Other postal and courier activities				-29%		-13%														7%					
I551 Hotels and similar accommodation	17%		-33%	11%		-23%	-3%		-6%	41%	9%	24%	64%	-9%	28%	-23%	-41%	-2%	3%		-28%	-6%			-14%
I552 Holiday and other short-stay accommodation	-6%					-11%	28%	-15%	-72%	30%		9%		-50%	34%	-42%	-65%		-15%					-65%	47%
I553 Camping grounds, recreational vehicle parks and trailer parks	-5%					-43%		-6%	-79%	-5%	-55%			-61%	33%				-67%		-65%		-22%	-48%	
I559 Other accommodation																									
I561 Restaurants and mobile food service activities	15%	26%	-57%	21%		-19%	-20%	-26%	-92%	2%	23%	54%		-48%	-4%		-49%	-13%	-23%	-20%	-33%	17%			6%
I562 Event catering and other food service activities	34%	45%	-53%	-1%		-15%	25%	-35%		-18%	21%	54%	-22%	-44%	10%		-52%	14%	-37%		-34%	39%			-18%
I563 Beverage serving activities	2%	20%	-63%	38%		-28%	-16%	-31%	-99%	-13%	40%	127%	-9%	-60%	1%	-49%		23%	-56%		-23%		-11%	-47%	30%
J581 Publishing of books, periodicals and other publishing activities	-4%	25%	-70%			-7%			-76%	-20%	-21%	-2%		-44%					-25%	-39%		-32%			20%
J582 Software publishing																									
J591 Motion picture, video and television programme activities						-24%				-16%				-73%											23%
J592 Sound recording and music publishing activities				-75%		74%	-66%			-32%	-56%			-84%		-90%	-88%	-58%				-45%	-79%	-81%	35%
J601 Radio broadcasting	28%			-62%		25%			-75%	-14%			-70%		-6%										32%
J602 Television programming and broadcasting activities				-77%		45%			-50%	-40%			-64%		0%		-70%								42%
J611 Wired telecommunications activities		33%	-80%	-36%		40%				47%	-25%	-17%		-36%	24%					24%		-9%			-53%
J612 Wireless telecommunications activities				-86%		62%			-30%	108%		4%		-8%	93%				7%		0%				
J613 Satellite telecommunications activities				498%		38%			-35%						-1%		-66%								
J619 Other telecommunications activities						-20%			-84%	-55%		-50%			-58%				-74%					-55%	14%
J620 Computer programming, consultancy and related activities																									
J631 Data processing, hosting and related activities; web portals			-47%			10%	-14%								-41%					-38%				-37%	113%
J639 Other information service activities			-47%			-25%	-41%				-24%				-20%	-69%						-26%		-27%	120%
L681 Buying and selling of own real estate	121%	16%	-99%	-39%		163%			-70%			112%	4%	-48%		-46%			-30%	-62%	-14%	83%		-34%	
L682 Renting and operating of own or leased real estate				-47%		60%	38%					8%	-19%	-57%	43%	-54%	-67%		-58%	-22%		64%		-41%	
L683 Real estate activities on a fee or contract basis		16%	-61%	-28%		19%	9%		-46%	-29%		8%		-54%					-33%			-11%	-31%	-12%	10%
M691 Legal activities		34%	-21%	-14%		-2%	27%		-83%	-30%	25%	18%	-33%	-35%	-17%		-59%	5%		-50%	-58%	47%		-52%	16%
M692 Accounting, bookkeeping and auditing activities; tax consultancy		7%	-65%	3%		0%	20%			-21%	-13%	25%		-49%	-10%	-57%	-65%	17%		-57%		3%			40%
M701 Activities of head offices	77%	98%	-117%	24%		-17%	11%		-80%	73%		52%	-154%	-28%	79%	-46%		81%							-64%
M702 Management consultancy activities	-5%	5%	-39%	-23%		12%	-1%		-67%	-7%	-28%	-3%	-49%	-56%	-10%	-42%		-7%				-4%	-49%		13%
M711 Architectural and engineering activities and related technical consultancy		2%	-48%			9%	28%	-40%	-85%	-18%	-7%	10%		-51%	27%		-97%	3%	-52%		-49%	-2%			25%
M712 Technical testing and analysis		46%		-40%		18%	21%	-24%	-29%	-9%	-3%	6%		-44%	4%	-29%	-27%	21%	-28%		-26%	7%	0%	-48%	-27%
M721 Research and experimental development on natural sciences and engineering	3%					-16%	129%		-73%	-30%		-25%				-53%	-60%							-50%	
M722 Research and experimental development on social sciences and humanities	-35%					24%	-15%		-58%	-29%	-25%	-23%		-55%		-34%	-65%					66%		-32%	
M731 Advertising		-4%	47%			22%			-55%	-24%	-27%	5%	-26%	-44%	-16%	-53%	-60%	-17%		-36%		-9%	-33%	-33%	127%
M732 Market research and public opinion polling		7%	-10%			1%	-43%		-55%	-28%	-22%	25%	-15%	-32%	0%	-26%	-41%	-8%		-42%		-19%		-36%	21%
M741 Specialised design activities		-26%		-55%		-13%	-17%		-79%	117%	-32%		-58%	-74%	-12%	-66%			-60%	-63%	-63%			-93%	
M742 Photographic activities	3%			-24%		43%	-1%	-34%		-44%			-44%		-26%		-70%		-69%		-48%	80%	-33%		
M743 Translation and interpretation activities	-15%	23%	-49%	-11%		47%	-39%			1%				-43%	4%					-50%					
M749 Other professional, scientific and technical activities n.e.c.	-27%	-20%	-33%	-28%		104%	31%		-70%	-26%	-29%		-43%		-22%		-66%					3%			3%
M750 Veterinary activities																									
N771 Renting and leasing of motor vehicles		96%				-17%				-26%	-26%	5%	-51%	-44%	22%		-86%				-26%				28%
N772 Renting and leasing of personal and household goods	71%	26%		-69%		15%			-86%	-49%				-66%											2%
N773 Renting and leasing of other machinery, equipment and tangible goods	61%	-3%	63%			-4%	-11%		-88%	-50%	-30%	14%	-71%	-61%	34%	-60%					-49%		-62%		
N774 Leasing of intellectual property and similar products, except copyrighted works		-84%		-97%		203%			-94%	-67%	-78%			200%		-92%			-91%	-90%			-90%	-84%	
N781 Activities of employment placement agencies	33%	17%	-35%			-18%	84%			-20%	15%			-40%			-11%		-32%	-32%	-49%	-25%		-58%	12%
N782 Temporary employment agency activities	37%	22%	-31%			-14%	-4%			-8%	-14%	33%		-35%		-27%	-53%	-46%	-18%	-47%	-30%	-12%	-12%		30%
N783 Other human resources provision	64%		-41%			20%				-13%	6%			-46%		-12%			-16%	-30%		26%			70%
N791 Travel agency and tour operator activities	-39%		-70%	-46%		-18%				-31%			-58%		-50%	-66%		36%	-64%	-55%	-73%			-51%	108%
N799 Other reservation service and related activities	-21%		-61%	-41%		18%	-22%		-78%	-21%	-34%		84%		-32%	-55%			-15%	-50%				-72%	70%
N801 Private security activities		82%	-60%			4%				25%		16%	-36%	-39%					-18%		-56%	54%			33%
N802 Security systems service activities		77%				-5%			-44%				-2%		-23%				-9%			81%			
N803 Investigation activities																									
N811 Combined facilities support activities			-67%			-31%				-37%	-17%	14%	-25%	-50%											27%
N812 Cleaning activities	43%	21%	-56%			-18%	41%		-40%	-3%	46%	9%	-25%	-41%	5%		-52%	11%	-8%	-50%	-39%	41%			-8%
N813 Landscape service activities			-52%			6%	22%		-75%	-16%	6%	14%	-28%	-69%		-55%				-47%	-40%				-18%
N821 Office administrative and support activities	23%		-32%	0%		-21%	65%		-72%	-11%	2%	-13%	-51%						-20%			26%		-47%	43%
N822 Activities of call centres	18%					-18%	-29%			-29%		-14%			-32%				-14%		-15%	-23%			80%
N823 Organisation of conventions and trade shows	-28%	16%				1%			-41%	-36%		25%	-49%	-74%						-48%					23%
N829 Business support service activities n.e.c.	40%	30%	-50%	-59%		-4%			-20%	-38%	42%	25%	-12%	-44%	-6%	-42%		31%	-19%	-75%	-35%	64%			48%
S951 Repair of computers and communication equipment		67%	63%	-47%		21%	23%			-17%		27%	55%	-27%	-6%					-45%	-46%				23%
S952 Repair of personal and household goods		18%		-29%		42%	79%			0%		-3%	-8%	-54%	-11%	-47%				-38%		84%			62%

Scale (%): <-25% -15% -5% 5% 15% >+25%

Note: Value added figures have been adjusted by GDP-based purchasing power parity.

Source: Own calculation based on SBS data for 2016 (or latest).

Table 20. Percentage points contribution of the size distribution effect on the difference in labour productivity relative to the EU28 aggregate by NACE group of sections G to N (excluding K) and division S95.

NACE Group	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IT	LT	LV	NL	PL	PT	RO	SE	SI	SK	UK
G451 Sale of motor vehicles	3.9	-15.1				1.2	2.0		-14.1	-10.7	10.3	-3.4		-19.0	-28.4	-27.6	-15.2	-9.4	-16.9	-4.3		6.2		1.1	25.4
G452 Maintenance and repair of motor vehicles						9.7			-15.4		6.1	-4.3	-10.3			-7.8					6.7	2.5	-10.2	-24.2	0.4
G453 Sale of motor vehicle parts and accessories			-4.6	-6.7		3.8		-5.3	-30.1		1.6	2.9		-6.4			-9.7	2.4	-12.9		-6.6	5.1		-8.3	2.0
G454 Sale, maintenance and repair of motorcycles and related parts and accessories	26.4	-15.6		-36.1		8.1		-17.8	-17.1	0.5	22.9	-7.0	-16.3	-9.3	-20.0	-17.3				-22.4		10.9			23.2
G461 Wholesale on a fee or contract basis			-3.6			3.9	21.9	-19.4	12.7			18.6	1.7	11.4	-24.3				8.8	-21.7			1.5	-16.1	7.9
G462 Wholesale of agricultural raw materials and live animals	7.1					1.4			-12.7			2.4	-2.4	1.0	-18.2	-1.9	-0.4	0.5	-11.3	-11.0	0.9		-6.5	1.4	-6.2
G463 Wholesale of food, beverages and tobacco	3.2	-4.9	-2.0			0.2	3.1		-15.2	-0.9	0.3	0.8	0.4	-0.3	-11.2	1.2	0.8	3.1	-6.2	-9.1	2.5	3.8	-5.0	6.0	-2.0
G464 Wholesale of household goods	-0.9	-1.4	-2.2			6.5	-0.8	-14.8	-19.8	-7.1	-6.1	4.5	-0.7	-4.1	-11.7	-12.9	-15.7	-1.3	-7.9	-11.5	-2.8	2.6		4.2	3.5
G465 Wholesale of information and communication equipment	-2.7	-2.4	-16.9	-19.6		6.1	1.6	-18.4	-10.8	-2.9		-3.3	3.2	-7.0	-16.0		-22.3	0.7	-6.9			-1.1	-21.4	-18.3	7.3
G466 Wholesale of other machinery, equipment and supplies	-2.4	0.2		-21.4		3.8	-0.5	-8.4	-49.1	-4.8	-0.4	2.5			-12.8		-12.3	-0.2	-4.2	-10.7		1.2		-7.8	4.3
G467 Other specialised wholesale	3.0	-4.8	-2.3	-13.1		3.5	-1.2	-5.9		-18.7	-1.5	4.4	-1.4	-6.8	-13.4	-2.5	-4.1	3.7	-11.3	-8.9	-1.9	1.5	-4.7	2.4	-5.2
G469 Non-specialised wholesale trade			0.2			-57.1			-15.3		10.0	-0.7	-7.5	0.4	-3.0		-6.3		1.2		3.4	-5.3		-3.4	0.2
G471 Retail sale in non-specialised stores	6.8	0.5	-28.1			3.7	4.1	5.0	-15.1	2.4	1.2	1.2	2.5	-9.1	-5.4	0.5	-1.4	4.0	-13.5	-3.9	-24.9	-0.6	7.0	-15.2	6.1
G472 Retail sale of food, beverages and tobacco in specialised stores	1.9	-2.4	-9.4	-5.2		4.0			-11.4	-5.6		-4.4	16.1	-4.8		2.7	3.0	-4.7	2.4	-12.9					5.7
G473 Retail sale of automotive fuel in specialised stores	-22.1								-30.7		-23.5	-19.2	31.7			46.8		12.4	-3.7	-0.8				-13.3	63.9
G474 Retail sale of information and communication equipment in specialised stores	-5.6		-5.1	-15.0		5.2				1.5		-0.1	-8.6	-17.4	-23.3	-7.8			-3.6		4.0	9.3		-19.5	27.2
G475 Retail sale of other household equipment in specialised stores	5.7	-1.3	-8.0			4.9	11.2	4.2	-25.0	-17.6	1.8	7.1	1.9	-13.8	-22.1	3.4	7.2	2.1	-1.6	-19.9	11.0	6.5	8.2	-2.4	7.1
G476 Retail sale of cultural and recreation goods in specialised stores	3.3	-11.0	-7.5			-1.4	2.4			-5.9	2.0	-0.9	7.2	-15.6	-20.6		-8.4	-2.7	-7.1	-10.4	-13.4	1.8	1.8	1.4	0.6
G477 Retail sale of other goods in specialised stores	5.9	-4.4	21.0			5.4	2.5	0.8	-25.0	-6.5	1.6	-2.6	1.3	-11.4	-15.9	3.7	-2.1	2.4	-7.4	-9.2	-2.7	5.1	-5.3	-8.1	9.7
G478 Retail sale via stalls and markets	14.6	5.2	2.0	-15.5			5.1		1.0		6.0	-41.4		6.5	-0.4	-12.1	13.8			-19.3			-2.7		
G479 Retail trade not in stores, stalls or markets	2.1		-28.5	-55.2		-23.4	-6.4		-35.3	0.0	-17.2	-38.8			6.0		-25.4	-19.6	-27.3	-39.3	-0.4	17.2		-35.7	
H491 Passenger rail transport, interurban																									
H492 Freight rail transport						5.7					208.8														
H493 Other passenger land transport	-2.7		-3.4			-3.0	0.4		-17.9				17.7	7.5			10.9		-10.0		-1.7	0.8			11.6
H494 Freight transport by road and removal services	2.3	3.3	-3.3			2.6	1.4	-4.9	-17.4	-7.7	-2.4	2.2	-1.3	-0.4	-3.8	4.8			-9.8	3.9	-1.6	0.0	-4.2	-0.8	5.2
H495 Transport via pipeline																									
H501 Sea and coastal passenger water transport									-11.0					3.9								0.0	-43.6	-15.5	
H502 Sea and coastal freight water transport									-4.5		-13.5	-21.4		60.4	-27.3			24.8				-0.5			
H503 Inland passenger water transport						-71.4							-18.3				-25.2								
H504 Inland freight water transport						4.4								-14.7	-2.4										
H511 Passenger air transport				13.3		-5.9									8.2										
H512 Freight air transport and space transport	-41.3					8.4									-26.4										
H521 Warehousing and storage		1.7	9.5			-2.6	17.8		12.5	-1.8		1.6		18.9	-5.4		8.6	11.1	0.3			16.7		-11.7	-9.2
H522 Support activities for transportation		-0.4	2.5			-2.8	-1.6		-8.4	-4.2		1.8		0.5	-5.6		-1.0	-1.4	-1.4			-0.3		-5.6	5.3
H531 Postal activities under universal service obligation				-0.5																					
H532 Other postal and courier activities				-5.2		-1.0														-6.6					
I551 Hotels and similar accommodation	-5.2		-0.8	1.6		-4.5	1.3		0.6	7.0	7.0	-8.0	17.7	2.9	-13.3	-2.3	1.6	2.0	-5.2		-0.2	0.6			3.7
I552 Holiday and other short-stay accommodation	-17.4					7.6	4.1	-19.0	-25.3	1.4		-3.3		-16.9	-28.3	-22.5	-24.7		-19.1					-28.3	14.5
I553 Camping grounds, recreational vehicle parks and trailer parks	-4.7					-8.6		8.0	-11.7	-2.3	-12.8			-15.0	-4.4				-24.1		-14.8		-9.8	-19.1	
I559 Other accommodation																									
I561 Restaurants and mobile food service activities	-6.7	-13.9	-1.1	0.6		-2.3	3.2	4.0	-10.3	-1.4	0.4	-13.2		-6.3	-14.6		7.5	-4.2	-5.5	-4.0	4.1	-0.8			19.9
I562 Event catering and other food service activities	-4.2	-14.0	-4.7	-16.6		-7.4	-4.2	-24.3		-1.0	0.4	3.9	-21.6	-6.2	3.1		-25.0	-7.3	-25.1		-13.1	-4.8			4.2
I563 Beverage serving activities	-13.3	-12.5	-16.2	-9.1		-4.6	8.5	-11.3	-5.2	-14.3	-11.6	-24.2	-18.1	-19.5	-14.1	-9.1		-11.9	-25.7		-3.9		-22.2	-16.6	35.6
J581 Publishing of books, periodicals and other publishing activities	-4.7	1.0	-30.1			4.2			-14.0	-10.7	4.5	0.4		-16.9					-9.2	-17.1		-0.6			8.2
J582 Software publishing																									
J591 Motion picture, video and television programme activities						2.8				0.8				-35.9											2.7
J592 Sound recording and music publishing activities				-48.3		34.9	-43.6			-32.7	-41.6			-52.2		-55.3	-48.7	-47.5				-38.1	-53.8	-46.9	33.3
J601 Radio broadcasting	-5.4			-38.7		-12.1			-33.2	-2.1			-48.6		-31.3										0.1
J602 Television programming and broadcasting activities				-44.3		-30.7			1.9	-1.0			-1.5		-19.6		-42.0								-0.9
J611 Wired telecommunications activities		-6.8	-20.9	3.3		-1.8				-2.5	-4.9	-1.8		-11.2	4.7					4.1		0.0			-2.1
J612 Wireless telecommunications activities				-74.1		7.9			-15.1	-4.8		4.0		4.8	-5.7				-17.1		3.1				
J613 Satellite telecommunications activities				206.3		42.1			22.7						21.5		-5.3								
J619 Other telecommunications activities						-1.7			-6.2	-16.5		-29.8			-16.9				-52.5					7.2	10.1
J620 Computer programming, consultancy and related activities																									
J631 Data processing, hosting and related activities; web portals			7.3			15.5	3.4								-24.2					12.8				-19.2	40.6
J639 Other information service activities			-33.0			-4.7	-32.1				-26.7				-14.7	-45.7						-27.5		-47.9	40.8
L681 Buying and selling of own real estate	-15.0	13.1	-4.8	-0.4		-47.8			-1.0			21.9	9.6	1.9		-14.1			-10.5	6.3	0.6	-7.1		13.2	
L682 Renting and operating of own or leased real estate				-21.3		-14.1	0.0					7.0	-0.2	2.4	-42.9	-11.5	-9.4		-8.6	-1.0		-0.6		-6.5	
L683 Real estate activities on a fee or contract basis		2.7	-9.5	-12.5		-6.1	-21.1		-20.4	-25.8		-2.3		1.0					6.5			-1.7	-7.2	-3.7	3.5
M691 Legal activities		-22.6	-15.9	0.5		-0.5	20.1		-38.3	-11.2	3.0	-11.9	-14.8	-24.8	-45.5		-25.3	3.5		-46.6	-31.5	5.9		-30.2	-16.8
M692 Accounting, bookkeeping and auditing activities; tax consultancy		-5.2	-16.1	13.4		0.3	15.9			-10.4	0.5	-3.0		-10.3	-16.4	-19.9	-9.0	5.9		-16.8		7.9			16.4
M701 Activities of head offices	22.7	-2.3	2.9	41.2		9.8	5.3		10.2	-0.5		1.4	-8.8	33.0	5.8	23.1		-6.4							-53.6
M702 Management consultancy activities	-4.5	-4.6	-0.2	0.3		-1.9	-1.9		-2.9	5.0	-2.3	-1.1	-8.7	-3.6	0.5	-7.1		-6.2				0.1	-11.6		0.6
M711 Architectural and engineering activities and related technical consultancy		-10.7	-14.9			2.6	19.1	-14.0	-10.6	-1.3	8.4	5.3		-11.5	32.1		-14.6	3.1	-14.2		0.0	6.5			7.2
M712 Technical testing and analysis		3.4		-20.7		3.8	1.2	-8.5	-16.7	-2.1	0.5	0.9		-17.1	-12.2	-8.4	-6.7	5.0	-8.9		0.9	3.9	-6.4	-25.5	-2.0
M721 Research and experimental development on natural sciences and engineering	-13.5					5.4	17.3		-15.0	-5.6		-5.6				-43.7	-50.6							-38.7	
M722 Research and experimental development on social sciences and humanities	-10.3					14.5	5.9		6.8	-15.9	-9.2	-25.6		-31.0		-5.4	-37.3					29.7		-31.3	
M731 Advertising		-15.1	-16.3			2.5			-12.8	-2.6	-10.5	4.8	-3.7	-21.0	-0.7	-16.6	-18.8	-25.9		-14.0		-6.6	-30.7	-21.3	24.7
M732 Market research and public opinion polling		-9.9	-8.2			2.7	-1.4		-7.3	-1.5	-1.1	1.6	-2.4	-19.0	-5.5	-5.0	-7.2	0.6		-4.7		-3.8		-14.1	-1.2
M741 Specialised design activities		-22.3		-26.5		0.0	-2.2		-20.5	-41.0	-13.0		-12.8	-24.3	-3.8	-13.5			-13.0	-14.1	-1.6			-28.8	
M742 Photographic activities	2.9			-15.1		15.4	-4.2	-12.2		-8.7			-5.4		-11.0		-7.5		-12.5		-0.2	-1.2	-17.0		
M743 Translation and interpretation activities	-13.5	-7.9	-4.5	-20.3		8.5	36.8			3.0				-9.3	-5.6					-19.2					
M749 Other professional, scientific and technical activities n.e.c.	-13.4	-15.5	2.1	-10.0		26.7	15.1		42.6	10.1	-9.1		-10.1		-10.6		-17.3					-15.4			0.5
M750 Veterinary activities																									
N771 Renting and leasing of motor vehicles		9.9				-0.2				3.9	-22.8	9.0	-40.2	-33.7	-1.1		-55.8				-29.9				25.9
N772 Renting and leasing of personal and household goods	18.4	5.2		-40.5		4.3			-31.5	-14.7				-22.0											-13.7
N773 Renting and leasing of other machinery, equipment and tangible goods	-8.3	7.0	10.4			-4.2	6.7		1.4	11.2	-3.8	-22.3	19.0	10.5	-7.4	-10.6					0.6		26.6		
N774 Leasing of intellectual property and similar products, except copyrighted works		-16.2		-31.9		44.5			-41.3	-39.4	-46.3			-22.3		-29.1			-16.8	-26.9			-23.3	-36.3	
N781 Activities of employment placement agencies	24.8	1.7	6.3			2.1	36.3			0.9	15.1			-4.3			7.4		-7.6	2.9	-3.6	1.4		-10.4	1.6
N782 Temporary employment agency activities	-1.5	-3.6	3.8			-1.4	0.2			-1.7	1.1	3.1		-3.3		2.6	-5.8	0.1	-3.8	-8.2	-0.4	1.3	-0.8		-5.1
N783 Other human resources provision	0.7		-0.2			-1.2				2.4	0.3			-0.9		7.8			-1.2	-5.6		21.8			13.1
N791 Travel agency and tour operator activities	-2.5		28.6	-22.7		-1.1				3.6			-25.3		-12.6	-27.3		27.2	-15.5	-3.2	-7.2			-34.2	1.6
N799 Other reservation service and related activities	-5.7		-19.4	-36.3		12.7	-0.4		-15.7	-1.0	-1.4			7.5		-38.5	-42.0		-16.6	-23.6				-57.3	-49.4
N801 Private security activities		1.3	-0.3			-2.0				5.3		-0.4	1.6	-2.8					-2.3		-2.4	-7.2			0.3
N802 Security systems service activities		16.4				-1.6			-14.1				0.6		-7.7				2.1			4.6			
N803 Investigation activities																									
N811 Combined facilities support activities			-40.6			-18.3				0.1	-13.0	-1.6	-26.6	3.8											17.4
N812 Cleaning activities	-0.8	-0.7	3.1			-3.8	-0.1		-0.5	0.1	1.5	-0.7	6.0	0.4	0.6		3.3	0.7	-1.7	-2.9	2.3	1.2			-0.9
N813 Landscape service activities			0.9			1.1	0.0		-12.6	4.1	0.7	-7.1	1.1	-7.8		-7.5				-2.7	3.5				-2.8
N821 Office administrative and support activities	0.6		-5.0	2.5		-5.4	13.5		-19.2	3.4	8.3	-9.7	-24.7						-14.2			-3.0		-36.3	9.9
N822 Activities of call centres	-4.6					-1.6	-1.9			-2.1		0.3			0.5				-7.2		-0.4	-0.7			4.8
N823 Organisation of conventions and trade shows	-3.9	-21.4				3.2			-8.2	-2.8		-2.1	-27.0	-13.1						-14.3					5.1
N829 Business support service activities n.e.c.	6.9	-4.1	0.9	-11.4		2.5			6.8	-0.3	3.3	-0.9	9.8	0.4	0.1	-4.1		4.1	7.1	-30.3	6.4	-34.0			1.1
S951 Repair of computers and communication equipment		13.9	33.7	-37.8		8.6	2.8			-5.8		-0.1	8.9	-10.5	-14.4					-11.8	1.1				-4.8
S952 Repair of personal and household goods		-44.7		-25.5		13.8	14.7			-1.2		-31.8	0.6	-9.7	-10.2	-9.5				-10.4		2.1			-46.1

Scale (percentage points): <-25 | -15 | -5 | 5 | 15 | >+25

Note: Value added figures have been adjusted by GDP-based purchasing power parity.

Source: Own calculation based on SBS data for 2016 (or latest).

7.2.5 Policy considerations: potential determinants of firm size

Productivity differences across EU Member States, which are still considerable, are largely explained by persistent divergences in productivity levels for a given sector and firm size class, and to a much lesser extent by sectoral composition effects or the impact of firm size distributions. In addition, these 'genuine' productivity differences show a very strong country component, suggesting economy-wide obstacles for further convergence within the EU.

Nevertheless, and despite the limited data availability, our methodology for decomposing productivity differences relative to the EU benchmark and analyse role of the firm size distribution still provides some interesting insights.

First, we have identified a number of countries in which the firm size distribution has a significant negative impact on aggregate productivity, such as Greece, Italy, Portugal and Spain. It remains to be seen whether positive contributions in recent years could be further extended in these countries to close the existing gap.

Second, according to our analysis there are a number of sectors in which the firm size distribution shows a larger contribution – when compared with their employment share – to explaining overall productivity differences across countries: manufacturing, ICT services and professional activities.

Unfortunately, as pointed out before, data availability is rather limited when working at a more granular level, what prevents us from giving more systematic conclusions both on a country and economic activity basis.

Policy considerations

Having in mind the findings above, there are a number of research areas worth exploring for the EU case in order to refine policy recommendations on productivity when taking into account the firm size dimension.

First, Syverson (2011) provides a comprehensive work on why businesses differ in their productivity levels, ranging from internal to external factors. This would help differentiating general country prescriptions from specific aspects affecting certain economic activities, particularly when explaining what we called size class (or 'pure') productivity effects.

Second, Restuccia and Rogerson (2017) and Bento and Restuccia (2018) explore the role of misallocation in accounting for productivity differences. The identification of distortions and the quantification of their costs in terms of productivity would help prioritising policy action. Let´s point out that misallocation potentially affects not only productivity differences across countries and sectors but also the firm size distribution.

And third, specifically on the determinants and dispersion of firm size, Kumar et al. (1999) underline the interaction between technological and institutional factors (such as judicial efficiency and patent protection), whereas Guner et al. (2008) find that size-dependent policies are widespread across countries[119].

Since that is the focus of this analytical piece, in Box 4 we provide a first empirical approach identifying potential determinants of firm size. In line with findings of references aforementioned, we confirm the significant role played by the institutional framework in shaping firm size distributions, being judicial and government efficiency a supportive factor for increasing firm size.

[119] Although the dynamic perspective is not the focus of our analysis, it´s relevant to mention the work by Moral-Benito (2018), which explores the direction of causality between size and productivity growth for the case of Spain.

Box 4. A first empirical approach to firm size determinants in the EU

Identifying factors behind firm size distributions could help us providing more thorough policy implications based on SBS data. For this purpose, we would ideally like to exploit the largest heterogeneity possible across countries and sectors. The latter is unfortunately not possible due to data limitations and we should restrict to the NACE sections used for the overall picture: manufacturing (section C), trade (G), transport (H), accommodation and food services (I), ICT services (J), professional activities (M) and support service activities (N).

We work with a number of firm size indicators at the country-sector level: 1) the employment share for firms with 10 or less persons employed ('sh10'), 2) the employment share for firms with 50 or more persons employed ('sh50'), 3) the employment share for firms with 250 or more persons employed ('sh250'), 4) the ratio between 2 and 1 ('rsh50_10'), 5) the ratio between 3 and 1 ('rsh250_10'), 6) the simple average firm size (the total number of persons employed over the total number of enterprises) ('savg'), 7) the persons employed-weighted average firm size following Kumar et al. (1999) ('wavg'), which gives more weight to larger firms, 8) the simple average firm size class (using discrete values: 1 for 0-9 persons employed, 2 for 10-19, 3 for 20-49, 4 for 50-249 and 5 for 250 or more) ('savg_c'), and 9) the weighed version of 8 ('wavg_c').

We estimate then the country and sector effects for each indicator, which are shown in Table 21 in terms of rankings. Lower numbers (green cells) are associated with larger employment shares for bigger companies or a higher average size compared to other sectors or countries.

Table 21. Ranking of sector and country effects for different firms size indicators, ordered by the average ranking.

Firm size indicator >>>	1 **(-) sh10**	2 **sh50**	3 **sh250**	4 **rsh50_10**	5 **rsh250_10**	6 **savg**	7 **wavg**	8 **savg_c**	9 **wavg_c**
Sector effects (NACE sections)									
C	1	1	3	1	1	1	5	1	1
N	2	2	1	2	2	3	2	4	2
H	3	3	2	3	3	2	1	3	3
J	4	4	4	4	4	6	3	6	4
G	5	5	5	5	5	5	4	5	5
I	6	6	6	6	6	4	6	2	6
F	7	7	8	7	7	7	8	7	7
M	8	8	7	8	8	8	7	8	8
Country effects									
UK	1	1	1	1	1	2	1	6	1
DK	2	2	3	2	2	5	5	3	2
DE	3	3	5	3	3	1	9	1	3
FI	6	5	6	6	5	6	10	8	5
RO	5	6	8	5	7	4	12	4	6
SE	4	4	4	4	4	15	4	15	4
FR	10	7	2	9	6	9	2	21	7
AT	7	10	13	7	9	3	15	2	9
NL	11	8	7	8	8	11	3	20	8
IE	8	9	12	10	10	12	16	10	10
BE	16	14	9	15	11	13	6	13	15
HR	14	12	14	13	14	8	14	12	12
BG	12	15	18	12	16	7	19	7	14
LT	9	13	21	11	15	16	21	11	11
ES	19	17	11	17	12	18	7	18	16
CZ	15	11	15	14	13	24	17	23	13
HU	20	18	16	19	18	17	8	16	17
EE	13	20	24	16	22	10	25	5	18
PL	23	16	10	21	17	19	11	24	19
LV	17	19	23	18	20	14	24	9	20
PT	21	21	17	22	19	22	18	19	21
IT	24	25	19	25	21	20	13	17	25
CY	18	22	26	20	25	21	26	14	22
SI	22	23	22	23	23	23	22	22	23
SK	25	24	20	24	24	25	20	26	24
EL	26	26	25	26	26	26	23	25	26
R2adj.	0.82	0.85	0.84	0.84	0.83	0.75	0.73	0.78	0.85

Source: Own calculation based on SBS data for 2016.
Note: Country (μ_c) and sectoral (μ_s) effects are estimated for each size indicator following: $size_{c,s} = \mu_c + \mu_s + \varepsilon_{c,s}$. Indicator 'sh10' with inverted sign. LU and MT not included.

At sectoral level, manufacturing, support activities and transport services appear systematically on top of the ranking across all indicators, showing either larger employment shares for bigger firms or a higher size average (or both), whereas the opposite happens for construction and professional activities. Since the determinants behind this characterization are mainly given by inherent aspects of sectors that are common across Member States, such as the intensity of technology or physical capital (Kumar et al., 1999), we see limited interest at this point to elaborate more on this topic with a policy purpose.

We focus instead on explaining the country effects shown in Table 21, which Kumar et al. (1999) estimates to be the result of the market size, human capital and judicial efficiency. Accordingly, we use a broad set of indicators to account for the estimated country effects, ranging from country size and economic development, to educational attainment and institutional variables, such as regulation, labour relations or government and judicial efficiency.

Table 22 shows results of regressions on the country effects for each firm size measure using the country size (log of population) as control variable and one additional indicator. Sign interpretation is based on the expected relationship with economic development, i.e. higher education, less restrictive regulation and higher government and judicial efficiency for countries with higher GDP per capita.

Table 22. Estimated sign and significance of country effects explaining different firm size indicators.

Firm size	1	2	3	4	5	6	7	8	9
indicator >>>	**(-)sh10**	**sh50**	**sh250**	**rsh50_10**	**rsh250_10**	**savg**	**wavg**	**savg_c**	**wavg_c**
Population as single explanatory variable									
Sign&significance	**+**	**+***	**+*****	**+**	**+****	**+**	**+*****	**+**	**+**
R2adj.	0.02	0.12	0.39	0.06	0.22	0.12	0.46	0.01	0.10
Including Population as control									
GDP per capita	**+****	**+****	**+****	**+****	**+*****	**+**	**+***	**+**	**+****
	0.21	0.30	0.54	0.26	0.43	0.20	0.53	0.06	0.30
EDU	**+****	**+*****	**+*****	**+*****	**+*****	**+***	**+***	**+**	**+*****
	0.24	0.38	0.57	0.31	0.45	0.24	0.53	0.09	0.36
EWR	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**
	0.11	0.20	0.44	0.16	0.30	0.17	0.50	0.05	0.19
FDIR	**+**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
	0.02	0.12	0.40	0.06	0.22	0.13	0.46	0.01	0.10
EPL	**+**	**+**	**+**	**+**	**+**	**+**	**+***	**-**	**+**
	0.02	0.14	0.45	0.07	0.24	0.13	0.54	0.01	0.12
GVWB	**+****	**+****	**+***	**+****	**+****	**+****	**+**	**+****	**+****
	0.25	0.31	0.46	0.29	0.36	0.33	0.51	0.20	0.30
IPRI	**+*****	**+*****	**+*****	**+*****	**+*****	**+****	**+*****	**+***	**+*****
	0.41	0.51	0.67	0.47	0.61	0.29	0.61	0.13	0.51
ENFC	**+****	**+****	**+***	**+****	**+****	**+****	**+**	**+****	**+****
	0.27	0.28	0.46	0.28	0.38	0.32	0.49	0.24	0.30
GVTEF	**+*****	**+*****	**+*****	**+*****	**+*****	**+***	**+*****	**+**	**+*****
	0.32	0.42	0.62	0.38	0.53	0.23	0.60	0.08	0.42
REGQ	**+*****	**+*****	**+*****	**+*****	**+*****	**+*****	**+****	**+****	**+*****
	0.48	0.54	0.62	0.52	0.60	0.35	0.58	0.20	0.54
RLAW	**+*****	**+*****	**+*****	**+*****	**+*****	**+****	**+*****	**+***	**+*****
	0.44	0.54	0.70	0.50	0.64	0.29	0.63	0.13	0.54
1st Pcal.Comp.	**+*****	**+*****	**+*****	**+*****	**+*****	**+****	**+*****	**+***	**+*****
	0.43	0.53	0.66	0.49	0.60	0.33	0.61	0.16	0.52

Note: Sign, significance (*90 %, **95 %, ***99 %) and degree of adjustment using as dependent variable the previously estimated country effect ($\hat{\mu}_c$) and as explanatory variables the country size (log of population, POP_c) and one additional variable (X_c) in standardized units (except for GDP per capita, in logs), following $\hat{\mu}_c = \alpha \times POP_c + \beta \times X_c + \epsilon_c$. Indicator 'sh10' with inverted sign. Population and GDP per capita sourced from Eurostat, Education Index (EDU) from UN, Economy Wide Regulation (EWR), FDI Regulatory Restrictiveness (FDIR) and Employment Protection Legislation (EPL) from OECD, Government Participation in Wage Bargaining (GVWB) from ICTWSS database, Government Effectiveness (GVTEF), Regulatory Quality (REGQ), Rule of Law (RLAW) and Enforcing Contracts (ENFC) from World Bank, and International Property Rights Index (IPRI) from Property Rights Alliance. '1st Pcal.Comp.' corresponds to the first principal component for all explanatory variables except population and GDP per capita.

A number of interesting features are worth highlighting. First, the country size variable is only significant when explaining country effects for firm size indicators capturing the presence of largest enterprises, such as the share of firms with 250 or more persons employed ('sh250') or the employment-weighted average firm size ('wavg'). Second, the degree of economic development – measured here by the GDP per capita – and the level of education (EDU) seems to be more relevant to explain the distribution of firms rather than the simple average. Third, the OECD restrictiveness indicators (i.e. EWR, FDIR and EPL) show the lowest significance and explanatory power among regulatory variables, in contrast with the government participation in wage bargaining (GVWB) and the more general regulatory quality (REGQ) and government effectiveness (GVTEF, which includes, among other issues, the quality of public services). Four, variables relative to the judicial area are significant explaining country effects, particularly the protection of property rights (IPRI) and the overall rule of law (RLAW). And five, institutional variables that are significant show in general the largest explanatory power for indicators related to largest firms, but they add more relative to GDP per capita regressions when including other firm size classes or estimating size averages.

Another dimension that might be worth analysing is the unexplained part of country-sector indicators (i.e. once country and sector effects have been removed following estimations shown in Table 21). The purpose of this exercise would be to identify strong deviations from the expected value given by country and sector effects. According to preliminary analysis, there are a number of cases in which either the employment share of firms or their average size (or both) deviate significantly from the estimated value. The goal of further research would be to disentangle whether these deviations stem from specific factors affecting a particular sector in that country (such as regulation, or size-dependent policies as studied by Guner et al., 2008), or from the interaction of country and sector determinants, as found by Kumar et al. (1999) for patent protection and R&D intensity or judicial efficiency and capital per worker. A particular field of interest are the so-called 'correlated distortions' – i.e. a positive relation between productivity and the degree of misallocation, which are found to have a detrimental effect on firm size by Bento and Restuccia (2018).

8 Labour dynamics, zombie firms and productivity: a firm-level data analysis

8.1 Labour dynamics and productivity

8.1.1 Employment flows and firm-level productivity

A key question regarding productivity growth is its distribution across firms. Do labour resources flow to the most productive companies? Do the least productive companies become smaller in size and hence allow for more productive companies to hire? Can newly established companies grow? In order to answer some of these questions, we look at firm level data.

In this section, we investigate firm-level labour productivity and its connection to employment flows: job creation and destruction. We rely on a representative sample based on ORBIS, a firm level databank collected and maintained by Moody's Analytics. Our sample covers the period 2007-2013[120] and includes the following countries: Belgium, Bulgaria, Denmark, Germany, Estonia, Spain, France, Croatia, Italy, Hungary, Portugal, Romania, Slovenia, Finland and Sweden. The inclusion of countries is contingent on the availability of firm level information allowing productivity measurement as well as the representativeness of employment. The final sample contains about 4.8 million firms and over 28 million observations from both the manufacturing and service sectors.[121]

8.1.2 Productivity distribution of job creation and destruction

Figure 46 reports the share of jobs created/destroyed by companies at various quantiles of the labour productivity distribution. Where we measure the labour productivity of a firm in our sample by calculating its real value added per employee[122] and we sort the firms in function of their productivity within a country and in a year and define job creation as the sum of jobs gained by growing firms, and job destruction as the sum of jobs lost by shrinking firms.[123]

We observe that current labour reallocation dynamics are in line with an economy that is increasing its allocative efficiency. Allocative efficiency suggest that more jobs are held by more productive firms. We see allocative efficiency increase if jobs flow to more productive firms as displayed in Figure 46. It shows that over two thirds of job creation is attributable to firms in the top productive half of the firm population. Firms in the top quarter of the productivity distribution alone contribute to about 40 % of job creation. At the other end, firms in the productivity lower half contribute to about 55 % of job destruction.

[120] The end of the sample period is determined by the last representative year common across all countries. We omit the last two years to better model exit.

[121] For details, see Hallak and Harasztosi (2019).

[122] Real value added is calculated using OECD-STAN sector level GDP deflators with the base year of 2010.

[123] We observe only net job flows of each firms: growing (shrinking) firms are those who hire more (less) than fire.

Figure 46. Job creation and destruction along the productivity distribution.

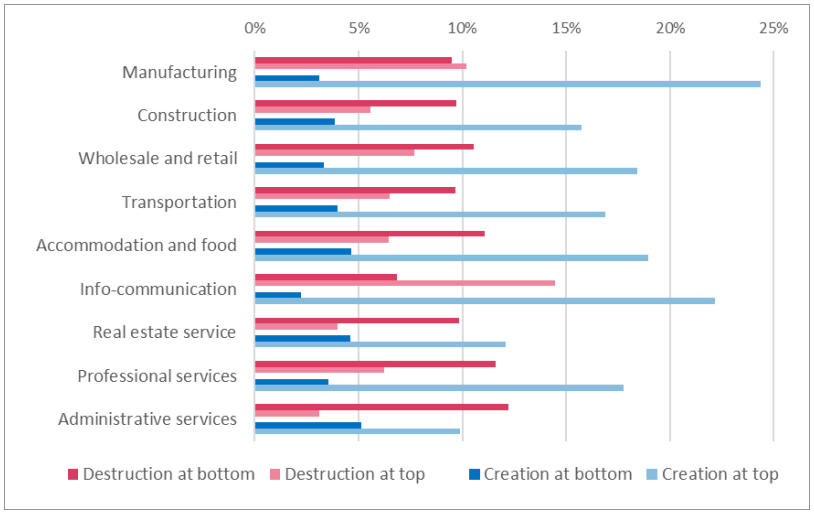
Note: The figure shows the share of jobs created/destroyed by the companies in various parts of the distribution of lagged productivity. The shares represent averages across countries over the sample period. Job creation is the total employment increase of growing firms, while job destruction is the total employment decrease in shrinking firms.

One can look at the productivity distribution of job creation and destruction by sector as well. Here, the relative asymmetric of the distribution would tell us in which sector labour flows from less to more productive firms to a greater extent. Figure 47 looks at the tails (top and bottom) of the productivity distribution of Figure 46 by sector. In red we show the destruction shares, in blue the creation shares are depicted.

We find that i) sectors differ considerably in the destruction and creation shares of the most and the least productive firms, ii) the job creation shares of the most productive firms ranges between 10 % to 25 %. The creation shares of the least productive are between 2 % and 5 % only. The gap between the top and the bottom shares within industry is large, 14 percentage points on average. Note that the high creation share at the top and the low at the bottom is indicative of a competitive industry where reallocation is productivity enhancing. We find that Manufacturing and Info-Communication sectors exhibit this feature the most. On the other end of the spectrum are the Administrative services. In this sector the share of low productivity jobs created is the highest and share of top productivity jobs created is the lowest across sectors in the sample.

iii) In the case of destruction, the gap between the shares at the top and the bottom is lower than in the case of job creation. It is 3 percentage points on average, and is of opposite sign: destruction at the bottom is higher. This suggests that low productivity firms are responsible for higher share of job destruction, which can be taken as a sign of creative destruction. The only sector where the share of destruction at the top is high is Info-Communication, which can be an indication of a churning at the top: quick entry and exit of very productive firms. The manufacturing sector exhibits a similar pattern: the share of job destruction at most productive is the second highest across the sectors.

Figure 47. Job creation and destruction by sector at the tails of the productivity distribution.

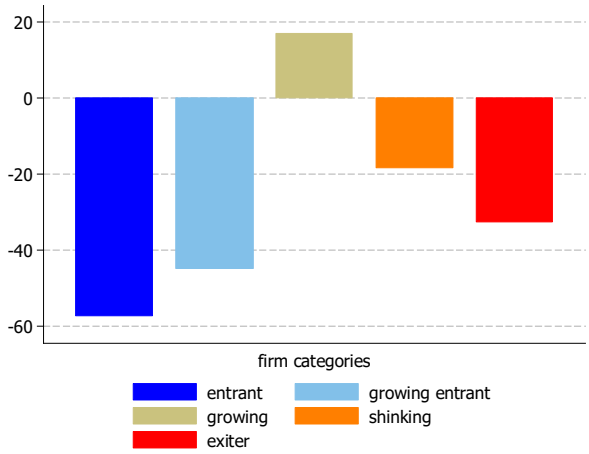


Note: The figure shows the share of jobs created/destroyed by the companies in the top (above p90) and bottom (below p10) parts of the productivity distribution. The shares represent averages across countries over the sample period. Job creation is the total employment increase of growing firms, while job destruction is the total employment decrease in shrinking firms.

8.1.3 Entrants are less productive than incumbents

Figure 48 shows the productivity gap of firms where employment is hired or fired with respect to stable firms, where employment change is zero. In order to gain further insights about the impact of the labour reallocation on productivity, we add entering and exiting firms in our sample.

Figure 48. Relative productivity of firms by growth status.

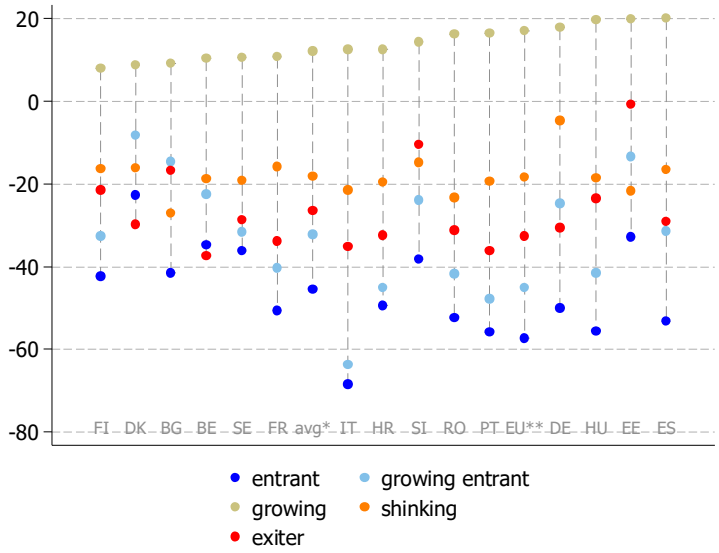


Note: The figure shows the relative labour productivity of firms classified by their growth compared to non-growing firms. The values are obtained from regression analysis where labour productivity levels are explained by growth status and controls for country, year and firm size.

We find that firms that enter the market are nearly 55 % less productive than stable firms. Note, though, that entering firms may thrive and grow fast later, but also tend to fail shortly after birth. Therefore, we look at those entering firms that survive and grow, and compare their productivity in their first year with other entrants. These "growing entrant firms" report higher productivity than other entrants, however it still takes time for them to catch up with incumbents. We investigate this in detail below, later.

We also find that growing firms are 17 % more productive than stable firms on average, while shrinking firms are 18 % less productive. In addition, we also find that the productivity of exiting firms is on average 32 % lower than that of stable firms.

Figure 49. Cross-country comparison of relative productivity of firms by their growth.



Note: The figure shows the relative labour productivity of firms classified by their growth compared to non-growing firms. The values are obtained from regression analysis which controls year and firm size and is carried out by country.
* shows values averaged across countries.
** replicates the results shown in Figure 48.

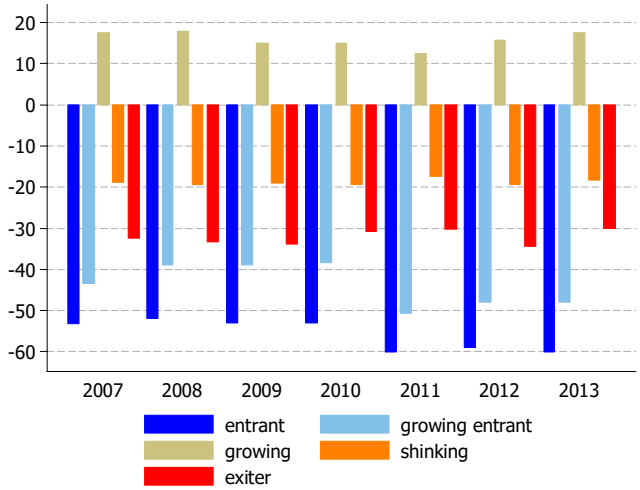
Figure 49 reports the analysis at the country level. Countries show considerable heterogeneity in the productivity differences across firm types by growth, except for growing firms, albeit there is evidence on productivity enhancing reallocation in all of them: in all countries the growing companies are the most productive and their labour productivity is 8 % to 20 % higher than that of non-growing firms. In addition, entrants and shrinking firms are less productive than stable firms in all countries.

While we find evidence of productivity enhancing labour reallocation in all countries, as in all countries labour flows increase allocative efficiency as more productive firms grow, least productive shrink and exit. We do not find however simple cross-country correlations between the margins. That is, i.e. relative low productivity of shrinking firms does not explain or go together the relative high productivity of growing firms or vice versa.

Figure 50 reports cross-country result analogously to Figure 48 in each years in our sample. The results suggest that even though the relative productivity difference across firms change slightly over time, the differences across groups remain mostly stable and significant. Besides, the relative high productivity of growing firms decreased between 2009 and 2011, but is growing since then. We find the opposite for exiting firms, while the relative low productivity of shrinking firms is stable over time.

The most remarkable finding is that productivity of entrants has substantially dropped relative to stable firms: in the 2007-2010 period, entrants were 53 % less productive than stable firms on average; 60 % in the period 2011-2013.

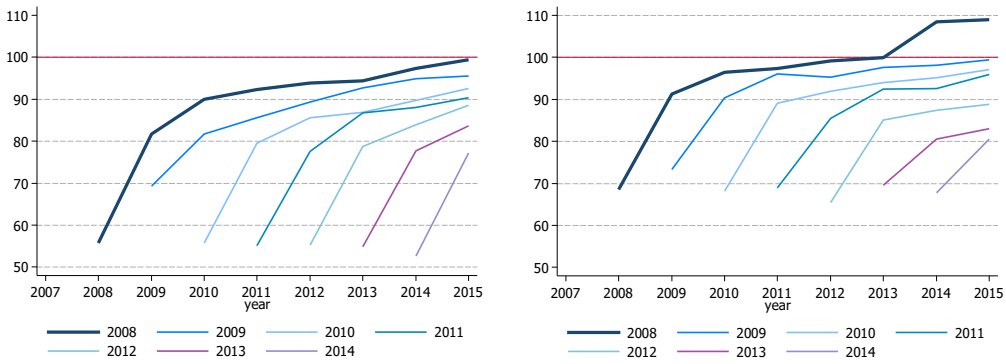
Figure 50. Relative productivity of firms by growth status over time.



Entrants are less productive than incumbents and it takes them time to learn how to best operate and live up to their full potential. Their productivity gap is still detectable if we know they will grow in employment in the next year. To estimate how much time for the entrants it takes to catch-up, we report the timeframe of their productivity gap with respect to incumbents in Figure 51.[124]

We follow the same cohort of firms and each line shows a statistic about the productivity distribution of the surviving firms in a year. The left Panel (a) of Figure 51 compares the median of the productivity distributions of entrants by generations to the median of productivity of the firms which entered before 2008. The latter serve as the comparison group and takes on the value of 100 in each year and is depicted by the red horizontal line.

Figure 51. Productivity of entrants over time relative to incumbents.



Panel (a): Comparison of medians

Panel (b): Comparison of top deciles

Note: Each line tracks the productivity gap of a cohort of new entrants compared to incumbent firms (created before 2008). Panel (a) compares the gap between the median productivity of entrants and incumbent firms (the latter being depicted by the horizontal red line). Panel (b) reports the gap between the top 10 % of the productivity distribution of entrants and incumbent firms (the latter being depicted by the horizontal red line).

The median productivity of firms entering in 2008 is less than 60 % of the median incumbent. While, within one year this gap decreases significantly to the 80 % of the incumbent, it takes 6 years for the median to reach the productivity for the incumbents. The median productivity of every new generation converges to the productivity of the previous entrants: either via individual productivity growth or the through the exit of the least productive firms.

[124] It is important to note that the definition of productivity gap in this study does not refer to the gap from the frontier.

Right Panel (b) of Figure 51 compared the top decile statistics of the productivity distributions of cohorts and incumbents across the years. That is, it shows the productivity gap of the top 10 % entrant firms with the productivity of the top 10 % most efficient, previously existing firm. The most productive entrants catch up to productivity frontier faster and even exceed the productivity of the incumbents. The most productive entrants in 2008 report productivity worth 70 % of most productive incumbents. Within a year their productivity increases such that it reaches the 90 % of the incumbents and in 4 years their productivity exceeds those of the best incumbents. We find, however, that newer generations take more and more time to converge: while the oldest generations reach 90 % on the productivity of top incumbent in their second year, newer generations only reach 80-85 %. This finding is in line with that of Andrews et al. (2015) who find that newer cohorts have more difficulty to catch up.

In this section, we have looked at the relationship between firms' employment dynamics and productivity. We have found evidence for the presence of productivity enhancing reallocation and creative destruction. The productivity difference across firms who hire or fire is detectable across countries, however the extent of differences differs greatly. We find after the 2009 crisis the average productivity of entrant firms is lower compared to other firms as before. However, successful entrants overcome this gap within a few years.

8.2 Impact of zombie firms on productivity

In this section, we look at the prevalence of zombie firms using ORBIS firm level data for European countries and their possible effect on productivity. This note is an extension to our work on zombie firms (Hallak et al., 2018) and is based on the sample of firms constructed to investigate labour dynamics in Europe (Hallak and Harasztosi., 2019). The sample includes the following countries over the period of 2006-2015[125]: Bulgaria, Czech Republic, Denmark, Germany, Spain, France, Italy, Latvia, Portugal, Romania, Slovenia, Slovakia, Finland and Sweden.

The sample excludes countries for which information about firms is insufficient, i.e., interest payments and/or profits are missing. These data requirements result in the exclusion of the following countries: Austria, Belgium, Croatia, Estonia, Hungary, and Lithuania. Remaining EU countries have been excluded due to insufficient representativeness.

8.2.1 Zombie firms: definition and performance

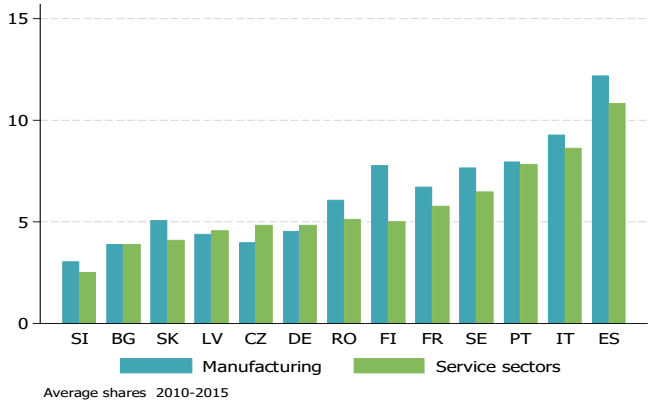
Zombie firms are firms financially supported by banks, which would be non-viable otherwise. In this note, we follow Adalet McGowan et al. (2017) and define zombies as firms which are at least ten years old and report interest coverage ratio below one in three consecutive years. Interest coverage is the ratio of profits before interest payments, taxes and depreciation (EBITDA) over interest payments. Interest coverage ratio below one thus suggests that the firm is unable to generate sufficient cash in order to pay out its debt interest obligations three years in a row, let alone the debt principal obligations. Because creditors could alternatively opt for the liquidation of the firm, this suggests that they receive re-financing support.

In recent years, zombie firms have become significant in Europe. In the aftermath of the crisis, our sample detects that the share of zombie firms was especially high in Portugal, Italy and Spain. In the latter case share of zombie firms exceeded 10 %, on average, both in the service and manufacturing sectors. See Figure 52 for cross-country comparison of zombie shares.[126]

[125] The end of the sample period is determined by the last representative year common across all countries.

[126] Data suggest that share of zombies are declining in IT, ES and PT after 2013.The trend is the most detectable where firms show both deleveraging and increased profitability.

Figure 52. Average share of Zombie firms between 2010 and 2015.



Beyond the support of bankers, low interest coverage ratios suggest poor performance of zombie firms. This is detectable in Table 23, which compares zombies to other indebted non-zombie firms using a regression analysis across the sample of firms. We find that zombies have both lower labour and total factor productivity (TFP)[127]. In addition, create less jobs and invest less in capital.

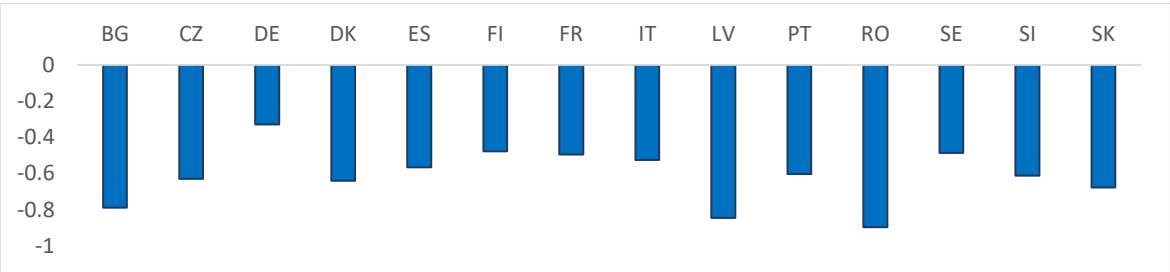
Table 23. Poor performance of zombie firms in European countries.

Variable	Employment Growth	Investment Rate	Labour Productivity	Total Factor Productivity
Zombie	-0.113***	-0.117***	-0.451***	-0.485***
	(0.000)	(0.000)	(0.002)	(0.002)
Observations	10,457,077	11,283,453	10,989,731	10,255,375

Note: OLS estimates of the performance of firms. All estimates include firm size category, year, sector and country controls. Dependent variables in the first row: Employment growth is measured as 2*(et-et-1)/(et+et-1) where et is employment stock of the firm in year t, investment rate as log change in real capital. Productivity measures are in logs, which implies that -0.451 parameter estimate suggest at zombie firms are 36 % less productive using the eb-1 formula.
*** denotes significance at the 1 % level. Standard errors are in parentheses.

The poor productivity performance also suggests that the larger the share of zombies in an economy, the lower the productivity. The lower productivity of zombies is detectable in all the countries in our sample. Figure 53 compares the productivity of zombies with that of non-zombie firms and shows that zombie firms are substantially less productive in all countries. We observe some cross country variation: in Germany, zombie firms report 30 % lower productivity on average, while in Romania the gap amounts to nearly 90 %.

Figure 53. Relative total factor productivity performance of Zombie firms.



Note: Each column shows parameter estimates from separate regressions run at the country level controlling for firm size, year, and sector. Each bar represents the average productivity gap between zombie and non-zombie firms. For instance, in Bulgaria, zombie firms report 80 % lower productivity with respect to non-zombie firms.

[127] We measure labour productivity as real value added per worker, while TFP is measured using the method proposed by Wooldridge (2009), except for Denmark where due to the lack of data availability on materials used we rely on firm fixed effects estimation.

8.2.2 Zombie congestion negatively impacts other firms

A major policy concern related to the existence of zombie firms is their impact on the rest of the economy. In particular, some authors argue that zombie firms may prevent productive resources to be funnelled to other, more productive firms, especially new entry firms in the sector. Consequently, their prevalence may be a hurdle to the creative destruction process and the productivity enhancing reallocation of resources. When non-zombie firms are affected by the presence of zombies, this phenomenon is referred to as zombie congestion in Adalet McGowan et al. (2017).

The effects on non-zombies

Table 24 investigates the impact of the share of the resources held by zombies on the performance of non-zombie firms. We measure the industry zombie share as the share of real capital held by zombie firms within a 2-digit NACE sector in a year and include sector-year fixed effects to capture aggregate shocks to the sector[128]. The results suggest that the larger the industry zombie share is, the more likely it is that the performance of non-zombie firms is lower.

In order to capture the economic significance of the congestion, we compute the effect of the Industry zombie share variable at median and top quartile values.[129] The computed effects at median and top quartiles are reported in the bottom lines of Table 24. The effects of the zombie congestion are the largest in the case of labour productivity: in a sector with a median level of zombie share, non-zombie firms are 4.8 % less productive compared to non-zombie firms active in a sector without zombies.

Table 24. The effects of zombie congestion on non-zombies.

Variable	Employment growth	Investment rate	Labour productivity	TFP
Non-zombie	0.0203***	0.0814***	0.613***	0.606***
	(0.001)	(0.001)	(0.003)	(0.003)
Non-zombie × Industry zombie share	-0.0340***	-0.315***	-0.906***	-0.642***
	(0.010)	(0.009)	(0.033)	(0.032)
R^2	0.109	0.049	0.511	0.740
Observations	9,768,728	11,262,951	10,853,346	10,236,654
Congestion at p50	-0.2 %	-1.7 %	-4.8 %	-3.5 %
Congestion at p75	-0.3 %	-2.6 %	-7.3 %	-5.2 %

Note: Each column shows results from separate regressions. They include controls for firm size, year, sector and country controls. Dependent variables in the first row: Employment growth is measured as 2*(et-et-1)/(et+et-1) where et is employment stock of the firm in year t, investment rate as log change in real capital. Congestions refer to the percentage difference in the outcome variable between non-zombies in sector with median or p75 zombies share and those in sectors without zombies.
*** denotes significance at the 1 % level. Standard errors are in parentheses.

The zombie congestion varies considerably by sectors and also across countries. Figure 54 combines results from regressions executed at the country and macro-sector levels. This latter allows us to compare results for the manufacturing and service sectors. The figure shows results for two outcome variable labour productivity (LP) and total factor productivity (TFP), where each column shows the effects of congestion on non-zombie firms at the p75 industry zombie share levels.

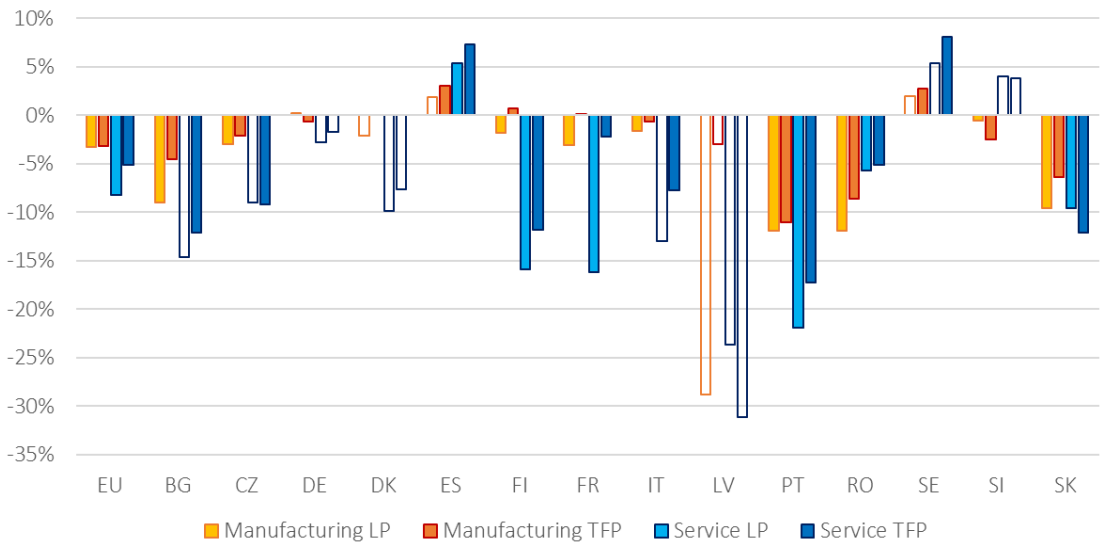
Figure 54 reveals that: i) congestion effects are mostly negative except for Spain and Sweden;[130] ii) both labour productivity and total factor productivity measures show similar results; iii) the congestion effects for the Service sectors are higher than in the case of Manufacturing in most countries; iv) we find the largest congestion effects in the service sectors are detected in Portugal, Finland and Slovakia. This does not necessarily correspond the list of countries with zombie prevalence suggesting other, unobserved factors at play.

[128] Note that by this approach the zombie share itself is absorbed and we measure only the relative effect of zombies on healthy firms compared to zombies. See Schivardi et al. (2017) for details and another approach.

[129] In our aggregate sample the median Industry zombie share is 5.4% and the top quartile is 8.3%.

[130] Positive congestion effects on TFP can be explained by the idea that banks will only finance the best ideas of the non-zombie firms hence zombies can create positive selection effects. See Adalet McGowan et al. (2017).

Figure 54. Zombie congestions by country –disadvantage of non-zombies in p75 zombie shares.



Note: Each bar represents the economic significance of the impact of the zombie congestion on non-zombie firms TFP at EU aggregate and country level by macro-sectors. In each country, we rank NACE2 industries by their Industry zombie share and evaluate at p75. Empty bars show that regression results were not significant at even 10 %.

The effects on young firms

Does zombie congestion further hit the younger firms? In general, young firms are more likely to be more dynamic, they create more jobs and search for new resources. The impact on young firms is of high policy relevance, since the young firms' growth potential is an essential part of the creative destruction process and efficient reallocation of resources.

In order to investigate the phenomenon, we complement the model used in Table 24 by introducing interaction terms with young firm dummies(less than six years old firms).The new results are reported in Table 25.

We find that young non-zombies are affected by zombie congestion differently than older non-zombie firms. A young non-zombie firm is affected less by congestion than an old zombie firm in the case of employment and investment. When evaluated at the median level zombie share of capital, young non-zombies do not seem to be affected negatively by congestion as for job creation.

Table 25. Effects of zombie congestion on young firms.

Variable	Employment growth	Investment rate	Labour productivity	TFP
Non-zombies	0.0225***	0.0852***	0.602***	0.597***
	(0.001)	(0.001)	(0.003)	(0.003)
Non-zombies × Industry zombie share	-0.0197*	-0.301***	-0.727***	-0.506***
	(0.010)	(0.009)	(0.033)	(0.032)
Non-zombies × Young	0.0883***	0.129***	0.0415***	0.0282***
	(0.001)	(0.001)	(0.002)	(0.002)
Non-zombies × Industry zombie share × Young	0.0527***	0.139***	-1.218***	-0.903***
	(0.013)	(0.014)	(0.023)	(0.022)
R^2	0.112	0.054	0.512	0.740
Observations	9,768,728	11,262,951	10,853,346	10,236,654
Congestion at p50 for young firms	0.2 %	-0.9 %	-10.1 %	-7.4 %
Congestion at p75 for young firms	0.3 %	-1.3 %	-15.0 %	-11.1 %

Note: *** and * denote significance at the 1 % and 10 % levels, respectively. Standard errors are in parentheses.

However, young non-zombie firms show lower productivity performance in sectors with high zombie shares than old non-zombie firms do. When comparing firms across zombie-free sectors to those with 8.4 % zombie shares (p75), young non-zombies show 15 % lower labour productivity and 11 % lower total factor productivity than old non-zombies.

Table 26. Effects of zombie congestion on young firms by sector.

	Employment growth	Investment rate	Labour productivity	TFP
Manufacturing				
Congestion at p50 for young non-zombies	-0.30 %	-0.40 %	-4.60 %	-5.00 %
Congestion at p75 for young non-zombies	-0.40 %	-0.60 %	-6.50 %	-7.10 %
Services				
Congestion at p50 for young non-zombies	0.60 %	1.00 %	-7.50 %	-5.50 %
Congestion at p75 for young non-zombies	0.90 %	1.50 %	-11.10 %	-8.20 %

Finally, Table 26 looks at the zombie congestion on young firms by sector. Showing only the regression results evaluated at two moments of the distribution reveals important differences between the Manufacturing and Service sectors. While in the case of Manufacturing the congestion on young firms effects all outcomes negatively, in the case of service sectors Employment and Investment are positively affected. This shows not only the heterogeneity hidden in the aggregate results of Table 25, but also indicates that in the service sector higher zombie share correlates with the creation of jobs and investments of lower productivity.

In conclusion, above results imply that zombie congestion has important job creation and reallocation implications. Healthy young firms are the fountainhead of job creation and our results suggests that zombie congestion has only a small effect on this phenomenon. However, our results also imply that in zombie ridden sectors the jobs created by young firms are low productivity jobs.

9 Conclusions

It is commonly admitted that growth has slowed down in Europe since the mid-1990s partly due to poor labour productivity performance. The reasons for this underperformance in productivity are manifold. This report has aimed at, first, briefly summarising the current state of play and the most recent productivity developments in the EU as well as providing a thorough overview of the most salient potential explanations behind such productivity slowdown that have been put forward in the related literature. Second, it has presented in-depth quantitative analyses on a range of topics which are commonly acknowledged as the most prominent around the issue of productivity stagnation. In what follows a concise recapitulation of the main findings and policy messages contained in the report is offered.

A comprehensive literature review of academic contributions on the matter has shed light on some prominent factors behind the puzzle. TFP growth, which is considered to be a key determinant of labour productivity growth, did not experience a substantial boost despite a more extensive use of ICTs and a better skilled workforce. Thus efficiency gains brought about by technological change did not materialise into higher productivity growth in Europe. This is particularly true for ICT-intensive sectors such as wholesale and retail trade, and business and professional activities. Relatively poor performance in these service subsectors partly explains the diverging gap in aggregate labour productivity between the EU and the US. On the link between internationalisation and productivity growth, there is some evidence pointing to trade playing a potentially larger role for productivity gains within services than within manufacturing. Concerning the relationship between service regulation, measured through product market regulation indicators, and productivity, the collected evidence shows that aggregate effects are negative and quantitatively important, and can help explain the extant wide productivity differentials between OECD countries in that sector. However, it appears more difficult to evaluate the productivity impact of labour market reforms, given the relative complexity of the policy mix in this case. When looking at whether measurement issues can represent a large part of the puzzle, it is difficult to conclude to what extent this issue is prevalent and relevant in the European context, given very limited (empirical) research on the topic. However, it is likely that there exists large heterogeneity across EU countries in the size of mismeasurement, due to different diffusion rates of digital technology as well as divergences in methodological approaches between national statistical offices.

Unveiling the link between the process of secular structural change and productivity growth is an area that has attracted research interest, especially in the context of advanced economies. For most countries in the EU-15, we observe that the increase in the economic weight of low-productivity services has ultimately contributed to lower aggregate long-run labour productivity growth. Importantly, however, services are not a homogeneous block in terms of productivity performance, and some subsectors such as ICT have exhibited growth rates in labour productivity as high as those in the primary and secondary industries. The EU might be converging to a new paradigm in which slower productivity growth stems from large shifts in demand away from manufacturing and other goods toward more productivity-stagnant services.

Turning to the interplay between labour hoarding, firms' churn rates and productivity developments over the business cycle at the sectoral level, TFP growth is observed to be in general more synchronized with output growth than labour productivity growth, due partly to the use of labour hoarding as an instrument of adjustment. Furthermore, the enterprise churn rate is generally associated with higher labour productivity; too steep a rise in business dynamism is linked with lower labour productivity growth, especially when combined with labour over-utilisation. This indicates that caution should be exerted with regard to policies that aim at increasing business dynamism as much as possible, since its impact on labour productivity growth might be maximised within moderate ranges. Labour hoarding (conversely, labour over-utilisation), can help cushion the negative effects of excessive (conversely, insufficient) business dynamism on labour productivity growth..

The government is an important actor in the economic system which can play a crucial role by stirring investments towards its most productivity-boosting uses. This can be materialised through different channels, such as directly affecting output growth or indirectly through fostering a better quality labour force. Indeed, better educated and skilled workers are expected to be more productive. In the literature, education and skills are often presented as one the main sources for labour productivity growth. However, these factors are currently unable, on their own, to explain most cross-country variation in productivity growth. In this report we have shown that the current short time series data available does not allow detecting any significant impact

of higher expenditures on education[131], pointing to the need for more complete data to critically analyse the medium to long term expected effect of education expenditures on productivity.

By contrast, public expenditures related to economic affairs and better institutions (control of corruption and the rule of law) can support productivity enhancing framework conditions. Their positive effects on productivity growth are expected to be more immediate, thus more easily quantifiable with short term series, which is actually the case in our analysis for market services. The time lag dimension is therefore crucial when analysing the potential impact of different public expenditures.

The vital role of general investments for generating productivity growth is a well-established fact. Intangible investments are nowadays higher in Europe than investments into tangible assets, and the analysis presented in this report shows that not only are intangible investments an important driver of labour productivity growth but also the type of intangible assets matters. Indeed, National Accounts intangibles such as software and R&D are instrumental in manufacturing industries while non-National Accounts intangibles such as design, brand, organisational capital and training are a major contributor to productivity growth in services. As a consequence, this calls for a better account of non-National Accounts intangibles.

By exploiting a larger information set, firm-level analyses are able to shed light on issues not captured by studies based on more aggregate levels of analysis. For example, business dynamism at the firm level is a well-known important determinant of productivity growth. Births and deaths of firms, reallocation of resources across firms, productivity of entrant and exiting firms, and the role of small vis-à-vis large firms in productivity growth are all relevant topics for research. At the same time, these topics usually rank high on the policy agenda, as there seems to be a direct link to the regulatory framework. Indeed, product and labour market regulation may create or alleviate barriers to entry, may hamper or facilitate reallocation and may increase or decrease the legal and administrative burden on small firms relative to large ones.

One such firm-level analysis presented in this report shows that productivity gaps across Member States are closely related to differentials in average productivity levels within firm size classes within sectors. Sectoral composition effects (i.e. those due to intrinsic differences in sectoral productivity levels) or the impact of firm size distributions by sector (i.e. those due to intrinsic differences in firms' productivity levels owing to size) play overall a minor role in explaining aggregate productivity differences. Nevertheless, the firm size distribution has a significant negative impact on productivity in Southern European countries such as Greece, Italy, Portugal and Spain, where companies tend to be smaller compared to other Member States. Our analysis also shows that firm size distributions are largely influenced by the institutional framework, with judicial and government efficiency being strong determinants for increasing firm size.

High levels of creative destruction and reallocation of employees toward more productive firms are considered to be important mechanisms of well-functioning markets. Another firm-level data analysis seems to confirm that such mechanisms are in place in Europe: less productive firms destroy more jobs than more productive firms while more productive firms create more jobs than less productive firms. However the extent to which these mechanisms are at play varies greatly both across sectors and countries. We also observe a widespread decline in firm entry rates in services over the last decade across Europe, with this decline being more country specific than sector specific. This lower dynamism ultimately represents a drag on productivity growth. More effort is needed in Member States to remove some of the obstacles which impede seamless reallocation of the labour force, including barriers to new entrants, rigid labour market regulations, limited access to finance, but also limited opportunities for upskilling and reskilling. However, each country has a specific socio-economic context and policy environment, which implies that remedies to implement should differ from one Member State to another.

Another important aspect stemming from the firm level but affecting aggregate labour productivity is the presence in the economy of so-called zombie firms, which are stagnant firms that prevent production factors from flowing to healthy firms. This type of firms appear to be a persistent concern in some Member States, especially in Southern Europe. As our firm-level analysis shows, healthy firms are significantly negatively affected in a number of performance outcomes in zombie ridden sectors, while the younger firms, which are the source of job creation, are even more strongly impacted in terms of productivity, albeit on average, they are less affected in terms of employment and investment. With respect to the latter, there is however significant sectoral heterogeneity: in the presence of zombies, young healthy firms in the manufacturing sector create fewer jobs and are less productive while in services they tend to create more jobs but also of low productivity.

[131] The same applies to health expenditures.

This report has thoroughly discussed the most recent potential explanations provided in the literature on the factors behind the current EU productivity puzzle as well as examined in-depth some of the most salient hypotheses with novel research. The insightful results reached throughout this volume can be further expanded and complemented with a number of potentially fruitful avenues for further research.

The analysis on structural change could be deepened by investigating at higher levels of disaggregation what the impact of the different subsectors within services at the 2-digit level is. In addition, the empirical analysis conducted in this report lends itself to building a theoretical model that can determine to what extent structural change is the consequence of supply ("Baumol") versus demand ("Engels") effects. This model could then be used to project forward the paths followed by different sectors in terms of a series of outcome variables, including labour productivity.[132]

We have established that during certain downturn periods firms hoard on labour if they expect the cycle to pick up, and 'overutilise' labour once an upturn starts. This is observed taking the prevailing regulatory environment as given in the data. A potentially fruitful avenue for future research would consist of investigating how labour hoarding and business dynamism are affected by different regulatory environments. Specifically, one could exploit variation in terms of the costs of hiring and firing workers across Member States to see how labour productivity growth is ultimately affected via firms' reactions.

The key importance of investment in intangibles has been duly established in this report, but the question remains, for policy purposes, how this investment is best simulated. Human capital and employment regulation have been shown in the literature to condition intangible investment, but further research is still needed on what the main triggers and barriers to investment in intangibles are.

Lastly, on the relationship between investment in education and skills and productivity growth, it must be reckoned that this debated research question still faces many methodological issues unsolved (e.g. the measurement of skills, consideration of complementarities between inputs), which makes it hard to estimate the full extent and nature of the contribution of skills to productivity growth. As underlined in the review section, this is a field that would deserve more attention.

[132] This could be done for Member States for which there are enough reliable consumption data in the distant past.

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Annexes B: Technical annexes

Annex B1. List of industries used for the test of Baumol's theory

Table 27. Industry breakdown used for testing Baumol's theory.

Code	Sector
A	AGRICULTURE, FORESTRY AND FISHING*
B	MINING AND QUARRYING*
C	TOTAL MANUFACTURING*
10-12	Food products, beverages and tobacco*
13-15	Textiles, wearing apparel, leather and related products*
16-18	Wood and paper products; printing and reproduction of recorded media*
19	Coke and refined petroleum products*
20	Chemicals and chemical products*
22-23	Rubber and plastics products, and other non-metallic mineral products*
24-25	Basic metals and fabricated metal products, except machinery and equipment*
26	Computer, electronic and optical products*
27	Electrical equipment*
28	Machinery and equipment n.e.c.*
29-30	Transport equipment*
D	ELECTRICITY, GAS, STEAM AND AIR CONDITIONING SUPPLY*
E	WATER SUPPLY; SEWERAGE; WASTE MANAGEMENT AND REMEDIATION ACTIVITIES*
F	CONSTRUCTION
G	WHOLESALE AND RETAIL TRADE; REPAIR OF MOTOR VEHICLES AND MOTORCYCLES*
45	Wholesale and retail trade and repair of motor vehicles and motorcycles*
46	Wholesale trade, except of motor vehicles and motorcycles*
47	Retail trade, except of motor vehicles and motorcycles*
H	TRANSPORTATION AND STORAGE*
I	ACCOMMODATION AND FOOD SERVICE ACTIVITIES*
J	INFORMATION AND COMMUNICATION
K	FINANCIAL AND INSURANCE ACTIVITIES
L	REAL ESTATE ACTIVITIES
M-N	PROFESSIONAL, SCIENTIFIC, TECHNICAL, ADMINISTRATIVE AND SUPPORT SERVICE ACTIVITIES
O	PUBLIC ADMINISTRATION AND DEFENCE; COMPULSORY SOCIAL SECURITY
P	EDUCATION
Q	HEALTH AND SOCIAL WORK
R-S	ARTS, ENTERTAINMENT, RECREATION AND OTHER SERVICE ACTIVITIES
T	ACTIVITIES OF HOUSEHOLDS AS EMPLOYERS; UNDIFFERENTIATED GOODS- AND SERVICES-PRODUCING ACTIVITIES OF HOUSEHOLDS FOR OWN USE

Note: * denotes that the industry in question also corresponds to one of Hartwig's (2010) "well-measured" industries. Please note that not all the variables analysed have data for all the subsectors identified as "well-measured", thus the number of asterisks here is higher than the number of observations actually used in the econometric results shown in Table 6. Likewise, the results for "all industries" are obtained using as a disaggregated industry level as possible. Data at the 1-digit industry level in these cases is hence excluded.

Annex B2. Derivation of aggregate labour productivity growth rates.

Actual aggregate labour productivity growth rates are calculated using the sum of the thirteen one-digit industries' individual labour productivity growth rates weighted by their contemporaneous nominal value added shares. The *counterfactual* growth rates are calculated by using nominal value added shares fixed at their values at any given period instead. Algebraically,

$$APG_{agg,f} = \frac{\sum_{t=1971}^{2017}\left(\sum_{j=1}^{13} s_{j,t}\,\Delta\varphi_{jt,jt-1}\right)}{47} \quad ; \quad APG_{agg,c} = \frac{\sum_{t=1971}^{2017}\left(\sum_{j=1}^{13} s_{j,T}\,\Delta\varphi_{jt,jt-1}\right)}{47}$$

Where, respectively, $\mathrm{APG_{agg,f}}$ and $\mathrm{APG_{agg,c}}$ stand for the actual and counterfactual average productivity growth rates in the 1970-2017 period, $\Delta\varphi_{jt,jt-1}$ is the sum of each industry *j*'s individual labour productivity growth rates (in logs), $s_{j,t}$ is the nominal value added share of industry *j* in year *t*, and $s_{j,T}$ represents the nominal value added share of industry *j* at fixed year *T*. In our baseline case, *T=1970*. The size of the structural change effect is thus given by the difference between these two average productivity growth rates:

$$APG_{agg,f} - APG_{agg,c} = \frac{\sum_{t=1971}^{2016}\left(\sum_{j=1}^{13}(s_{j,t} - s_{j,1970})\Delta\varphi_{jt,t-1}\right)}{47}$$

Annex B3. A simple approach for uncovering the relationship between productivity growth and intangible investment

Here we present the result of a simple approach to link productivity growth with intangible investment. As a robustness check of the results in Section 4, this is a useful exercise considering the high number of assumptions needed to perform the production function estimation. We estimate the following equation:

$$\Delta log\left(\frac{Y}{L}\right)_{is} = \lambda_1\left(\frac{I_{tangible}}{Y}\right)_{is} + \lambda_2\left(\frac{I_{NA\ intangible}}{Y}\right)_{is} + \lambda_3\left(\frac{I_{non-NA\ intangible}}{Y}\right)_{is} + \mu_i + \nu_s + \varepsilon_{is} \qquad (25)$$

where the dependent variable is the growth rate of labour productivity, and the explanatory variables are tangible, NA intangible and non-NA intangible investment-to-value added ratio, respectively. All the variables are averaged over the period of 1995-2015. We also include country and industry fixed-effects.

The advantage of this approach is that the capitalisation of investments is not needed, as we do not estimate a production function. As a natural consequence we do not assume a special form of the production function (Cobb-Douglas, in our case). Averaging over time is also an easy and sure method to avoid spurious regression results due to business cycle effects (productivity growth is pro-cyclical while the intangible investment-to-value added ratio tends to be counter-cyclical). The disadvantage of this approach is the reduction in sample size and the inability to control for country-industry fixed-effects. Also the functional form is ad-hoc in this case.

The results of estimating equation (25) show (see Table 28) that the relationship between labour productivity growth and both NA and non-NA intangible investment is significant and positive, even after controlling for tangible investment and country and industry fixed-effects. This means that this positive correlation is not due to time-invariant country-specific factors simultaneously influencing productivity growth and intangible investment. It is neither because of time-invariant industry-specific factors. In contrast, common time-invariant country-industry-specific factors can explain this co-movement of productivity growth and intangible investment. In this latter case the relationship is not causal.

Regressions separately for services and for the industry (this latter regression uses a very low number of observations) show (regarding both statistical significance and the point estimate of the coefficients) that NA intangibles are important only for industry while non-NA intangibles are important only for the service sector. This result is in-line with the results that we got from the production function estimations in section 6.3.

The coefficient of tangible investment is not significant in either specification. One possible explanation is that the effect of tangible investment is very different by asset typethus rendering the overall impact of this type of investment statistically insignificant. Another possibility is that different industries have different

technologies, making the coefficient differ across industries. The first case could be handled by dividing tangibles by asset types. The second case cannot be solved in this framework.

Table 28. Estimated coefficients of the simple approach.

Dep.var.: dln(Y/L)	(1)	(2)	(3)
VARIABLES	All	Serv	Ind
I_Y_tan	0.0381	0.0434	-0.00426
	(0.0283)	(0.0385)	(0.0353)
I_Y_intan_NA	0.0780	0.0532	0.151**
	(0.0479)	(0.0679)	(0.0601)
I_Y_nonNA	0.0858**	0.171**	0.0365
	(0.0429)	(0.0784)	(0.0411)
Observations	108	75	33
R-squared	0.772	0.776	0.898

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: dln(Y/L) is the (logarithmic) growth of labour productivity (value added per hours), I_Y_tan, I_Y_intan_NA and I_Y_nonNA is tangible, National Accounts intangible and non-National Accounts investment-to-value added, respectively. Column 2 and 3 are results from the estimation done on the service sectors and on the industrial sectors sub-sample, respectively. Country and sector fixed effects are always included.

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