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# A SURVEY ON CHALLENGES TO GROWTH:

# The productivity puzzle in the context of (new) growth determinants

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## Summary

The European Union and other developed countries have been struggling with declining and sluggish productivity growth compared to the emerging economies. On top of this falling productivity growth, the productivity gap between the EU and the USA measured by output either per worker or hour remains significant. This is also the case with the productivity gaps between EU economies. The productivity growth slowdown became even more apparent after the recent crisis with the slack contribution of supply-side determinants being worsened by the negative impact of demand-side factors. As a result, the productivity puzzle has become a key issue discussed in the literature and primarily also among policymakers on different levels.

The crucial question is how to boost productivity growth. Unfortunately, productivity is the outcome of a complex set of factors, some demand- and others supply-side dependent. On the demand side, factors such as the institutional environment in the broadest context, macroeconomic characteristics, technological and the business environment in general, the international links of the economy, financial markets, macroeconomic, industrial and social policies and many other factors affect the firm's performance and its behaviour as outside determinants. This behaviour constitutes supply-side characteristics. On the firm level, supply-side factors shape the company's conduct and its productivity growth. Most often, these are labour and human capital (i.e. the qualities and structure of human capital), R&D, capital, the composition of capital, allocation of resources, new technologies, intangible capital, and other. The endogenous loop of demand- and supply-side factors creates a path-dependent loop, resulting in higher productivity and ultimately quality of life.

This paper highlights the links productivity determinants have with productivity growth. Only a comprehensive understanding of the underlying bases can lead to policy solutions able to improve future productivity growth – of both existing and new growth determinants. Therefore, this paper also focuses on future research challenges, which chiefly include:

(1) Theoretical challenges: establishing strong theoretical foundations for the research into the impact of new productivity determinants.
(2) Methodological challenges: where needed, contributing to the preparation of measurement and data collection or emphasising the use of existing registry and survey data to define measurements of the new productivity growth determinants.
(3) Empirical analysis: investigating the link between the »old« and »new« productivity growth determinants and identifying their contributions to growth.
(4) Preparation of policy implications to support productivity growth and for catching up.

# A SURVEY ON CHALLENGES TO GROWTH
# The productivity puzzle in the context of (new) growth determinants

**Tjaša REDEK, Polona DOMADENIK, Daša FARČNIK, Tanja ISTENIČ, Matjaž KOMAN, Črt KOSTEVC, Jože SAMBT, Rok SPRUK, Vesna ŽABKAR[1]**

*(...) three puzzles – the recent weakness of labour productivity growth, the long-standing potential for international catch up, and presence of persistent, wide variations in the productivity of businesses – present a considerable challenge to both the academic literature and to policy-makers. (Wales, 2019)*

## 1 INTRODUCTION

Productivity growth is the key indicator of how an economy is performing in the competitive global environment (OECD, 2015) and is also directly linked to the population's rising living standards which is or should be the end goal of the growth process. This link has primarily been discussed in the literature since the 1980s (Redek & Godnov, 2019). A vast body of literature began to emerge, directly addressing the growing gap in productivity (Acemoglu & Dell, 2010; Barcenilla, Gimenez, & Lopez-Pueyo, 2019; Nelson, 1981) and the link between productivity growth and living standards (Baumol, 1986; De Long, 1988). Both the level as well as chiefly the (comparative) dynamics of productivity have become a central economics topic in developed and developing countries.

Productivity and productivity growth are concepts closely linked to economic growth and growth accounting. (OECD, 2001) states that productivity may generally be defined »as a ratio of a volume measure of output to a volume measure of input use«. Productivity estimates can be used for various purposes also because productivity may be measured in several different ways. According to the OECD Productivity Manual (OECD, 2001), productivity estimates are able to link the output measure, which can be either gross output or value added, to different inputs. Typically, labour productivity is the most often cited measure of productivity, including related measures such as labour compensation per employee, per hour, unit labour costs, comparisons between labour cost and productivity growth etc. (Ark, de Vries, & Jäger, 2018; Barcenilla et al., 2019; Bergeaud, Cette, & Lecat, 2016; Nelson, 1981; Roth & Thum, 2013). However, labour productivity is not the only measure of productivity in use. Capital

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[1] All authors are affiliated with the University of Ljubljana, Faculty of Business and Economics. This work forms part of the *H2020 Globalinto project*, with the full title: »*Capturing the value of intangible assets in micro data to promote the EU's growth and competitiveness*«.

productivity, but mainly multifactor productivity, are also considered. Especially the latter is used to determine the contribution of factors which are not directly labour or capital or whose contribution is not embodied in capital and labour. The disembodied impacts along with the possible impacts of labour and capital due to mismeasurement and certain other impacts (scale etc.) are reflected in multifactor productivity ("OECD Statistics Multifactor productivity," 2019).

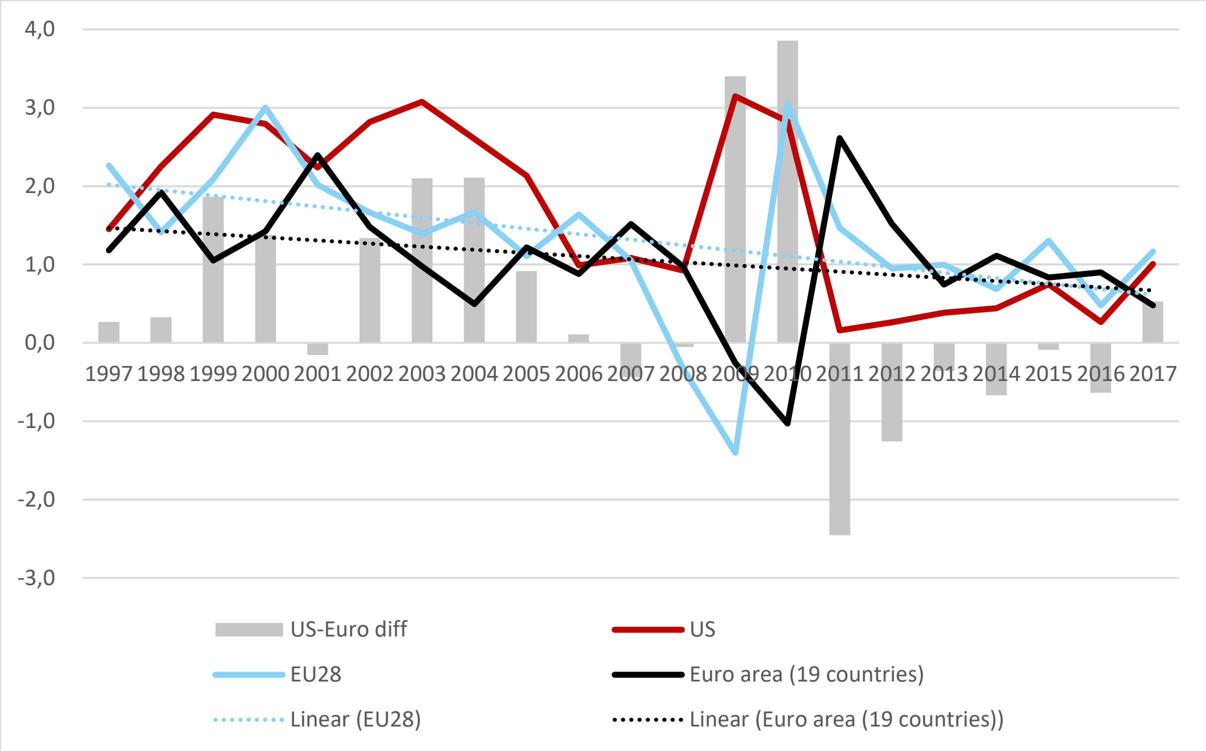
The link between productivity and rising living standards has made the study of productivity data a crucial topic in economic and political discussions. Recent trends in labour productivity also discussed in the literature (see below) show that: **(1)** developed economies have been lagging in productivity growth behind the emerging markets, although differences appear in the growth mechanism between technological-frontier and catch-up economies; **(2)** the gap between European economies (the EU) and the USA is still large, despite the gradual decline in the post-crisis period due to the sluggish productivity growth in the USA compared to US productivity growth before the crisis; **(3)** productivity growth in both the euro area and the EU-28 has been slowing since the second half of 1990s, with this trend not being overturned by the 2004 EU expansion; and **(4)** the differences in productivity levels within the EU remain large notwithstanding the decline in the productivity gap. Despite this decline, the slower productivity growth also seen in catch-up economies, even though it is higher than in the more developed economies, does not facilitate any fast catching up. In part, these trends can be explained by the general economic situation (macroeconomic trends), partly by standard productivity-driving factors, and partly by the differences in levels and dynamics.

To fully understand the depth and dynamics of this gap, the determinants of the productivity must be studied. These can be broadly classified as supply- and demand-side determinants of productivity. These factors are discussed in greater detail below. Before then, some basic data about productivity trends are discussed.

# 2 RECENT TRENDS IN PRODUCTIVITY

A central topic in the analysis of productivity differences is the growing divide between developed countries (Bergeaud, Cette, & Lecat, 2016), principally the comparative sluggish performance of the EU-28 and Euro19 area in contrast to the USA between 2000 and 2010/2011 when measured in GDP per hour worked as well as GDP per employee (OECD, 2019). Although on average both the EU-28 and Euro19 area performed better than the USA in terms of GDP per hour worked (but not systematically better in terms of GDP per employed), what continues to be a concern is the systematic drop in overall productivity measured in both GDP per hour as well as person employed (Figure 1, Figure 2, (The Conference Board, 2018).

*Figure 1: Labour productivity measured by GDP per hour worked growth in selected countries and the difference between labour productivity in the USA and the Euro19 area (in p.p.)*




Data: (OECD, 2019)

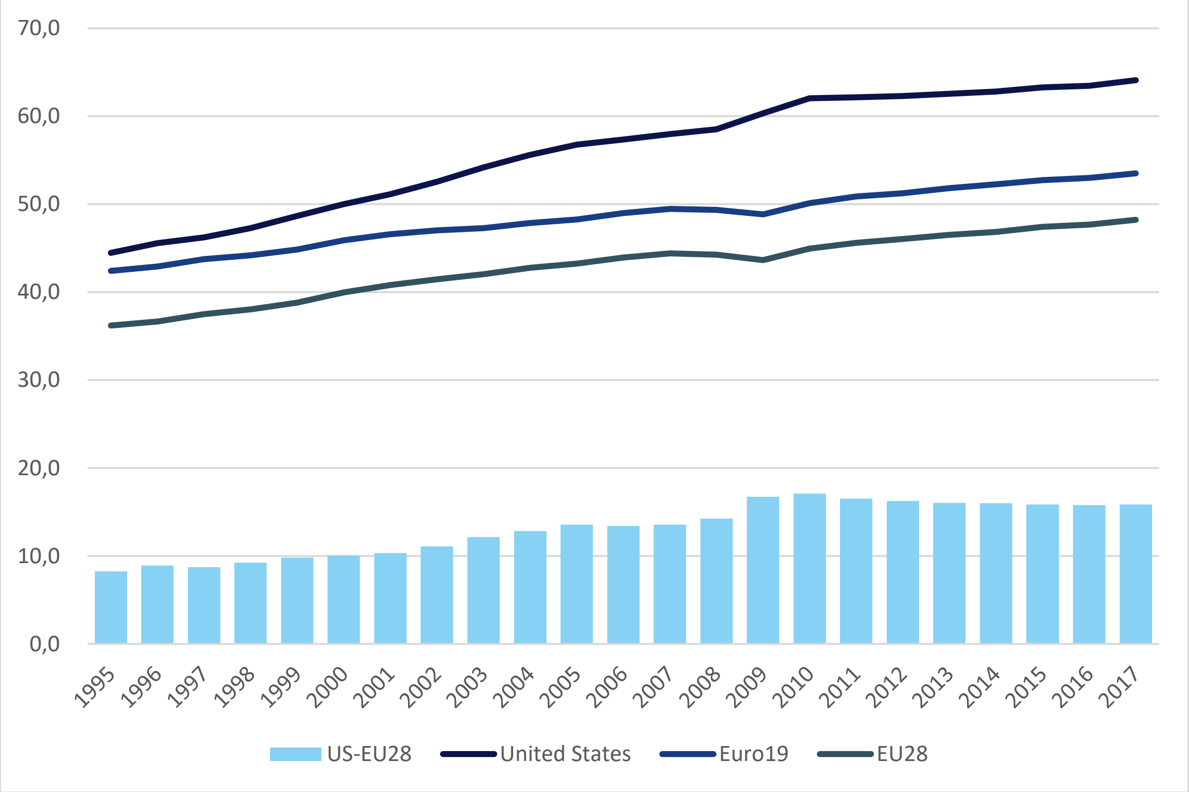
*Figure 2: Labour productivity growth (%) measured by GDP per hour worked**


*Euro19= Euro area 19

Data: (OECD, 2019)

Moreover, the productivity gap between countries is also significant. Like (Dolphin & Hatfield, 2015) find, the latest OECD data (OECD, 2019) available reveal that: 1) the productivity gap between the USA and the EU as well as the Euro19 area remains high, having expanded significantly between 1995 and 2010. Irrespective of the very slight drop in the recent post-crisis period, the USA remains around 30% more productive than the EU-28 and around 20% more productive than the euro area. Further, there are also considerable differences between the EU-28 and Euro19 area countries. Among EU countries which are also members of the OECD[2], the most productive in 2017 – Ireland – produced 2.8 times more than the least productive Latvia, when measured in GDP per hour in purchasing power parity. Despite this wide divergence, convergence has been taking place in the EU. In 2000, the divergence between EU countries of the time and future members was significantly greater, with the most productive Luxemburg then being five times more productive than Latvia (OECD, 2019). This considerable narrowing of the gap has been a result of the higher growth enjoyed by (primarily) new(er) EU members, including Ireland.

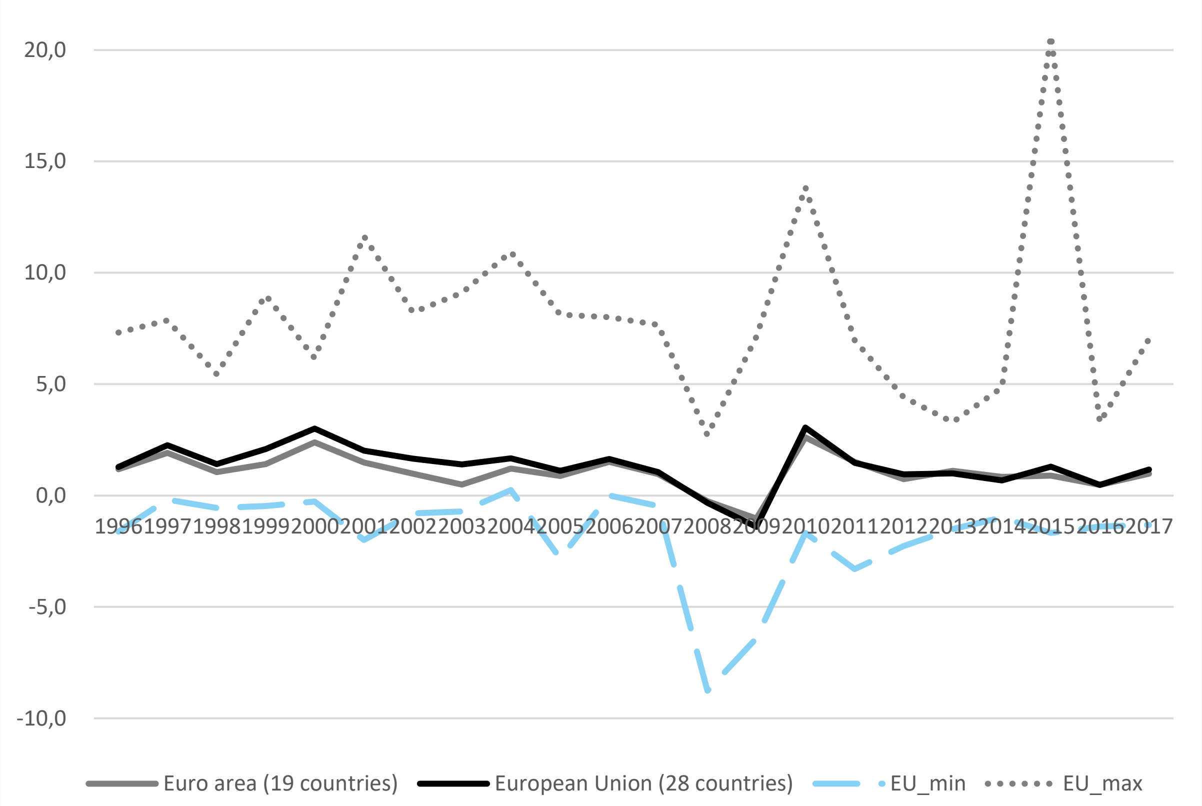
*Figure 3: GDP per hour worked (USD, constant prices, 2010 PPPs) in the USA, Euro 19 area and EU-28 and the gap between the USA and EU28 (USD, constant prices, 2010 PPPs)*




Data: (OECD, 2019)

[2] Excluding Bulgaria, Malta and Romania which are part of the EU, but not in the OECD. The OECD database (OECD, 2019) does not provide data on these countries.

*Figure 4: Labour productivity growth (%), measured by GDP per hour worked: EU and Euro19 average, and minimum and maximum growth in a specific year (the value represents the value in the country with the highest productivity in a given year)*




Data: (Eurostat, 2019)

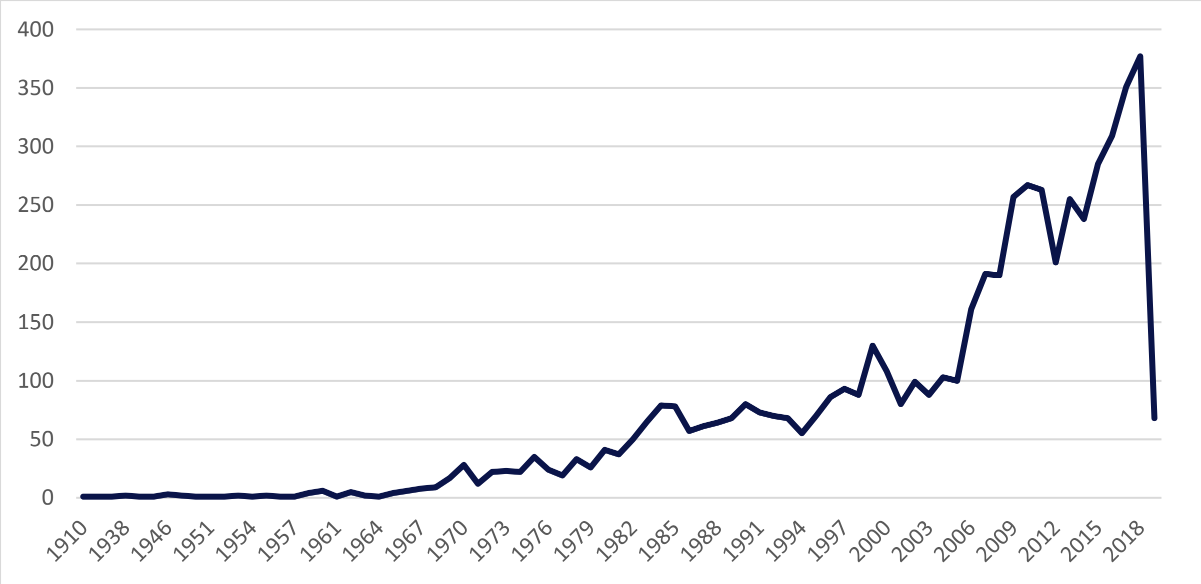
## 3 SOLVING THE PRODUCTIVITY PUZZLE

Productivity is a relatively simple concept that relates gross output or value added to different inputs. We typically encounter labour productivity and total factor productivity. In Scopus, the first scientific article on labour productivity as well as total factor productivity emerged in 1910 when the Quarterly of Economics published a paper by H. J. Davenport entitled "Social productivity versus private acquisition" (Davenport, 1910). This paper, however, focused more on the problem of the division of output than the standard notion of productivity. P. Sargeant Florence then published a paper in 1920 on measuring labour productivity called "The measurement of labour productivity" (Florence, 1920). The earliest mention of "total factor productivity" in both Scopus and Web of Knowledge is in 1970 with a study of US real product and real factor input movement between 1929–1967[3] (Christensen & Jorgenson, 1970). Since then, the study of labour productivity, capital productivity and also total factor productivity has expanded considerably. Today, the body of literature on mainly labour and total factor

[3] A bibliometric analysis of Scopus and Web of Knowledge was conducted between 15 and 27 February 2019. References available at that time containing the words »labour productivity« or »productivity of labour«, »total factor productivity« or »capital productivity« or »productivity of capital« in the English language, published either in economics, business and management or social sciences were considered. Sources were limited to scientific articles, published and those in press, books, book chapters and conference papers.

productivity is not only growing quickly in number, but expanding to include many related topics in an attempt to solve the puzzle of productivity.

*Figure 5: Scientific work on "labour productivity" in the Scopus database*




Source: Own.

The vast body of literature studies the productivity challenge from many different angles. Productivity depends on several different factors linked to specific theories or streams in the economic literature (real-business cycle theories, supply- and demand-side-focused theories) as well as further classified depending on the nature of the factors and the level of study (micro, sectoral or macro).

For the purpose of this analysis, which also provides the foundations for the in-depth study of intangible capital accumulation, we divided the determinants of productivity into external (those chiefly relating to those outside the firm, in the business environment) and internal (primarily the determinants within firms). In some cases, it can be difficult to classify a factor as external or internal, such as in the case of ageing. In the remainder of this text, the factors are classified and discussed, while a review of the empirical literature assessing the impact of a determinant is also presented.

## 3.1 The external determinants of productivity

The demand side impacts productivity in several ways by influencing aggregate demand, shaping the business environment, motivating technological dynamics in the economy, challenging the competition, affecting capital dynamics, labour dynamics, job creation, knowledge transfer, learning, and many other aspects. A selection of demand-side determinants is discussed below. A short summary is provided in Table 1.

*Table 1: A summary of external determinants of productivity*

| Determinant of productivity | Selected links to productivity | Selected authors |
|---|---|---|
| Institutions | North, 1987, Buchele&Christiansen, 2010, Nickell & Layard, 1999, Freeman, 1992, Blanchard, 2017, Uhlig, 2006, Pagano & Volpin, 2005, Égert, 2017 | Institutions generally shape incentives and guide behaviour<br>Labour market institutions, collective bargaining, wage-setting and social security systems impact productivity, employment patterns, and job creation<br>Legal institutions linked to contractual uncertainty, enforcement costs and direct and indirect labour costs<br>Impact of labour market policies on TFP growth |
| Macroeconomic environment | King & Levine, 1993, Lorenzoni, 2009, Boar, Gambacorta, Lombardo, & Pereira da Silva, 2017, Stiglitz & Greenwald, 2014 | Importance of macroeconomic stability and growth-supporting macroeconomic environment, stable prices, balanced budgets and declining debt for higher investment and productivity growth<br>Importance of demand-side policies (public investment) and demand shocks<br>Role of macroprudential regulation |
| International trade, exchange rates, FDI | Palley, 2011a, Bernard & Jensen, 2004, Auboin & Borino, 2017, Wagner, 2007, Shu & Steinwender, 2018, Baldwin, Gu, & Yan, 2013 | Export-led hypothesis and demand impact<br>Link to productivity via competition, learning-by-exporting, technology transfer, open innovation<br>Impact of FDI via demand effect, market opening, and technology transfer |
| Technological environment | Porter, 1990, Porter, 2008, Sala-I-Martín et al., 2012, Atkinson, 2013, Cavalcante, 2013, Russmann et al., 2015, Chang, Chen, & McAleer, 2013 | Technological environment improves the general nature of how companies operate and compete, business models, stimulates innovation, impacts consumers |
| Access to finance and financialisaton | Heil, 2017, Cournède, Denk, & Hoeller, 2015, Pagano & Pica, 2012, Dethier, Hirn, & Straub, 2011<br>Gatti & Love, 2008 | Financial development and availability of finance positively affect productivity, lower costs of financial frictions, affect capital, labour and R&D dynamics. Access to finance lowers costs of capital, moves the financial frontier outwards, yet the effect not linear, but diminishing. Inefficiencies in finance due to low financial development is key to explaining the large differences in productivity among countries. |
| Financialisaton in the economy | Philippon & Reshef, 2012 Hein, 2012, Stockhammer, 2004, Orhangazi, 2008, Levine, 2005; Mishkin, 2007, Tori and Onaran, 2018. | Financialisaton (financial markets, financial institutions and financial elites gain greater influence over economic policy and economic outcomes) linked negatively to investment and lower productivity, but relationship is complex, non-linearities are present |
| Policies | Delgado, 2011, Stiglitz & Greenwald, 2014, Kneller & Misch, 2014, Barrios & Schaechter, 2008, Jin, Shang, & Xu, 2018, Görg & Strobl, 2007, Hud & Hussinger, 2015, Crescenzi, Blasio, & Giua, 2018 | Demand- and supply-side policies are both relevant. Building a "business environment" (including infrastructure, public administration, education, health and social security) is relevant. Industrial policy measures and targeted measures (subsidies, R&D supports, cluster supports etc.) also important, but results often mixed. National and supranational models seeking competitive advantages and supporting key industries (smart specialisation) and new technologies. |

Source: Own.

### *3.1.1 Institutions and productivity growth*

The institutional framework's impact on labour productivity is long recognised (North, 1987, Norton, 1989). The institutional framework imposes formal and informal constraints on economic agents, thereby shaping the incentives to engage in productive activities and matters for agent-specific transaction costs and economic outcomes such as productivity and the unemployment rate. To date, the empirical evidence shows that labour market institutions have a strong impact on firm-level and aggregate productivity growth.

Several authors stress the importance of labour market institutions for labour productivity and the unemployment rate (Blau & Kahn, 1999; Freeman, 1992; Uhlig, 2006). For instance, Blanchard (2017) highlights the valuable role of institutional design in the labour market. Namely, the persistence of labour market rigidities like excessively generous unemployment insurance, high employment protection and high minimum wages is regarded as a pivotal mechanism in the slow productivity growth in the EU-15 compared to the USA (Bertola & Rogerson, 1997; Siebert, 1997). By hindering the dynamic matching of employees and employers, institutional rigidities hamper job creation and restrain labour market flows, both recognised as important factors in the longer durations of unemployment seen in Europe. The most likely transmission mechanism from labour market institutions to labour productivity and the unemployment rate includes the labour costs relative to the firm-level productivity level, technological change, barriers to entry, and the degree of job security.

Labour market institutions relatively strong impact on productivity growth is not confined to the short-run horizon but appears to hold in the long run. For instance, Buchele and Christiansen (1999) examine the growth of long-term employment and productivity in a set of major industrialised economies from the 1960s to the early 1990s. Their results suggest that institutions promoting stronger collective bargaining, employment security and social protection negatively affect employment growth but positively affect productivity growth. Their implications suggestion that labour market deregulation would foster employment growth and labour supply. On the other hand, the positive employment and labour supply impacts would be offset by the rising inequality and employment insecurity, thereby questioning the notion that labour market institutions matter for economic growth.

Against this backdrop, Nickel and Layard (1999) revisited the relationship between labour market institutions and economic outcomes empirically. More specifically, they point to unions and social security systems as key labour market institutions. In typical circumstances, strong labour unions and generous social security systems tend to have adverse employment and growth effects. They conclude that encouraging product market competition is a crucial policy to eliminate the negative effects of trade unions in addition to linking social security benefits to the design of active labour market policies to encourage labour supply. Contrary to the dominant stream of literature, their analysis suggests that strict labour market regulations, employment protection and minimum wages have almost no impact on productivity growth and employment rates once product market competition is taken into account.

An additional strand of literature suggests that legal institutions are an important driver of labour productivity growth (Porta, Lopez-de-Silanes, & Shleifer, 2008). Specifically, legal institutions tend to impact labour productivity through numerous forms of regulations related to contracting institutions (Perotti & Thadden, 2006). The regulatory environment can facilitate low-cost enforcement of contracts and thus enable employee–employer matching without frictions. On the other hand, the legal and regulatory environment might hinder productivity growth through barriers to employment and a lack of productivity incentives. The importance of the regulatory and legal environment for labour productivity growth is empirically confirmed by numerous studies (Almeida & Carneiro, 2009; Dufour, Lanoie, & Patry, 1998; Storm & Naastepad, 2017). Relatedly, several studies suggest that labour productivity is driven by varying degrees of economic uncertainty (Bai & Wang, 2003). Uncertainty may hold far-reaching implications for labour productivity growth. By increasing the expected direct and indirect labour costs, a high degree of uncertainty may induce skill-biased technological change and cause a structural mismatch in the labour market that most likely would increase the unemployment rate and skill gaps both within and across firms. Indirectly, the economic uncertainty might also influence the rate of return on human capital, which could have direct implications for labour productivity growth in general. The impact of the legal and regulatory environment translates into labour productivity differences through numerous transmission mechanisms, as demonstrated empirically, such as the level of transaction costs, security of property rights, quality of corporate governance, and distribution of bargaining power between employers and employees (Nelson, 1994; Pagano & Volpin, 2005; Schoar, 2002).

More recently, Egert (2017) examines the impacts of labour market policies and quality of institutions on country-level total factor productivity. For a balanced panel of OECD countries, his findings suggest that biased product market regulations tend to have a strong interaction effect with labour market regulation. Further, Restuccia and Rogerson (2008) show that such distortions which create price heterogeneity tend to decrease output and total factor productivity in a range between 30 percent and 50 percent. The notion that institutions matter for labour productivity is well established. Yet it remains less clear which layers of institutions and specific policy distortions are the most important for labour productivity (Spruk & Kovac, 2018) and how these channels of influence can be credibly identified (Klick, 2010). In this study, we combine the variables capturing the legal and regulatory environment, labour market policies and economic uncertainty and seek to examine how they have contributed to labour productivity level and the rate of change over time.

### *3.1.2 Macroeconomic environment and productivity*

The recent crisis was accompanied by negative productivity growth (Figure 2), showing the macroeconomic environment 's possible impact on productivity growth. In addition, according to McKinsey (McKinsey Global Institute, 2018) the recent post-crisis, productivity-weak, yet job-rich, post-crisis recovery is caused by three factors together, including macroeconomic. First, the weakening impact of the third wave of the industrial revolution and the new economy. Second, the impacts and after-effects of the financial crisis, which also caused a demand shock, accompanied by excess capacity in firms and greater uncertainty. The positive effects of the third factor, digitisation, have been unable to significantly counteract the negative impacts of the first two factors.

**Macroeconomic stability and a growth-supporting macroeconomic environment** are identified in the literature as core elements for sustainable, persistent growth and for the successful implementation of industrial policies in support of productivity growth (Stiglitz & Greenwald, 2014). Yet the definition of a growth-supporting macroeconomic environment is still a matter of discussion. While the recent crisis experience also shows that economic shocks are negative and stability is important, a discussion is still underway between the supply-side economists and those with more trust in the demand side. Typically, according to the Centre for the Study of Living Standards (1998) the supply-side belief stresses that a favourable macroeconomic environment is one with **stable prices, balanced budgets and a declining government debt** since this increases business confidence, contributes to lower costs of capital, and promotes investment. The literature argues that high public debt stifles private investment in the longer run (Teles & César Mussolini, 2013), like inflation and an increasing budget deficit do. Afonso & Jalles (2013) also show on a sample of OECD countries that the effects of high public debt on economic growth are generally negative. Further, the financial crisis' effects on economic growth were negative, and the fiscal situation is related to economic performance in a non-Keynesian manner, with Afonso and Jalles (2013) claiming that that fiscal consolidation promoted growth as well as longer debt maturity.

Tsionas (2003) investigates the relationship between inflation and productivity. He first refers to the literature and shows that **inflation can negatively impact productivity growth** due to: (1) distorted price signals; (2) possibly causing an inefficient factor input combination; (3) increased uncertainty which may cause firms to increase their inventories and have fewer sources available for more productive uses, including investment; and (4) raising the cost of capital and lowering investment. However, in his empirical analysis, the results are method-sensitive. Empirical analysis also reveals there is no systematic pattern as to where (perhaps groups of countries) the relationship exists or does not. Furthermore, he claims that "causality fails exactly where it would be most useful, the European South (with the exception of Greece) and the smaller member states of the Union. This implies that nominal convergence in rates of inflation (…) is not expected to generate real benefits in terms of productivity or per capita output". Freeman and Yerger (2000) also find no systematic relationship in either magnitude or sign on a sample of 12 OECD economies. In contrast, studies find a **negative relationship between inflation and productivity growth**, for example (Bulman & Simon, 2003) establish a negative relationship between productivity at industry-level and industry-level inflation in Australia, where the impact is more pronounced in concentrated industries. The authors add that the transmission mechanism occurs through a reduction of capital accumulation and a reduction of multifactor productivity growth. Interestingly, Yellen (2005) also warns about the **impacts of lower productivity on inflation**, where: (1) inflation could rise due to the faster increase in wage costs; and in response to lower profit margins firms could increase prices; (2) while lower aggregate demand could moderate this effect.

On the other hand, demand-side economists consistently stress the **role of demand-side policies** in supporting aggregate spending and helping to keep the economy functioning near full potential (Centre for the Study of Living Standards, 1998). For example, Abiad, Furceri & Topalova (2016) argue that **increased public investment is positively related to output** and that in the long term it crowds

IN private investment and reduces unemployment. The authors also argue that public investment contributes more efficiently to output in those countries where public investment efficiency is greater and is financed by the issuing of debt. **The crowding-in of private investment** can rationally be expected to increase productivity. Similarly, Felice (2016) shows that, besides the level, the allocation and composition of productive public expenditure are also mainly important for supporting growth. Fournier (2016) argues that public investment positively impacts long-term growth and labour productivity and adds that public investment can support convergence. He stresses the composition of public investments, primarily the role of public investment in health and in research and development. On the other hand, Afonso & Furceri (2010) study the link between the size and volatility of government revenue and spending in the EU and the OECD. They find the relationship is negative where, in terms of spending, the size of subsidies and the volatility of government investment are significantly negatively related to growth. Checherita and Rother (2010) investigate the relationship between indebtedness and growth in the EU-12 from 1970 to 2010 and also argue the impact is non-linear, but that **both the level and speed of the increase in debt negatively impact** growth through their effect on private savings, total factor productivity, public investment, and long-term nominal and real interest rates.

Further, in relation to macroeconomic variables and productivity, the literature shows that while **demand shocks affect productivity**, they also have a wider impact on firm behaviour, including that related to **firm exit**. Unexpected demand shocks are important for both capital investment and firm exit decisions. While capital investment is more closely related to longer-term productivity trends, it is also connected with demand shocks. But, besides being linked to capital investment, demand shocks are more strongly linked to exit decisions (Kumar & Zhang, 2019). It is important to note that in the context of this discussion investment decisions should be viewed in a broader context and may also include technology implementation, R&D, human capital investment, which all affects productivity in the longer run.

Lorenzoni (2009) adds to the discussion the **interplay of a heterogenous productivity shock and consequent perceived demand shock**. If companies are hit by a productivity shock, Lorenzoni (2009) argues they will be influenced by the difference between their own productivity and the noisy observation of the aggregate productivity. A positive difference will simulate a demand shock, which in the short run will increase output, employment as well as prices, but in the long run have no impact.

The recent productivity slowdown has also been linked to the crisis where the crisis impacted firm performance through its impact on the financial sector, as well as demand impacts. While demand shocks have already been discussed, **financial markets are also linked to productivity** in several ways. King and Levine (1993) show for a large panel data set of 80 countries for the period 1960–1989 that financial system development promotes growth, capital accumulation and improves economic efficiency. The literature also positively links stock-market development with economic growth (Levine, 1996; Levine & Zervos, 2012). Dabla-Norris, Kersting, & Verdier (2012) link firm-level productivity with financial development and show that innovation has a greater effect on productivity in financially more developed countries. This impact is even bigger and also more significant for high-tech firms. This finding speaks in favour of a positive spiral.

Concerning this, Manaresi and Pierri (2018) confirm the existence of problems in the financial system in relation to crisis in a negative aspect. They show **the credit supply crunch** between 2007 and 2009 in the OECD was followed by a **productivity slowdown**. The possible transmission channels are linked to credit access, which facilitates IT-adoption, easier and more innovation, stimulates exports and the adoption of other productivity-boosting practices, including organisational change and management ones. The authors show that in Italy the credit crunch itself contributed to about one-quarter of the productivity decline. Similar confirmations are provided by Dorr, Reiss and Weber (2017).

To conclude, it may be argued that macro-prudential regulation on the side of the state and the central bank is important and should not only be occasional but consistent. (Boar, Gambacorta, Lombardo, & Pereira da Silva (2017) show that countries with more macroprudential regulation have stronger and more stable growth as influenced by openness of the economy and financial development. Te Velde (2017) also claims that macroprudential regulation and credit information-sharing are crucial for balancing financial stability and credit growth as well as supporting growth, especially in low-income economies.

### *3.1.3 Population growth and age*

The twentieth century was an era of population growth whereas the twenty-first century will be characterised by population ageing (Bloom, Lutz & Prskawetz, 2008). Persistent low fertility and increasing longevity have created a population structure that will drive rapid population ageing in the next few decades, regardless of the sensible assumptions used in various projections. Population ageing will profoundly impact both the supply and demand sides of the economy and the public sector.

Population ageing impacts growth through various channels. Along with development, countries are undergoing a demographic transition from high to low levels of mortality and fertility. This drop in fertility means fewer transfers are needed to support children, freeing up resources for investment and economic growth. However, this positive (first) economic dividend eventually turns negative. Namely, children born during the low-fertility period join the labour market while numerous cohorts are at the end of their working age and entering the period of old age when they are economically dependent. In European countries the first demographic dividend turned from being positive from around 1970–1980 to around 2000–2010 to being negative in the future decades – at least till about 2050 (Alexia Prskawetz & Sambt, 2014). Thus, in the following decades the "accounting effect" (Alexia Prskawetz, Bloom, & Lutz, 2008) of population ageing on economic growth will be negative.

However, there could also be a positive impact of population ageing on growth in the form of a second demographic dividend if people finance their consumption in old age by asset income. By living longer, they are forced to save more and capital deepening has a positive impact on growth (A. Mason & Lee, 2007). A substantial positive second demographic dividend is expected in the UK, Germany and Spain, although the net impact on growth will remain negative because the second demographic dividend's positive impact will be dominated by the negative impact of the first one (Alexia Prskawetz & Sambt, 2014).

Moreover, the publicly financed allocation of resources is expected to change in the future, especially publicly funded pensions, health and long-term care. The increasing longevity is usually not accompanied by the suitable postponement of retirement. Projections show that in the next few decades this will put a heavy strain on the public pension system's sustainability in most developed countries, particularly those that rely heavily on the mature pay-as-you-go pension system (European Commission, 2018d).

Health and long-term care are two more groups of (public) expenditure expected to increase relative to GDP in the future. People are living longer and therefore spending more years in the higher age groups in which per capita health and long-term care expenditure is rising. However, there is greater uncertainty about the factors influencing such expenditure. Income elasticity greater than one and above-average medical inflation are factors in the over-proportional growth of those expenditures. On the other hand, less than proportional growth can be expected, for example, to arise from improving health conditions at given ages and/or cost being related to proximity of death instead of age. In net terms, a moderate rise in health expenditure relative to GDP is expected and a strong increase in long-term care expenditure (European Commission, 2018d).

Public pension and health expenditure is often covered by contributions collected for this purpose. Yet, the gap is increasing between public expenditure and revenue available to cover pensions and health from the general budget. Therefore, these areas must compete with other public goods and transfers like education, scholarships, research etc. The elderly wield strong political power to allocate resources in their favour since their preferences are focused and they over-proportionally participate at elections (Thurow, 1999).

People's consumption needs vary by age. Ageing alters the age composition of the population and thus the aggregate market demand for goods and services. A striking example is the fact that in 2016 the production of diapers for adults overtook the production of diapers for babies (Herships, 2016). A comprehensive analysis of consumption and production by age is facilitated by the recently developed National Transfer Accounts (NTA) methodology (Istenič, Šeme, Hammer, Lotrič Dolinar, & Sambt, 2016; R. D. Lee & Mason, 2011; United Nations, 2013). The future impact of population ageing on aggregate categories of production and consumption can be simulated by using per-capita averages from the NTA results along with population projections by age.

Finally, a considerable amount of informal work provided in households is in the form of cleaning, cooking, doing laundry, providing care to children and the elderly etc. The production and consumption of such services are highly age-specific and peak after people retire (Vargha, Šeme, Gál, Hammer, & Sambt, 2016). The share of the elderly is growing rapidly and is not compensated by the increasing retirement age, making informal economic activities become increasingly important in the future.

### 3.1.4 International trade, exchange rates, FDI and productivity

The European "convergence machine" (Gill & Raiser, 2012) was also fuelled by trade within the sizeable European community, especially due to the large 2004 expansion, although Ridao-Cano and Bodewig (2019) believe its impact on economic convergence has been declining.

Nonetheless, international linkages via several channels have long been claimed and shown in the literature to impact productivity and growth. The first major hypothesis is the export-led model of growth, also closely related to the problem of global value chains. Second, the literature stresses the role of foreign direct investment. The third major question is the problem of the terms of trade and exchange rates. The problem of trade is both an external and internal (linking to knowledge transfer, innovation etc.) determinant. Therefore, we discuss trade twice, namely the external aspects here and those more closely related to the firm level subsequently. There is certainly also some interplay between these two levels.

Palley (2011) lists three strains in the literature that support the **export-led hypothesis** (in relation to import substitution). The first follows the standard HOS comparative advantage theory, the second adds that openness helps control rent-seeking behaviour while the third strain has become very popular and stresses that trade is linked to knowledge spillovers, technology transfer, learning, innovation, all of which increase productivity and its growth.

Exports are for several reasons perceived as a key driver of growth, especially in small, open and catch-up economies. First, exports represent a large share of aggregate demand (GDP) and can as such contribute to overall economic dynamics, also stimulating investment and productivity. Even for large economies, according to Hartley and Whitt (2003) demand shocks accounted for 70–80 percent of output growth variation in the post-war period in Germany, France and the Netherlands, whereas in Italy and the UK they contributed to more than 90 percent of growth variation. Export dependence is even greater in small open economies.[4] Although the elasticity of aggregate demand is falling, Auboin and Borino (2017) claim the slowdown in global value chains can explain a large proportion of trade variation and GDP.

The last big topic concerned with open economies and (productivity) growth is the exchange rate and terms of trade. Real exchange rate movements are traditionally expected to result from productivity changes as well as differences between the tradable and non-tradable sectors (e.g. the well-known Balassa-Samuelson effect, e.g. in Ito, Isard and Symansky (1997). While the nominal exchange rate directly or the exchange rate regime were not traditionally expected to impact productivity, Harris (2001) reminds of two possible channels of influence: (1) on the demand side, the exchange rate alters the external competitiveness and exports/imports, while (2) on the supply side a more pronounced change impacts the productivity gap between countries.

[4] For example, in 2018 exports represented 85% of GDP in Slovenia and contributed 6 percentage points to overall economic growth (imports contributed -5.7) (Data:(SURS, 2019)

Studies confirm the link to productivity, but bring mixed findings regarding the positive or negative impact of depreciation or appreciation. For example, Fung and Liu (2009) show the exchange rate impacts firm-level performance, specifically that real depreciation in Taiwan during the 1990s increased exports, domestic sales, total sales, value added and productivity. The latter is claimed to result from the expansion of firm scale. Tomlin & Fung (2015) also show that the real exchange rate has an impact on the productivity distribution. Appreciation can force the smaller and less productive from the market, influencing the left-hand side of the distribution and also the lower productivity of the rest. Alfaro, Cuñat, Fadinger and Liu (2018) show theoretically and empirically that real depreciation can be linked to faster TFP growth, sales and cash-flow growth, lowerg financial constraints, and increased probability to invest in R&D and to export.

Studies of the exchange rate also link exchange rate regime and exchange rate volatility and financial development with growth. For instance, Aghion, Bacchetta, Rancière & Rogoff (2009) link both and show that large exchange rate volatility with countries in weakly developed countries can slow growth, down especially in the case of financial shocks. Kassa and Lartey (2018) similarly show a link exists between the exchange rate and TFP growth, where financial development positively influences the relationship.

Nonetheless, the key channel of influence on productivity occurs where openness, trade and global value chains are present, essentially comprising demand factors that ultimately raise the production function through learning, technology transfer and innovation.

### *3.1.5 Technological environment, technological catch-up and firm-level productivity*

Two levels must be distinguished when speaking about how technology impacts firm productivity: (1) **general technological development in a specific environment**; and (2) **firm-level technological characteristics and dynamics**. Nowadays, technology is essential for sustaining a competitive edge. Growth is increasingly knowledge driven (OECD, 2013). Firms operating in an environment where they have access to advanced technologies and where they cooperate with firms or consumers that use advanced technologies have the ability to use and access new technologies (Sala-I-Martín et al., 2012), and are also often under the pressure of competition to adopt new technologies and new business models (André Cavalcante, 2013). **Technological environment** is typically a category included in a PESTEL analysis, a strategic firm decision-making tool (McGee, Thomas, & Wilson, 2010) used to define the environment in which companies operate. While the characteristics of the technological environment are to some extent linked to the abilities of countries and firms to conduct R&D, the two should not be linked too closely as firms operate in international environments and technological frontier, innovation and technological environment should not be used as synonyms (Sala-I-Martín et al., 2012).

Countries differ in the level of their technological development and the technological readiness of the economy generally, with the latter also impacting firm-level productivity for several reasons, namely by: (1) altering the general nature of how businesses operate and increases systemic competitiveness; (2) changing the structure of industries (Enrique Martinez, Ferreyra, & Zurita, 2018): (3)

impacting/modifying business models; (4) stimulating innovation at the firm level; and (5) changing consumer behaviour, which impacts the performance and behaviour of firms (Enrique Martinez et al., 2018; Porter, 1990, 2008; Takakuwa & Veza, 2014).

The technological environment as well as business sophistication, as defined in Global Competitiveness Report, **increases to the overall (systemic) competitiveness and productivity of firms** due to the increased efficiency of the overall economic system. Atkinson (2013) claims that "*The lion's share of productivity growth in most nations comes not from changing the sectoral mix to higher-productivity industries, but from all industries, even low productivity ones, boosting their productivity. The is also important, especially as it stimulates technological change and adoption as well*". This further stresses the importance of improving the general technological environment. While sectoral changes are stimulated by overall changes in the business (including technological) environment, World Bank estimates also show the majority of total factor productivity growth comes from the within-sector productivity growth, in the EU-15 almost all of it, while in catch-up economies, for example South-East Europe, the share of within-sector productivity growth was similar to that of sectoral shifts ("Unleashing Prosperity: Productivity Growth in Eastern Europe and the Former Soviet Union," 2008).

These findings underscore the need to consider improvements in the technological environment on firm-level performance. The technological environment also affects firms' performance through **organisational innovation**. The external environment is generally important for firm performance and addresses the links between the external environment and *"the creation, extension, revision or termination of business models*" (André Cavalcante, 2013), including the technological impact on business models. Especially in this age of Industry 4.0 and e-commerce, technological readiness and the technologically developed environment comparatively facilitates and stimulates companies to explore **marketing and market innovations** or they are forced to do so by consumers' behaviour. Amazon and Alibaba as platforms represent both a market and a marketing innovation for many companies using these platforms, increasing their productivity. Industry 4.0 and along with it for instance the emergence of e-commerce directly affects business models, for example in retail ((Deloitte, 2016) as well as their productivity by also making available or pushing into use other technologies such as big data, robots, artificial intelligence (Rüßmann et al., 2015).

The **presence and availability of technologies** as knowledge within **economies or industries or clusters** also stimulates learning and knowledge transfer, with both due to cooperation between firms (Carlino & Carr, 2013; Fallah, D Wesley, Howe, Ibrahim, & J Howe, 2004; Hendry, Brown, Ganter, & Hilland, 2001). Further, the availability of knowledge further stimulates both product and process innovation and the implementation of new technologies, which contribute to productivity growth (Lööf & Nabavi, 2015).

For catch-up economies, it is also especially important to perceive the technological environment in the broad context of exports and general global cooperation, including participation in global value chains. Open economies often rely in their growth on export-oriented models where foreign direct investment, cooperation with (more advanced) partners or being part of a strong global value chain can stimulate learning, competence building (Chang, Chen, & McAleer, 2012; Morrison, Pietrobelli, & Rabellotti, 2008; Prasnikar, Redek, & Drenkovska, 2017), technology build-up, innovation (e.g. the open innovation model, (H. Chesbrough, 2010; H. W. Chesbrough, 2003; West, Salter, Vanhaverbeke, & Chesbrough, 2014)) where exports are also particularly important.

The emergence of new technologies, wide digitalisation is changing not just production, but we are, as a society, moving also towards Society 4.0. Facilitated by technological presence, the changing consumer habits are causing **market-pull innovations**[5] (Brem, 2008; Noori, 1997) due to the firms' ability to offer consumers altered, improved etc. products, as well as **technology-push innovation** as the interplay between the market pull and technological availability can allow further innovation and productivity growth, such as developing technologies that permit easier customisation and thereby higher value added.

Although "technological environment" has a slightly intangible definition and in the classification of Porter and the WEF (Porter, 1990; World Economic Forum, 2019) forms part of "business environment", the environment is important for overall productivity and should thus be properly addressed by policymakers as it is an external factor that impacts the economy and the direction of its development (Robert Atkinson, 2013; "Unleashing Prosperity: Productivity Growth in Eastern Europe and the Former Soviet Union," 2008).

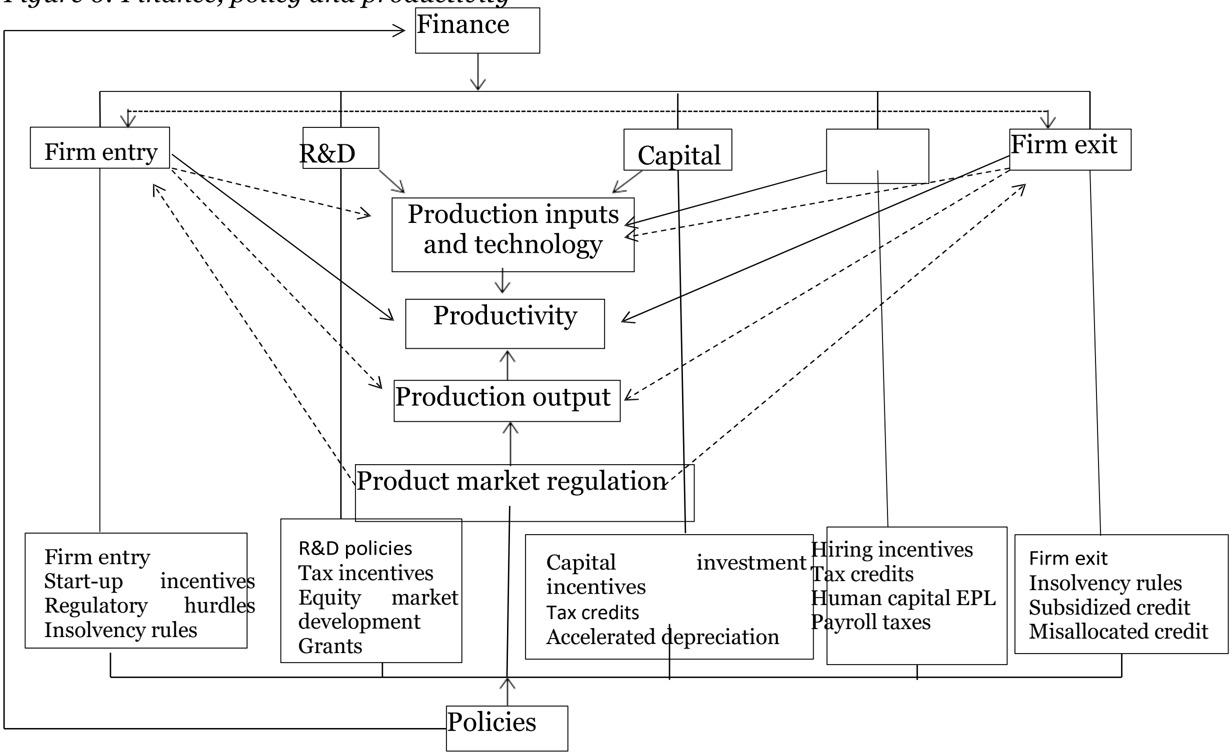
### *3.1.6 Access to finance and productivity growth*

A survey of the literature (Heil, 2017) on business finance and productivity reveals that: 1) financial development positively affects productivity; 2) financial frictions can mitigate the positive effects; and 3) the productivity costs of financial frictions are generally small in financially developed economies but considerably larger in developing economies.

The framework of how finance linked with policy affects productivity is shown in Figure 6. As seen in Figure 6, finance directly (full line) affects the productivity of the main inputs (capital, labour and R&D) and also firm entry and exit, which directly and indirectly (dashed line) affect productivity. Figure 1 also shows how policies affect financial decisions and productivity.

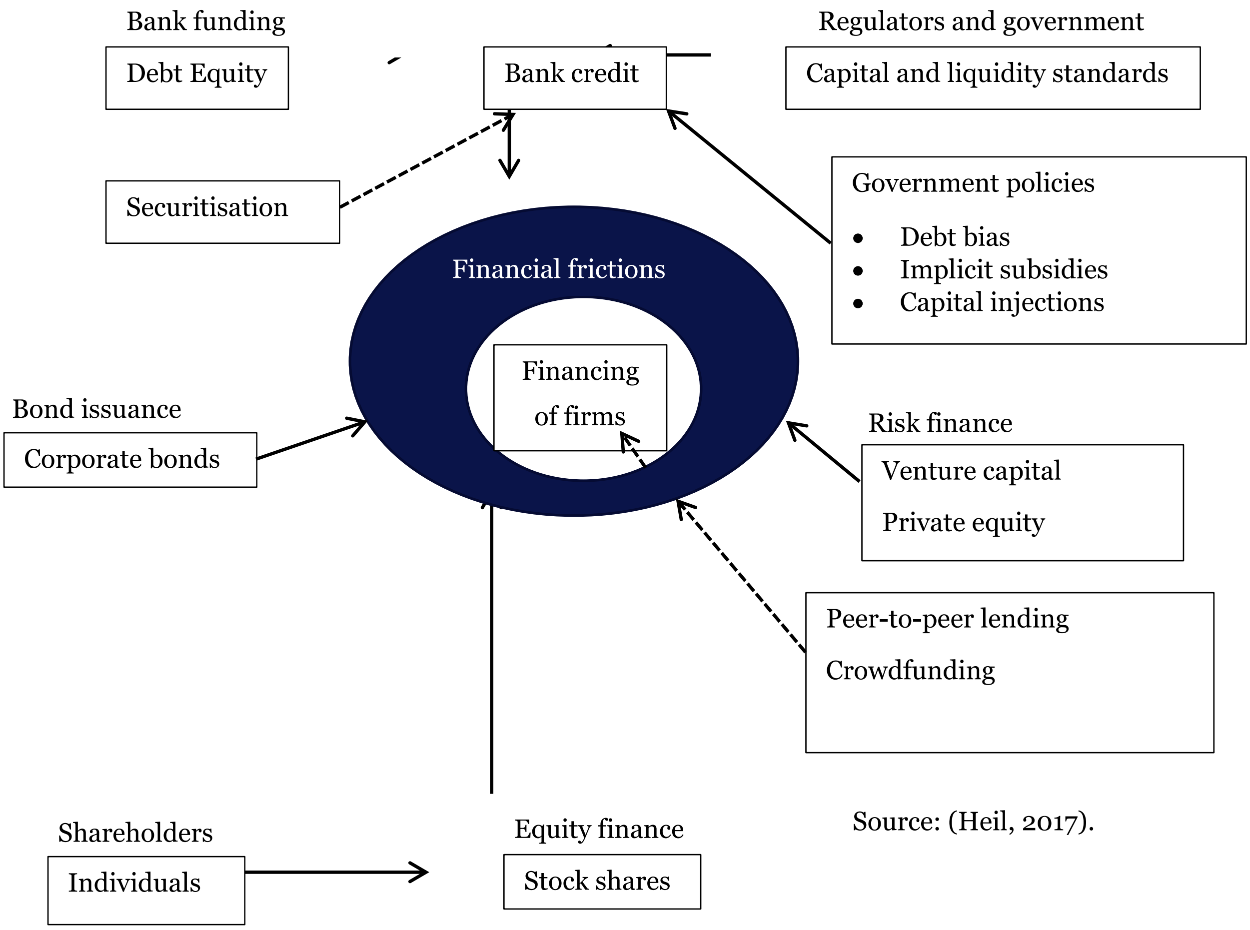
[5] Noori (1997) distinguishes market-pull innovations and technology-push innovations. Market-pull innovation are those driven by consumer demands and tastes, but also require firms' activity, primarily in gathering information. Technology-push innovations are those which happen due to the availability of technologies which can stimulate further innovation.

*Figure 6: Finance, policy and productivity*




Source: (Heil, 2017).

*Figure 7: Firm financing sources*




Source: (Heil, 2017).

Figure 7 illustrates how financial capital flows toward businesses. While firms have several financing options available to them, in practice a number of frictions can impede their ability to access finance. Financial frictions are broad and can be market-wide, internal to a financier, or originate from a prospective borrower firm. Hence, even well-developed financial systems encounter barriers to the optimal allocation of capital for its most productive uses.

Economic theory suggests that financial development from low levels leads to higher capital accumulation and results in economic growth. In a well-developed financial system, the provision of financial capital may become inefficiently high. Therefore, as (Cournède, Denk, & Hoeller, 2015) point out, the effect on economic growth can be either negative or positive. Empirical studies (see Heil, 2017, for a literature review) suggest that financial development from a low level improves economic growth by reducing capital constraints and allowing allocation to productive enterprises. However, this effect diminishes as the provision of finance rises. Beyond a certain threshold, additional credit finance can slow economic growth. For example, Manning (2003) shows that lending to firms increases growth in non-OECD countries, while this relationship is not significant for OECD nations. Similarly, Pagano and Pica (2012) describe how it increases growth of value added and employment in external-finance-dependent sectors of non-OECD countries, but not in the OECD. Cournède & Denk's (2015) results indicate that increased financial activity starting from a low base substantially increases GDP growth, yet this relationship becomes negative at a threshold of about 100 percent of GDP for credit and equity finance. The empirical study by Cecchetti & Kharroubi (2012) shows that financial development has an inverted U-shaped impact on productivity growth. They conclude that financial sector growth acts as a drag on productivity growth.

Heil (2017) states that inefficiencies in finance (due to low financial development or financial frictions) are key factors in explaining the big differences in productivity across countries. The literature here suggests that financial frictions can take the forms of limits on contract monitoring, collateral constraints, incentives created by insolvency regimes, or the adverse consequences of enforcing bank regulatory or supervisory practices slow economic growth and reduce productivity growth. For example, Andrews, Criscuolo, & Menon (2014) show that costly bankruptcy regimes lead to less favourable responses of firm capital to patenting. The study by Adalet McGowan, Andrews & Millot (2018) reveals that zombie firms reduce average productivity and impair the growth of productive firms. Bergthaler, Kang, Liu & Monaghan (2015) show that weak insolvency regimes in Europe limit the ability to restructure viable SMEs and liquidate nonviable ones. Using a large dataset of mostly private European firms, Warusawitharana and Levine (2012) establish that financial frictions inhibit firm-level productivity growth.

The review by Heil (2017) reveals that "*financial frictions in a country with a relatively efficient financial system like the US appear modest (less than 5% of TFP). However, when policies and practices create inefficient incentives in finance, like in Japan in the 1990s, the associated misallocation can exert sharper downward pressure on productivity. In developing countries, financial frictions appear to explain a considerable portion of the productivity gap with developed nations, implying large and persistent productivity losses*".

The fact that access to finance plays an important role in firms' productivity is also revealed by studies which use data from surveys of firms. These studies show that access to finance is among the top constraints cited by firms. The study by Dethier (2011) relied on a sample of over 39,000 firms across 98 countries and found that access to finance was ranked as either the biggest or second-biggest obstacle by firms in Eastern Europe and Central Asia, Sub-Saharan Africa, East Asia and the Pacific, Middle East and North Africa, and South Asia. Gatti and Love (2008) examined the relationship between access to credit and total factor productivity in a sample of Bulgarian firms. They found that access to credit increases the productivity of firms. A similar conclusion was made by (Butler & Cornaggia, 2011) who looked at access to finance and productivity in the USA. Using more than 10,000 firms from 30 African countries, Fowowe (2017) shows that constraints on access to finance exert a significant negative impact on firm growth. On the other hand, Adegboye & Iweriebor (2018) establish that while ease of accessing bank credit is the strongest positive force in driving innovation among SMEs in Nigeria, it may actually lead to lower productivity.

### *3.1.7 Financialisaton and productivity growth*

Financialisaton is a process whereby financial markets, financial institutions and financial elites gain greater influence over economic policy and economic outcomes. Financialisation of the economy is observed on three levels (G. F. Davis & Kim, 2015): industry, firm and household. At the industry level, the financial industry has become ever more prominent as the most profitable industry and its share has expanded. At the firm level, financialisaton resulted in a bigger emphasis on maximising shareholder value and the greater engagement in financial activities by non-financial corporations. At the household level, the proportion of financial assets relative to total household assets grew significantly. However, the very definition of financialisaton varies substantially among authors (L. E. Davis, 2017).

Initial macroeconomic research indicates that the national development of a financial services industry is a prerequisite for sustained economic growth (King & Levine, 1993). Yet, a positive impact of financial service growth on GDP requires institutions that prevent fraud and excessive risk-taking (R. Levine, 2005; Mishkin, 2007). Recently, some economists disclosed that increased financial services do not lead to higher economic growth (Rousseau & Wachtel, 2011) due to diminishing returns (Philippon & Reshef, 2012). Cecchetti and Kharroubi (2012) show that when the share of financial services in an economy becomes too large, the impact on economic growth is negative by crowding out investment and R&D in the non-finance sector. Cecchetti and Kharroubi (2012) find for a sample of 15 OECD countries that higher financial sector growth rates are associated with lower productivity growth, particularly in R&D- and capital-intensive industries. Tomaskovic-Devey, Lin & Meyers (2015) also show that financialisaton in the non-finance sector reduced economic growth in that sector.

The key question about the effect of financialisaton on productivity growth is therefore whether financialisaton crowds investment out. The impact of financialisaton on investment and therefore on productivity growth can be theoretically either negative or positive. Increased shareholder power would induce managers to make more efficient use of the funds at their disposal by reducing the principal–

agent problem (1976) and therefore lead to improved corporate performance (Jensen & Murphy, 1990). On the other hand, financialisaton, increasing shareholder power, and management's stronger orientation to shareholder value would cause a 'downsize and distribute' policy (Lazonick & O'Sullivan, 2000) since shareholders would demand high stock and share prices. This would lead to the low growth of capital stock and therefore negatively impact productivity growth (Stockhammer, 2004). Hein (2012), using a post-Kaleckian endogenous growth model, shows the most likely outcome of financialisation, rising shareholder power and a pronounced shareholder value orientation is a contractive regime, i.e. one in which increased financialisaton has a negative effect on productivity growth. However, he shows that under some assumptions (which are generally not empirically supported) increased finalisation has a positive effect on capital accumulation and therefore leads to higher productivity growth.

Empirical studies (at both the aggregate and firm level) reveal that financialisaton is systematically related to investment and therefore to productivity. Yet, the primary channels through which this relationship occurs and the direction of the relationship are unclear. Earlier studies suggested a clear negative impact of financialisaton on investment. (Stockhammer, 2004) studies the effect of capitalisation on the rate of growth of capital stock in the USA, the UK, France and Germany between 1963 and 1997. His aggregate analysis shows that in the first three countries capitalisation negatively affects the growth rate of capital stock. Using aggregate panel data of OECD countries in the period 1970–2008, Assa (2012) finds a significant negative effect of financialisaton on inequality, growth and unemployment. (Orhangazi, 2008) provides evidence of a negative relationship between real investment and financialisaton in the USA. His analysis is based on non-financial US firms in the period 1973–2002. The analysis of Demir (2009) is also based on non-financial firms. Using panels of publicly-traded industrial firms in Argentina, Mexico and Turkey in the period 1992–2003, he found an economically and statistically significant positive (negative) effect of the gap in rates of return between fixed and financial assets on fixed investment (financial investment) in all three countries. Further, while studying non-financial US firms in the period 1971–2014, Davis (2018) finds the shareholder-value orientation is associated with a statistically and economically significant decline in firms' investment rates. The stock of financial assets, conversely, is found to be a positive correlate of firm investment. The analysis also highlights key differences by firm size. In particular, shareholder-value norms are determined to primarily influence the investment behaviour of large NFCs, while growing volatility most substantially impacts small firms. The non-linear effect of financialisaton on investment is also emphasised in the study by Tori and Onaran (2018). Using non-financial companies in the period 1995–2015 in selected Western European countries, they found that finalisation crowds investment out in large firms and has a positive effect on investment only on small, relatively more credit-constrained firms. However, their general conclusion is that both financial payments and financial incomes adversely affect investment in fixed assets.

While the empirical evidence mainly supports the 'financialisaton thesis', namely, that the non-financial sector's increasing orientation to financial activities is leading to lower physical investment and hence to stagnant or fragile growth as well as long-term stagnation in productivity, recent research also makes it clear that the relationship between financialisaton and investment and therefore long-term productivity is more complicated. Therefore, more studies are needed to investigate the channels by which it works and therefore explain why in some cases (quite rarely) financialisaton can bring increased investment and long-term productivity.

### *3.1.8 Policy impact on productivity: demand- and supply-side policies*

Economic policies are traditionally expected to promote economic development and growth, including firm performance. Policies are normally divided into several groups, most often these include macroeconomic policies (fiscal, monetary, exchange rate policies as part of trade policies), which typically address the demand side, competition policies, social policies (including redistribution) and policies with longer-term economic development in mind, typically aimed at supply. These include trade policies (free-trade policies), industrial policies, privatisation policies, competition policies, regulatory changes, education policies, technology and investment policies. They address both the demand side (primarily macroeconomic policies of the economy) as well as supporting and stimulating development of the supply side. While several demand-side policies, such as macroeconomic, trade and the exchange rate, have already been dealt with, the industrial policy aspect must principally be stressed. (The other aspects are addressed in specific sections.)

Industrial policy is chiefly aimed at increasing a country's productive capacities, thus making it more supply-side-oriented. The literature brings diverging opinions on the need for industrial policy, especially due to the perceived interventionism and interference with the market. However, a "*combination of active competition policies and policies directed to the maximisation of positive externalities and spill-overs can configure a crisis resilient, growth-enhancing and competition-friendly industrial policy*" (Delgado, 2011). While wider aspects of industrial policy (broad measures such as investment promotion, trade and exchange rate policy, macroeconomic stabilisation policies) aimed at enhancing the general productive capacities of the economy, there are also horizontal measures that often address a specific set of companies (e.g. stimulation of small and medium-size companies, start-up promotions etc.) and sectoral measures (e.g. the lead markets initiative[6] on the EU level or the 'European Champions' policy approaches), while the promotion of future capacities is also stimulated by several forward-oriented policies like education and R&D promotion (Prašnikar, 2014; Stiglitz & Greenwald, 2014).

With regard to 'broad-band' measures, the literature stresses the focus of public expenditure on increasing productive expenditure, particularly spending more on infrastructure (transport, communication), education and health (Kneller & Misch, 2014). The authors add that, even if total expenditure remains constant, reallocation to these expenditure types will positively impact productivity, which they say is especially important in view of long-run productivity growth since it is

[6] The Lead Markets initiative was started in the EU by the "Aho Report" (Aho & Independent Expert Group on R&D and Innovation, 2006) and today within the Smart Specialisation Strategies encompasses several sectors, including bio-technologies, clean development etc. The national champions policy with respect to specific supports more tailored to the needs of a specific company, which is perceived to be of strategic developmental importance, has been widely discussed in the literature, stressing both positive and negative aspects (see (*Industrial Policy for National Champions*, 2011)).

not increasing the tax burden. But they also find that the impact depends on technology and that firms with a lower capital-labour ratio benefit more.

The size and structure of public finances along with the size of the public administration are linked to economic growth in the EU (Barrios & Schaechter, 2008). First, the authors show that "overall strong and sustainable budget positions" as well as sustainable debt levels are positive for economic growth. Otherwise, the crowding out of private investment can be observed. Moreover, a large public administration hinders growth, especially if the tax levels are also high and resources are inefficiently used. In relation to Kneller & Misch (2014) findings, Barrios & Schaechter (2008) stress the outcomes of policies such as education – more educated people contribute to growth, but not to spending itself. To foster growth, it is also important to raise the efficiency of spending and limit distortions.

Another aspect of fiscal policy, and primarily of industrial policy, is subsidies to companies regarding which the literature has mixed attitudes, where size, dispersion of subsidies, as well as ownership also matter. Domadenik, Koman and Prasnikar (2018) show that in Slovenia during 2009–2012 the dispersion of subsidies was positively related to productivity growth in general, but that firms in receipt of a larger proportion of subsidies were afterwards less productive than those without subsidies. Jin, Shang and Xu (2018), for example, show that government subsidies helped stimulate firm R&D in China between 2011 and 2015, where the subsidies are more efficient in private-owned enterprises.

As concerns the specific focuses of policies, R&D, education and digitalisation policies are in particular being discussed widely, together with smart specialisation in Europe. According to the European Commission (2018b), industrial policy is a supporting mechanism for growth in Europe, especially important since industry is "the engine of innovation, productivity growth and exports" as well as of employment. The policies are expected to support innovation, digital transformation, environmentally-friendly processes and products, and the transformation of skills.

R&D and innovation supports are key aspects of industrial policy. Generally, the empirical results show a positive link, but specific sectoral and size effects (both firm and subsidy) are relevant. Görg and Strobl (2007) find that R&D subsidies do stimulate R&D, but large subsidies could crowd out private R&D spending in domestically (but not foreign) owned firms because foreign owners decided to undertake R&D in the specific location because of the subsidy. Hud & Hussinger (2015) also find that R&D subsidies in Germany had a positive impact on R&D, while in 2009 crowding out was recorded due to the reluctancy of firms.

In its aim to promote productivity growth, Europe is stressing smart specialisation (European Commission, 2018c), which also encompasses digitalisation. The main idea of smart specialisation is that regions focus on their competitive advantages with policies supporting those with realistic potential; in other words, to stimulate "*knowledge-driven growth and to bring about the economic transformation needed to tackle the major and most urgent challenges for the society and the natural and built environment*" ("What is Smart Specialisation? – Smart Specialisation Platform," 2018). In this context, several policies are relevant: investment, education, R&D, digitalisation, and many more.

Specifically, besides direct financial support, the EU stresses the roles of infrastructure, support services, cooperation platforms suitable for the specific needs of the economy, which should be designed in cooperation with the business sector in order to target its specific needs ("What is Smart Specialisation? – Smart Specialisation Platform," 2018). The idea of smart specialisation was developed quickly in 2009 and its actual implementation in the 2014–2020 period was too fast to allow small-scale trials, and it is also too early for an ex-post evaluation (Crescenzi, Blasio, & Giua, 2018). These authors also evaluated the effects of the Collaborative Industrial Research (CIR) Programme in less developed Italian regions, a forerunner to the SS strategy which included EUR 1 billion for specific innovative sectors. The results did not show any significant impact on investment, value added or employment, but the programme was more successful in supporting low-tech sectors. The impact on value added was higher in firms with a high patenting capacity.

Another important aspect of SS is cluster support. Again, it is hard to assess the impact of SS, but several other studies have considered sectoral and cluster supports. Wise, Wilson and Smith (2017) overview estimates of cluster policy impacts in Denmark, France, Ireland, Norway and Sweden. Their meta-analysis shows the policies had a positive impact on collaboration, innovation and innovative capacities, competitiveness and international attractiveness, firm performance and had positive broader development impacts on clusters, their capabilities and the region. The results also show that firm connections and collaborative linkages (incl. international), cluster management, export/trade orientation and size matter as well. But not all studies show just a clear positive impact. Martin, Mayer & Mayneris (2011) analyse the effects of cluster supports in France between 1999 and 2003 on local value chains in order to strengthen their development. The results show that, policies were aimed at firms in relative decline and did not impact their productivity, but did support employment.

Overall, policies have been successful in promoting and directing economic development and productivity growth, particularly when combined with strong national development strategies which focus on supporting high value-added sectors in which countries hold potential. A good example of such development is Singapore which in the 1960s was an underdeveloped economy, but is today one of the most developed countries in the world. The strong support and development strategy, which targets sectors and offers necessary support (including education, HRM, innovation), is under the supervision of the Economic Development Board. As Ghesquiere (2006) says: engineering economic growth.

## 3.2 Firm-level determinants of productivity growth

Productivity growth depends on a complex set of supply-side factors as well. The classical equation for investigating contributions to growth or for productivity analysis reveals the importance of standard production factors, but numerous other factors have been examined in the literature so far. The chapter studies the role of several of these, with Table 2 summarises selected main factors.

*Table 2: A summary of the internal (firm-level) determinants of productivity*

| Determinant of productivity | Selected authors | Main links with productivity |
|---|---|---|
| Capital and composition of capital | Musso, 2004, Sakellaris & Vijselaar, 2005, Wilson, 2009 | Problems of measurement and estimates of productivity<br>The composition and quality of capital linked to productivity; it is also important to study complementarities between different kinds of capital (low/high tech) and substitution with labour |
| Resource allocation | Syverson, 2011, Maliranta & Määttänen, 2013, Banerjee & Duflo, 2005; Comin & Hobijn, 2004; Hsieh & Klenow, 2009, Bartelsman, Haltiwanger, & Scarpetta, 2013a | Productivity growth can result from factor movements from low- to high-productivity firms (whose productivity also depends on several external and internal factors)<br>Big and persistent differences also between plants of the same company<br>Externally imposed (including policy) frictions contribute to plant and firm differences in productivity, causing inefficient allocation |
| Labour and human capital | Abowd et al., 2005, Fox & Smeets, 2011, Blundell, Dearden, Meghir, & Sianesi, 1999, Huselid, 1995, Lazear, 2000, Black & Lynch, 1996, Ichniowski, Shaw, & Prennushi, 1997, Bloom, Sadun, & Van Reenen, 2012, Bandiera, Barankay, & Rasul, 2009 | The stock and quality of human capital related to productivity, education significantly improves productivity both directly as well as indirectly through TFP<br>Human capital linked to innovation and the adoption and adaptation of new technologies<br>Human resource management practices affect employee attitudes and behaviour as well as productivity, job satisfaction and general well-being improvement positively impact productivity, along with organisational form, social connections etc.<br>Wage differentials caused by different factors, including gender, related to productivity |
| Ageing | Skirbekk, 2004, 2005, 2008, Prskawetz, Mahlberg, Gabriele, Tundis, & Zaninotto, 2018; Bokwon Lee, Joowoong Park, Jae-Suk Yang, 2018; Hu, 2016; Feyrer, 2007; Werding, 2008; Loser, Fajgenbaum, Kohli, & Vilkelyte, 2017, Mahlberg, Freund, Crespo Cuaresma, & Prskawetz, 2013, | Empirical evidence does not indicate a straightforward relationship between productivity and individuals' age<br>Aggregate productivity negatively related to age composition<br>Firm-level age impact often shows a negative relationship between age and productivity, but studies sometimes show that older workers are even more productive than their younger colleagues<br>with productivity increasing at the beginning of working ages, then it stabilises and often decreases at older ages, especially in job tasks where problem-solving, learning and speed are important, less or no productivity reduction in older workers whose work tasks relate to experiences or verbal abilities<br>Sectoral differences important |
| Trade and global value chain participation | Wagner, 2005, Bernard & Jensen, 2004, Baldwin & Gu, 2003; Baldwin, Gu, & Yan, 2013, Wagner, 2007, Fryges & Wagner, 2008,<br>Shu & Steinwender, 2019, Wagner, 2007, Prašnikar, Redek, & Drenkovska, 2017; Ribeiro, Carvalho, & Santos, 2016; Salomon & Jin, 2006; Sharma, 2018, Vrh, 2017 | Self-selection into exports by more productive firms,<br>Learning-by-exporting causes a post-entry increase in performance<br>Directly or indirectly linked to learning, knowledge or technology transfer and links to innovation<br>FDI can benefit development in recipient countries as it brings a resources<br>position in global value chains |

| | | |
|---|---|---|
| R&D | Griliches, 1957, Mairesse & Sassenou, 1991, Griliches, 1992, Verspagen, 1995, Harhoff, 1998 | Firm investment in R&D increases productivity, but the estimated impacts differ significantly<br>A non-linear effect of R&D on productivity recorded, high-tech sectors invest more, but also benefit more, productivity gains are higher<br>Importance of the social return of R&D<br>R&D linked to financial constraints and firm size |
| Industry 4.0 | Schwab, 2019, McKee, 1982; Prašnikar, Redek, & Koman, 2017; Xu, David, & Hi Kim, 2018. Schwab, 2019. | Barriers and transaction costs between companies, inventors and markets (B2B and B2C) will decline, which improves productivity and enables the faster commercialisation of ideas.<br>Progress of artificial intelligence and its wider use: efficiency is expected to rise<br>Robots expected to support productivity growth due to their higher efficiency, higher quality and lower (labour) costs,<br>Connected processes and connected life through the IoT expected to help with rationalisation and lowering costs, thereby supporting productivity. |
| Intangible capital | Corrado, Hulten, & Sichel, 2005<br>"CoInvest Project," 2012; Corrado et al., 2009; Fukao, Miyagawa, Mukai, Shinoda, & Tonogi, 2009; Innodrive, 2008; van Ark, Hao, Corrado, & Hulten, 2009, Jona-Lasinio & Meliciani, 2018, Piekkola, 2011, Roth & Thum, 2013, Corrado, Haskel, Jona Lasinio, & Iommi, 2018 | Intangible capital positively contributed to country development, increases GDP and productivity growth.<br>Differences between European countries substantial, but convergence is observed<br>Link between FDI and intangible capital growth and labour productivity growth, intangibles explain a large proportion of the unexplained variance in labour productivity growth<br>All components of intangible capital are positively related to productivity growth, but the size of the contribution depends on the structure of the economy and development of the economy |

Source: Own.

### 3.2.1 Capital, capital structure and productivity growth

Physical capital is one of the inputs in the production function. It is generally measured in monetary units rather than the number of machines, computers etc. Despite being likely somewhat better measured than the quality of workers in a typical production function regression, there are still some substantial measurement biases associated with it.

Escribá-Pérez, Murgui-García & Ruiz-Tamarit (2019) use a theoretical model to empirically obtain an endogenous variable depreciation rate. Based on this, they construct economic capital stock which substantially differs from statistical capital stock. Similarly, Sakellaris and Vijselaar (2005) claim that productive capital stocks (more accurately, the service flows from capital that serve as an input in production) should be constructed after deflating nominal investment flows by a quality-adjusted price index and depreciating old vintages with a rate that does not include quality change. Otherwise, the growth of capital stock is underestimated.

There is consolidated literature proving that any distortion in the measurement of capital stock may cause a substantial bias in the measurement of total factor productivity growth. Musso (2004) and Mukoyama (2008) analyse this aspect in the context of a vintage capital model and show that it induced a long-lasting underestimation of the total factor productivity growth rate. Sakellaris and Vijselaar (2005) establish that the measurement error of capital input affects the composition of total factor productivity. More precisely adjusted for quality, productive capital stocks of equipment and software grow on average 3 percentage points faster annually – a doubling of their growth rates. The contribution of quality-adjusted capital to output growth is much higher than previously calculated. This relates not only to IT hardware, but also to most other machinery and equipment. Due to the effects of quality adjustment on output, TFP growth hardly differs from the original case in absolute terms. However, it declines as a percentage of total output: Quality adjustment subtracts 11 percentage points from the share of TFP in output growth and adds them to the contribution of equipment stock.

Studies also show the composition of capital has an important effect on productivity. Wilson (2009) argues that one can express capital services as a single aggregate only if different capital services are perfect substitutes. His analysis reveals that: 1) "high-tech capital tends to be complementary with low-tech capital", (2) high-tech capital tends to be substitutable with other "high-tech capital, (3) low-tech capital tends to be substitutable with other low-tech capital. He also finds that different types of capital affect labour differently. For example, software is found to be labour-saving (substitutable with labour) while general-purpose Machinery and Trucks are found to be labour-augmenting (complementary with labour). Therefore, to accurately estimate productivity one needs to adequately account for the capital mix.

### *3.2.2 Resource allocation and productivity growth*

Studies by Syverson (2011) show enormous and persistent measured productivity differences across firms, even within narrowly defined industries. For example, (Syverson, 2004) finds that within four-digit SIC industries in the US manufacturing sector, the plant at the 90th percentile of the productivity distribution creates almost twice as much output with the same measured inputs as the 10th percentile plant. This difference is even bigger in China and India where the average difference between productivity level in the 90$^{th}$ percentile and the 10$^{th}$ percentile of total factor productivity is 5:1 (Chang-Tai Hsieh & Klenow, 2009). These productivity differences are also persistent (Abraham & White, 2006; Foster, Haltiwanger, & Syverson, 2008). In his survey, Syverson (2011) points out that the reasons productivity levels vary so much across firms in the same industry may be due to the influences on productivity that operate primarily within the business or may be externally driven. According to (Syverson, 2011), the most important internal drivers of productivity differences among businesses are: managerial practice/talent, higher-quality general labour and capital inputs, information technology and R&D, learning-by-doing, product innovation, firm structure decisions. In contrast, the external drivers of the productivity difference are: productivity spillovers, competition (intramarket and trade competition), deregulation or proper regulation and flexible input markets.

Due to the enormous and persistent measured productivity differences among firms, a substantial part of industry productivity growth can be attributed to factor reallocation from low-to high-productivity firms (Maliranta & Määttänen, 2013). Lentz & Mortensen (2008) assess that 53 percent of aggregate labour productivity growth among Danish firms can be attributed to such reallocation. It has also been argued that differences in resource allocation between firms explain a large part of cross-country variation in aggregate productivity levels (Banerjee & Duflo, 2005; Comin & Hobijn, 2004; C.-T. Hsieh & Klenow, 2009). Related to this, model-based analyses such as in Restuccia & Rogerson (2008), Guner, Ventura & Xu (2008) and Bartelsman et al. (2013a) reveal that a certain type of allocation distortions may substantially lower aggregate productivity by making resource allocation between firms less efficient (see Restuccia & Rogerson (2008) for a survey of literature on role-allocation distortions).

Andrews & Cingano (2014) study why some countries are more successful at channelling resources to high-productivity firms than others. Their results suggest there is an economically and statistically robust negative relationship between policy-induced frictions and productivity, although the specific channel depends on the policy considered. In the case of employment protection legislation, product market regulations and restrictions on foreign direct investment, this is largely traceable to the worsening of allocative efficiency. By contrast, the adverse impact of financial market under-development on aggregate productivity tends to arise through shifts in the firm productivity distribution. Further, stringent regulations are more disruptive of resource allocation in more innovative sectors.

### *3.2.3 Labour, human capital and productivity growth*

The role of human capital in explaining productivity differences has been considered since at least the seminal papers published by Griliches (1957), with Becker (Becker, 1994) offering a review of studies that investigated the importance of human capital, human resources practices and social connections as well as organisational form for productivity. The following sections focus on these factors in turn.

**The stock and quality of human capital** ((Abowd et al., 2005), (Fox & Smeets, 2011)). There are two different approaches to accounting for the stock of human capital: human capital (estimated by average years of schooling) as an ordinary input in the production function (S. E. Black & Lynch, 2004; Mankiw, Romer, & Weil, 1992) and the endogenous growth theory where the growth of total factor productivity is a function of human capital stock (Benhabib & Spiegel, 1994). Black and Lynch (1996), for example, showed that for a 10-percent increase in education productivity would rise by 4.9 percent in manufacturing and 5.9 percent in non-manufacturing. Benhabib and Spiegel (1994) established that introducing human capital as a factor of production in a Cobb-Douglas production function has a non- significant effect on GDP growth per capita but, if the influence of human capital on total factor productivity is taken into account, the effects are visible in two ways: a) human capital influences the internal rate of innovation as evidenced by Romer (1990); b) human capital influences the rate of diffusion of technology in the spirit demonstrated by Nelson and Phelps (1966).

When investigating firm-level productivity as a function of human capital, studies proxied human capital as the skills and knowledge of the workers (G. Mason, van Ark, & Wagner, 1994). The highly cited review paper by Blundell et al. (1999) stresses the importance of human capital for an individual (as a return to human capital investment), a firm (for productivity, profitability and competitiveness) and for economic growth. In addition, Benhabib and Spiegel (1994b) found that human capital influences the internal rate of innovation (following Romer (1990)) and human capital influences the rate of diffusion of technology in the manner outlined by (Nelson & Phelps, 1966) and affects total factor productivity. Similarly, (Bishop, 1994) showed that the human capital of employees is linked to innovative capacity as well as the adoption and adaptation of new technologies.

There are several ways to measure the **quality of labour** such as a broad measure of "skilled" (college) and "unskilled" (non-college) workers or more specific measures like inclusion in schooling (Belman & Heywood, 1990; Sattinger, 1980); sex, total experience, industry-specific and firm-specific training and tenure and industry (Belman & Heywood, 1990; Y. S. Lee, 2018). Much of the investigation of the quality of the labour force and productivity has focused on **wages** as the outcome of interest since market wages reflect workers' productivity.

Wage differentials reflect: **(1) age, experience and education** (human capital models of wage growth – (Becker, 1992; Ben-Porath, 1967a; J. A. Mincer, 1974) and, among others, are applied by (Acemoglu & Pischke, 1999; Altonji & Spletzer, 1991; Blundell et al., 1999; Leuven & Oosterbeek, 2008; Lynch, 1992; Parent, 1999) while investigating a positive correlation between age and experience that is associated with the specific human capital investment and on-the-job training which is positively correlated with higher wages. Years of education and the quality of education received are positively correlated with wages (among others (D. A. Black & Smith, 2006; Brewer, Eide, & Ehrenberg, 1999; Card, 1999; Dale & Krueger, 2002; Long, 2010; Solmon & Wachtel, 1975); **(2) sex or race** (wage discrimination). The investigation of wage differences in terms of sex or race has been oriented to showing the existence of discrimination. For example, workers in companies with more male and white workers are paid more (Barth, Davis, & Freeman, 2017). A recent review paper by (Bishu & Alkadry, 2017) analyses 98 academic papers investigating the gender wage gap and concludes that disparity in access to workplace authority, disparity in access to hiring and promotion, and gender representation are the core factors associated with expanding the wage gap. Nevertheless, other studies focus on the topic from the productivity point of view. These studies find that productivity differentials for women range from 8 percent to 15 percent (Hellerstein, Neumark, & Troske, 1999); **(3) marriage** (reflecting productivity effects) (Hellerstein et al., 1999) finds that workers who have ever been married are more productive than never-married workers and are paid accordingly, while several papers show (Loh, 1996) that marriage is not per se a source of increased productivity as suggested by Becker (1994b); **(4) employer and industry** where studies find that workers are paid more in establishments with more employees, in older establishments (up to a point), with greater equipment capital per worker and greater exports, with a workforce that includes more educated workers; and in firms with greater R&D spending (Abowd, Kramarz, & Margolis, 1999; Barth, Bryson, Davis, & Freeman, 2014; Barth, Davis, & Freeman, 2017; Card, Devicienti, & Maida, 2014; Davis & Haltiwanger, 1991); **(5) union status** Wages are however an imperfect measure of worker productivity since they can reflect labour and product market characteristics, the burden of the cost of training (Dearden, Reed, & Reenen, 2006) or wages can be partly determined by sharing rents captured by innovation (Van Reenen, 1996).

Therefore, different measures have focused on adding labour quality measures and investigated the effect on productivity (Abowd et al., 2005). A study by Fox & Smeets (2011) on Danish firms showed that adding the quality of labour measures decreases the within-industry productivity dispersion between the $90^{th}/10^{th}$ percentile by 11% in manufacturing and by 22% in services. Konings & Vanormelingen (2014), for example, find that a 10-percentage-point increase in the share of trained workers is associated with 1.7% to 3.2% higher productivity.

**Human resource management practices, including incentive pay**. Labour economists who initially mostly focused on the importance of human capital, later also considered different **human resource management practices and their relationship with productivity** (S. E. Black & Lynch, 1996; Huselid, 1995; Ichniowski, Shaw, & Prennushi, 1997; Lazear, 2000). However, the question is not the implementation of HRM practices per se to achieve productivity, but how to properly select those that satisfy organisational requirements to increase productivity. Since human resource management practices affect employee attitudes and behaviour at the individual level which, in turn, affects behaviours and people-related outcomes like labour productivity and labour turnover, which then affects firm performance (Paauwe, 2009). Bloom and van Reenen (2011) review general HRM practices and the effects on productivity based on the highly cited papers of Huselid (1995), Ichniowski et al. (1997) and Black and Lynch (2004) and conclude that studies generally show a positive correlation between incentive pay (both individual and group) and productivity. Yet, not all HRM practices are related to productivity increases. Koch & McGrath (1996) already found that more sophisticated HRM practices exert a positive and significant effect on labour productivity. For instance, Black and Lynch (2001) investigated a set of HRM practices and found that profit-sharing for non-managers and benchmarking had the strongest correlation with total factor productivity, whereas the seminal paper by Bloom and van Reenen (2007) reports a positive and high correlation between HRM scores and productivity. Georgiadis & Pitelis (2016) state that non-managerial employees' training had a large positive impact on labour productivity and profitability, whereas there was a weak or no effect of managerial and HRM training services on firm performance. (Romano, 2019) provides the first evidence of the heterogeneous impact of such a managerial practice among different types of firms where pay-for-performance schemes are systematically associated with positive firm revenue, employment and productivity growth, but also that this positive association does not hold true for firms pursuing highly complex innovation strategies for which the effect is null or negative. Therefore, different HRM practices have a different effect on productivity.

Job satisfaction and general well-being are attracting growing research with studies showing that the increased satisfaction or happiness of workers is associated with higher productivity. For example, (Böckerman & Ilmakunnas, 2012) show that an increase in the measure of job satisfaction by one standard deviation increases value added per hours worked in manufacturing by 6.6%. Similarly, (Banerjee & Mullainathan, 2008) model labour productivity that depends on outside worries. Using a natural experiment, Oswald, Proto & Sgroi (2015) provide evidence of a link between human happiness and human productivity where productivity rises from 10 to 15 percent depending on the experiment.

**Organisational form** is important for productivity growth. Garicano and Heaton (2010) and Bloom et al. (2012) for instance show that social capital as proxied by trust increases aggregate productivity by facilitating reallocation between firms and allowing more efficient firms to grow (the theory originates in Penrose (1995) and Chandler (1962)).

**Social connections among co-workers** also matter for productivity. (Bandiera, Barankay, & Rasul, 2009) investigated social connections between managers and workers and found that, when managers are paid fixed wages, the productivity of a given worker is 9 percent higher when they are socially connected to their manager. When managers face low-powered incentives, they favour workers with whom they are socially connected, regardless of the workers' ability. An increase in the level of social connections between managers and workers has a detrimental effect on firms' average productivity when managers are paid fixed wages and has no effect when managers are paid performance bonuses.

**The role of productivity-driven reallocation on labour market dynamics via job creation and destruction** has also attracted attention (Haltiwanger, Scarpetta, & Schweiger, 2008). Studies mostly focus on capital misallocation and the effect on TFP (Chang-Tai Hsieh, Hurst, Jones, & Klenow, 2013; Chang-Tai Hsieh & Klenow, 2009; Klein & Ventura, 2009; Monge-Naranjo, Sánchez, & Santaeulàlia-Llopis, 2018) or explain the differences among countries (E. Bartelsman, Haltiwanger, & Scarpetta, 2013b). For example, Hsieh et al. (2013) concluded that 15–20 percent of the growth in aggregate output per worker between 1960 and 2008 may be explained by the improved allocation of talent that followed the reduction of discrimination (for women and blacks). In other words, declines in misallocation may explain a significant proportion of US economic growth over the last 50 years, while it was shown that efficiency losses arising from misallocation represent around 60 percent of the world's output. A recent paper by Salas-Valesco (2018) looked at allocation through the lens of skills mismatch and found that skills mismatch is associated with higher production inefficiency. Conversely, more flexible labour markets and better management and human resource practices lowered the inefficiency in production by 22.6 percent without consuming more resources.

However, labour quality does not explain most productivity dispersion. Productivity mainly represents some attribute of a firm that cannot be easily bought and sold on the market for inputs. Possibilities include management quality, business strategy, the appropriate use of new technologies and heterogeneous production technologies (for a review, see Bartelsman and Doms (2000)).

### *3.2.4 Ageing and productivity*

The variability of individuals' productivity at different ages is not straightforward. Previous studies generally show a drop in individuals' productivity at higher ages (see the extensive literature reviews by (Gabriele, Tundis, & Zaninotto, 2018; B. Lee, Park, & Yang, 2018; Prskawetz, Mahlberg, & Skirbekk, 2005a; Vegard Skirbekk, 2004). Productivity especially decreases after the age of 50 (Vegard Skirbekk, 2004) and in job tasks where problem-solving, learning and speed are important; yet, there is less or no productivity reduction among older workers whose work tasks are related to experiences or verbal abilities (V. Skirbekk, 2008).

Productivity during an individual's life cycle differs for several reasons such work experience, cognitive functioning, physical abilities, family obligations, motivation, matching of the worker and the task, loyalty etc. (Skirbekk, 2008). The assumption of lower productivity at higher ages goes back to the human capital models of (Ben-Porath, 1967b), Mincer (Mincer, 1958, 1974) and (Becker, 1994). During their life cycles, workers acquire more skills and experience, thereby increasing their productivity. After reaching a peak, at older ages workers' productivity decreases (J. Mincer, 1958). Compared to these initial theoretical papers, the empirical evidence does not establish a straightforward relationship between productivity and individuals' age, sometimes showing that older workers are even more productive than their younger colleagues.

The variability of individuals' productivity over the life cycle is examined in detail in the Skirbekk (2004) review of several empirical studies, based on which he concludes that previous studies mainly show a decrease in individuals' job performance (i.e. productivity) at higher ages, especially after the age of 50. Based on a detailed review of articles that use different approaches to examine performance variation over the life cycle, Skirbekk (2008) concludes that productivity increases at the beginning of working ages, then stabilises and often decreases at older ages, especially for job tasks where problem-solving, learning and speed are important. Further, there is less or no productivity reduction among older workers whose work tasks relate to experiences or verbal abilities. Similar conclusions are found in the comprehensive literature review by Prskawetz, Mahlberg and Skirbekk (2005b). These authors further indicate that productivity at older ages is possibly even biased upwards due to positive selection bias because old-age individuals staying in the labour market have higher productivity than the departing labour force. The negative connection between an ageing workforce and productivity is also revealed in some recent empirical studies, such as (Gabriele, Tundis, & Zaninotto, 2018) for Italy or (Hu, 2016) for China. (Hu, 2016) claims that more experiences gained over the life cycle become an obstacle to enhancing older workers' productivity as their knowledge and experience become out of date, especially in the current information era. Further, based on Korean firm-level data, researchers show a negative relationship between the share of workers aged 50+ and value added per worker, which is again consistent with the majority of studies that previously used European data (B. Lee et al., 2018). However, Lee, Park and Yang (2018) reveal that the relationship between the share of workers aged 50+ and value added per worker is positive in large manufacturing firms facing risky or growing conditions.

In contrast to widespread literature showing the negative effect of age on productivity, based on a matched employer-employee panel dataset for Austrian firms between 2002–2005 Mahlberg, Freund, Crespo Cuaresma and Prskawetz (2013) conclude that firm productivity is not negatively related to the share of older workers. Moreover, older workers are also not overpaid in relation to their productivity. Next, the authors show that age-productivity differs significantly across regions and sectors where sectoral differences are even more important (Mahlberg, Freund, Crespo Cuaresma, & Prskawetz, 2013). Similarly, based on German data for 1986–2006, Gordo and Skirbekk (2013 ) conclude that workers in their 50s have adopted well to technological changes that lead to cognitively more demanding tasks, and experienced greater growth in cognitive demanding tasks than younger workers in their 30s. This contradicts previous literature showing the elderly have lower cognitive abilities than their younger colleagues (Prskawetz et al., 2005) and can be explained by productive older workers remaining in the labour market for a longer time than unproductive workers (Burtless, 2013). Further, based on the Current Population Survey Burtless (2013) concludes that workers between the ages of 60 and 74 are on average more productive than those aged 25–59. In line with the positive relationship between productivity and the individual's age, the meta-analysis by (Ng & Feldman, 2012) of 418 empirical studies verifies the consistency of six common stereotypes about older workers: their lower motivation, lower willingness to participate in training and career development, lower willingness to change, lower trust, poorer health, and higher vulnerability to work-family imbalance. The authors found that the only stereotype consistent with previous research is that older workers are indeed less willing to participate in training and career development.

The workforce demographics is also strongly related with aggregate productivity and output. A significant part of the productivity gap between poor and rich countries can be explained by the difference in the population age structure that also partly explains the productivity divergence among countries since the 1980s (Feyrer, 2007). Based on empirical work and using a large macro-data panel for OECD countries, Werding (2008) concludes that the age composition of a country's labour force affects its total factor productivity and its growth. Workers aged 40–49 are the most important for high levels and faster growth of productivity, whereas the contributions of the young and the elderly are considerably smaller. Based on US data for the period 1980–2010, Maestas, Mullen and Powell (2016) show that a 10-percent rise in the proportion of those aged 60+ decreases the GDP growth rate per capita by 5.5%, where two-thirds of this decrease is attributed to older workers' lower productivity. Similarly, a recent empirical study by Loser (2017) that relies on worldwide macro data for the period 1990–2016 reveals that an increase in the share of workers aged 65+ decreases the output per worker, showing a decline in productivity with ageing. However, the effect of population ageing on productivity is also not straightforward on the macro level. For example, based on US and Australian data, Guest (2011) finds that population ageing will shift consumption towards goods that are capital intensive, causing an increase in labour productivity by 1–4 percent per annum up to 2050.

The negative consequences of population ageing, if they indeed exist, can be partially mitigated by appropriate policies. A better age-mix in the workplace could result in improved productivity of the ageing populations by older and younger workers benefiting from each other's competitive advantages. Yet, the age diversity of workers only has a positive effect on company productivity if the work tasks performed are creative and not routine (Backes-Gellner & Veen, 2013). Similarly, Göbel & Zwick (2013) analyse a German employer-employee dataset between 1997 and 2005 and conclude that mixed-age working teams are beneficial for younger and older workers' productivity. The authors also find the significantly higher productivity of older workers when equipment changes or age-specific job assignments are applied. Skirbekk (2008) concludes that later retirement could increase older workers' incentive to update their skills and to work hard at older ages. Finally, over time, the productive potential of older workers is likely to increase: (1) due to improved cognitive abilities and health of the elderly; (2) because modern jobs rely ever less on the physical strength of workers; and (3) since flexible job arrangements are more and more common.

### *3.2.5 R&D and productivity growth*

The impact of R&D on productivity growth has been a focus of theoretical and empirical contributions since the seminal paper of (Griliches, 1958). Research and development resulting in new (better quality) goods, new processes and improved knowledge is a major source of technical change that is crucial for long-run productivity growth in the context of endogenous growth theory (Romer, 1986), with OECD countries that made more R&D investment enjoyed significantly higher economic growth in the period 1996–2015. Yazgan and Yalcinkaya (2018) state that R&D comprises creative work undertaken on a systematic basis in order to increase the stock of knowledge. In modern economies, it is not only a source of new technology but also relates to design improvement or competence development since it comprises the broader spectrum of organisational changes. Although most findings support the hypothesis that firm investment in R&D affects productivity growth (Hall, Mairesse, & Mohnen, 2010, Yazgan & Yalcinkaya, 2018) as businesses use limited resources in a more efficient way, there is less of a consensus on the magnitude of the R&D contribution. Studies based on firm-level data report that the elasticity of productivity with respect to R&D investment ranges from 0.01 to 0.32 with the rate of return being estimated at between 8.0 and 170.0 percent (Mairesse & Sassenou, 1991; Mairesse & Mohnen, 2002). This means that by increasing R&D investment by 1 percent, productivity rises by 0.01 to 0.32 percent, on average, *ceteris paribus*. However, these estimates often lack robustness and statistical significance and are thus of little help to policymakers and businesses (Czarnitzki, Kraft, & Thorwarth, 2009; Khan, Luintel, & Theodoridis, 2010). (Mairesse & Sassenou (1991), for example, argue it is quite difficult to be sure the relationship between R&D and productivity is real and not simply a reflection of the specificity of particular studies. In order to improve the precision of estimates, studies tried to control for inter-sectoral firm heterogeneity. Griliches and Mairesse (1982) and Cuneo & Mairesse (1984) found that when inter-sectoral heterogeneity is controlled R&D investment has a bigger effect in high-tech (science-based) firms than in other sectors' firms. Similar findings were reported by Verspangen (1995) for OECD countries and Harhoff (1998) for German manufacturing firms in the period 1977–1989. High-tech firms also showed a systematically higher effect of R&D on labour productivity in Japanese (Kwon & Inui, 2019) and Taiwanese (Tsai & Wang, 2004) manufacturing firms. Kumbhakar, Ortega-Argiles, Potters, Vivarelli and Voigt (2009) used the Scoreboard data and reported that elasticities rose from 0.05–0.07 in low-tech sectors to 0.16–0.18 in high-tech sectors.

Few studies emphasise that the puzzle of imprecision may be explained by the non-linear impact of R&D on firm productivity. Geroski (1998) reports that absorption capacity (its ability to identify, assimilate and apply external know-how) and critical mass play important roles as no increasing returns to innovation could be detected until a certain threshold of R&D had been reached. González and Jaumandreu (1998) found that the threshold is between 0.2 and 0.5 of the median-performing firm's R&D intensity in their sample of Spanish firms in the period 1990–1995. Kancs and Siliverstovs (2016) support that finding with their study on OECD countries, reporting that R&D investment increases firm productivity with an average elasticity of 0.15 (smaller for low levels of R&D intensity and higher for high levels) but is non-linear and significantly positive only after a critical mass of R&D has been reached. High-tech sectors' firms not only invest more in R&D, but also achieve more in terms of productivity gains (Castellani, Piva, Schubert & Vivarelli, 2019). In relation to firm size, a study of a German panel of firms with less than 10 employees reports that micro firms engage in R&D activities with a lower probability, with R&D intensity being larger for smaller firms and a larger effect size for product than process innovation (Baumann & Kritikos, 2016). Micro firms benefit in a similar way as their larger counterparts from innovation activity.

To the extent that knowledge cannot be kept secret, the returns to the investment in it cannot be appropriated by the firm undertaking the investment, therefore making such firms reluctant to invest and leading to the under-provision of R&D investment in the economy. As many researchers (Griliches, 1992; Hall, 1996) document, the social returns to R&D are higher than the private level, the issue of who is supposed to finance R&D became very important in the context of endogenous growth theory and Arrow's argument that one person's use of knowledge does not diminish its utility for another (see Romer (1986) and Aghion and Howitt ((1997)) for example). Cohen and Levinthal (1989) and Li and Bosworth (2018)) pointed out that the implications of knowledge spillovers go beyond the free-rider problem in R&D expenses by increasing a firm's ability to assimilate knowledge from its environment (absorptive capacity). They argue that knowledge spillover may increase equilibrium R&D investment and positively affect firm-level productivity (Adams & Jaffe, 1996; Cockburn & Henderson, 1998). In empirical research, the dominant approach suggests constructing a "spillover pool" (i.e. a measure of outside R&D) and include this as additional explanatory factor (on top of the firm's own R&D expenses) in productivity analysis. (Bernstein & Nadiri, 1989), for instance, measure it as the stock of knowledge generated by other firms in the industry. Although most of these studies find a positive spillover effect on productivity, especially along the supply chain (Li & Boshworth, 2018), part of the literature stresses that identification of the strategic rivalry effect of R&D from technology spillover is impossible as industry R&D reflects both effects (Bloom, Schankerman, & Reenen, 2013). Alternative specifications which use "distance to the frontier" at the industry level as a proxy for spillover pool (such as Acemoglu, Aghion, Lelarge, Van Reenen & Zilibotti (2007); Pieri, Vecchi & Venturini, 2018) have similar drawbacks. By addressing the most important issue of the endogeneity of the R&D decision (treating productivity and R&D investment as jointly determined), the huge firm-level difference in R&D intensity and the business-stealing effect, Bloom et al. (2013) could show that the knowledge spillover effect (i.e. patenting in similar fields) dominates the negative ones (R&D by product market rivals has a negative effect on productivity due to business stealing). By applying US firm-level data in the period 1981–2001, they report that the social returns to R&D are two to three times as large as the private returns.

The usual way to examine the empirical relevance that R&D investment can be reduced when internal funds are unavailable is to estimate investment equations and test for the presence of "liquidity constraints" like in the case of fixed capital investment. Several studies have considered the impact of potential financial constraints on R&D activities. Attention was rekindled during and after the financial crisis due to greater problems with financing new investment (see, for example, Hall, Castello, Montresor & Vezzani, (2016); Altomonte, Gamba, Mancusi & Vezzulli, (2016); Qi & Xiaolan (2019). Older studies based on cross-sectional data for large firms or industries report mixed evidence. In Scherer (1965), Mueller (1967) and Elliot (1971), no significant impact of liquidity constraints or profitability on R&D expenses was reported, while opposite results were obtained by Grabowski (1968), Branch (1974) and Switzer (1984). Studies consider a longer time period by exploring panel data for firms. The studies by Hall (1992), Hao and Jaffe (1993) and Himmelberg and Petersen (1994) are based on samples of US firms, while Harhoff (1998) focuses on German data. Recently, an important contribution to the literature was made by a few comparative studies seeking to assess whether different financial and corporate governance regimes affect R&D activities at the firm level. Bond, Harhoff & Reenen (1999) conduct a comparative study of R&D investment behaviour between German and British firms, while Hall, Mairesse, Branstetter & Crepon (1998) and Mulkay, Hall & Mairesse (2001) provide comparative results for French, Japanese and US firms.

The study by Hall (1992) explores differences in the relationship between investment, R&D and cash flow on a data sample of 1,247 US large, publicly-traded manufacturing firms by taking care of firm-specific effects and simultaneity. She reports evidence of a positive impact of cash flow on both types of investment, although the coefficient is higher and more significant for fixed investment. The results also indicate a negative correlation between R&D and the level of leverage, suggesting that incurring debt is not the preferred way to finance R&D.

Similarly, Himmelberg & Petersen (1994) estimate the relationship between internal finance and R&D investment on a sample of 179 US small firms in high-tech industries. Their results support the Schumpeterian hypothesis that internal finance is an important determinant of R&D expenditures. The authors estimate several econometric specifications and take account of firm-specific effects and a differential response of R&D to the permanent and transitory components of cash flow.

Harhoff (1998) reports a weak yet significant cash flow effect on R&D for both small and large German firms, although Euler equation estimates were uninformative, probably because of the smoothness of R&D and the small sample size. Bond et al. (1999) find significant differences between the impact of cash flow on R&D and investment for large manufacturing firms in the UK and Germany. The German firms in their sample are insensitive to cash flow shocks, whereas the investment of non-R&D-performing firms in the UK does respond. Cash flow helps predict whether a UK firm does R&D, but not the level of the R&D. They interpret this finding as clear evidence that financial constraints are important for British firms, although R&D-performing firms are self-selected ones that face fewer constraints, a view that is consistent with the "smoothing-over-time" hypothesis.

Mulkay et al. (2001) perform a similar analysis using large French and US manufacturing firms. They establish that cash flow impacts are much bigger in the USA than in France, for both R&D and fixed capital investment. Except for the well-known fact that R&D exhibits a higher serial correlation than investment, differences in behaviour are more due to differences between countries and less due to firm-type differences. This result is also consistent with a previous study for the USA, France and Japan for an earlier time period (Hall et al., 1998), which basically finds that R&D and investment on one hand, and sales and cash flow on the other, are simultaneously determined in the USA (neither one 'Granger causes' the other).

Bougheas, Görg and Strobl (2003) examined the effects of liquidity constraints on R&D investment using firm-level data for manufacturing firms in Ireland, and also found evidence that R&D investment in these firms is financially constrained, in line with previous studies on UK and US firms. However, (Brown, 1997) argues that the existing tests of the impact of capital market imperfections on innovative firms cannot distinguish between two possibilities: 1. Capital markets are perfect and different factors drive the firms' different types of expenditure; or 2. Capital markets are imperfect and different types of expenditure react differently to a common factor (an immediate increase in internal funds, for example). Then he compares the sensitivity of investment to cash flow for innovative and non-innovative firms. The results support the hypothesis that capital markets are imperfect, determining that the investment of innovative firms is more sensitive to cash flow. The relationship between financing constraints, investment in R&D and innovations has attracted fresh attention after the financial crises and the limited access to funds. New studies (Hall, Castello, Montresor & Vezzani, 2015; Altomonte, Gamba, Mancusi & Vezzulli, 2015; Qi & Xiaolan, 2019) generally confirm the findings of previous empirical studies.

The body of empirical research offers several conclusions. First, there is solid evidence that debt is out of favour as a source of finance for R&D investment; second, with their thick and highly developed stock markets and relatively transparent ownership structures, Anglo-Saxon economies typically exhibit the greater sensitivity and responsiveness of R&D to cash flow than continental economies, which is probably linked with the higher price of external finance to cover R&D expenditures. However, the higher sensitivity might also stem from the fact that thick capital markets are more responsive to demand signals. Third, small and/or new firms are more likely to face higher capital costs than their larger competitors, suggesting room is still available for government intervention beyond tax credits that already exist in many OECD countries.

The literature suggests that company R&D spending is sensitive to cash flow, but the results are often weak. This is unsurprising. Two key features of R&D investment are that establishing an R&D programme involves significant sunk costs, and large fluctuations in the level of spending in an existing research programme are very costly. Financial constraints, if they are significant at all, may manifest themselves more in the decision to set up R&D facilities, rather than in decisions about the year-to-year levels of spending in existing research programmes. State subsidies are found to have a positive effect on patenting and revenue in the case of new ventures in the phase of financing prototypes (Howell, 2017).

### 3.2.6 Trade and global value chain participation

In the literature, exports are also linked to productivity through the firm-level aspect. In fact, when speaking strictly about just productivity and exports two possible links exist (Wagner, 2005): 1) self-selection into exports by more productive firms; and 2) learning-by-exporting causes a post-entry increase in performance.[7]

The literature chiefly supports the first – self-selection into exporting. For example, the findings of (Bernard & Jensen, 2004) support the first hypothesis. The results show that for the USA there was no strong evidence that exporting increases productivity; instead, productivity facilitates entry into exports. But he also shows that at the sector level exporters are growing faster (shipments and employment). He attributes the productivity difference to resource reallocation and notes that it contributed even 40% to TFP growth in manufacturing. Something similar was found for Europe. (John R. Baldwin & Gu, 2003a) show that first in Canada it is the more productive firms that enter and survive in the exports market. Second, exports did positively impact productivity, especially for older and domestically owned companies. The authors also show the effect is stronger for younger and domestic firms (John R. Baldwin & Gu, 2003b; J.R. Baldwin, Gu, & Yan, 2013). (Wagner, 2007) and (Fryges & Wagner, 2008) find that exporters are more productive than non-exporters. Nonetheless, due to the fierce competition, the findings suggest that more productive firms self-select into export markets. A recent NBER study by (Shu & Steinwender, 2019) shows that in emerging economies trade liberalisation is positively related to productivity and innovation, and the positive impacts are stronger in the initially less productive firms. On the other hand, (Wagner, 2007) claims that exporting does not necessarily enhance productivity.

Still, the literature offers several studies directly or indirectly linked to learning, knowledge or technology transfer and links to innovation. It is especially in emerging economies that international trade, presence in global value chains as well as FDI, the positive benefits of foreign trade as well as FDI are stressed. For example, (UNCTAD, 1999) suggests that FDI can benefit the development in recipient countries by bringing resources that are otherwise only partially tradable. This refers in particular to "*technology, management know-how, skilled labour, access to international production networks, access to major markets and established brand names*".

Especially given the declining productivity growth, trade and growth are also under pressure in emerging EU countries. In general, economic growth in smaller, very open catch-up economies followed a similar pattern of export-led growth which, besides facilitating demand and subsequent manufacturing growth, enabled technological transfer, knowledge spillover and the inclusion of emerging economies' companies in strong global value chains, thereby supporting their development and competitiveness (J. Prašnikar, Redek, & Drenkovska, 2017; Ribeiro, Carvalho, & Santos, 2016; Salomon & Jin, 2006; Sharma, 2018). Knowledge transfer and knowledge sharing are generally important for open innovation (European Union, 2014). For example, recent estimates made for Central and Eastern European economies (Vrh, 2017) show that CEE10

[7] Both hypotheses have been studied extensively in the literature, Wagner (2005) also provides an overview of literature between 1995 and 2004, showing that the more productive do start exports, while the learning-by-exporting signals have been mixed.

economies have benefited from their position in global value chains by obtaining new knowledge via their participation and subsequent convergence with older members. Similarly, FDI stimulates technology transfer as well, as also evident in CEE growth experiences, as reviewed by Staphan (2005).

### *3.2.7 Industry 4.0 and productivity growth*

Technology improvements have historically contributed about two-thirds to total productivity growth. Chadha (2019) showed that this was the case between 1760 and 2015 in the UK, similarly also in more recent times (1938–2016). At the moment, the global economy is facing the 4th industrial revolution characterised by changes in three key areas (Schwab, 2019): progress in physical capital (represented by robots, 3D technologies, smart devices, sensor technologies etc.); progress in digital technologies (artificial intelligence, big data, the IoT etc.); and progress in the field of biology (genetics, 3D&4D print in combination with genetics and medicine etc.).

Industry 4.0 is expected to positively impact firm productivity, but to also have positive socio-economic consequences and wider positive impacts for several reasons. First, the barriers and transaction costs between companies, inventors and markets (B2B and B2C) will decline, improving productivity and enabling the faster commercialisation of ideas. Second, due to the progress of artificial intelligence and its wider use, efficiency is anticipated to rise and grow further with the fusion of different new technologies. Next, robots are expected to support productivity growth due to higher efficiency, higher quality and lower (labour) costs as already shown by early robot studies. Finally, connected processes and connected life through the IoT is anticipated to help with rationalisation and lowering costs, thereby supporting productivity (McKee, 1982; Prašnikar, Redek, & Koman, 2017; Xu, M. David, & Hi Kim, 2018). Xu et al. (2018) and Schwab (2019) predict the impact will also have broader impacts on the »economy, business, governments and countries, society and individuals«.

Studies of how Industry 4.0 is related to productivity date back to the early use of robots. Already the initial studies on the impacts of robots and artificial intelligence on production (Manufacturing Technology Information Analysis Center, 1988; McKee, 1982)_showed the positive impacts of robots in production (welding) and artificial intelligence on performance. Specifically, speed, accuracy (even a 45% increase was reported), improved quality, more accurate cost estimation, large savings (20% was reported), better development and planning were among the observed results. These are all still observed today and are key contributors to increased productivity and among the main reasons explaining why companies implement new technologies. Table 3 displays the motivations for companies to implement new technologies. Among them are several standard productivity-increasing factors or value-added-increasing factors such as efficiency and quality increase, process standardisation, integration, customisation, process insight, and other.

*Table 3: Proactive and reactive factors impacting new technology introduction*

| REACTIVE FACTORS | OVERLAP | PROACTIVE FACTORS |
|---|---|---|
| Competition<br>Market share increase<br>New markets<br>New products/services<br>Compliance<br>Horizontal and vertical integration<br>Complexity of processes and products<br>Government support | Customer satisfaction<br>Understanding market requirements<br>Flexibility and customisation<br>Prioritisation<br>Reduction of employment | Revenue, turnover growth<br>Productivity and efficiency increase<br>Improving management<br>Process standardisation<br>Quality increase<br>Shorter delivery times<br>Data analysis (and monitoring)<br>Better process insights<br>Legislation adaptation<br>Consumer power<br>Employee satisfaction |

Source: (Černe, Ajdovec, Kovačič Batista, & Vidmar, 2017)

Robots are expected to raise productivity and competitiveness, increase demand and create new business opportunities and innovation (IFR, 2018). For example, Graetz and Michaels (2015) study the impact of robots at the industry level in 17 countries between 1993 and 2007. The results show that robots contributed about 0.36 of a percentage point to THE annual growth of labour productivity, accounted for about 15 percent of aggregate productivity growth, increased wages and lowered output prices, while having no significant negative impact on employment. Similarly, the McKinsey Global Institute (2017) also stresses that automation in general, not just robots, allows companies to improve their performance, reduce errors, improve quality and speed, and increase productivity. They estimate that productivity could increase by 0.8 to 1.4 percentage points annually, which in their view is especially important since labour productivity growth is expected to halt due to ageing.

Another study by Russman et al. (2015) estimated that in Germany Industry 4.0 can cause, due to cost change, an increase in productivity by 5 to 8 percent, contribute about 1 percent to GDP over 10 years, create 400,000 jobs, but will cause a restructuring in both sectors and employment.

The labour market impact of new technologies also worries policymakers and researchers. Studies are not unanimous in the evaluated impact. While Acemoglu & Restrepo (2017) calculate that 1 robot per 1,000 employees reduced the employment-to-population ratio in the USA by 0.18–0.34 of a percentage point and reduce also wages, Autor and Salomons (2018) show that automation has not been labour displacing in 19 OECD countries since the 1970s, but labour-share displacing, which is aligned with a weaker wage-productivity growth ratio. But Autor (2015) stresses that employment polarisation and a squeeze of middle jobs is currently observed, but this will not occur indefinitely since the skills combination will change.

It is extremely important to implement new technology considering the potential positive impacts of technological change on productivity, and given ageing and the changed structure of production. Therefore, the focus on technology-stimulating policies, including those in the EU (European Commission, 2018a), could help narrow some of the productivity gap and primarily address the obstacles to new technology implementation, such as the lack of funding, skills and access (Andulkar, Le, & Berger, 2018; Hecklau, Galeitzke, Flachs, & Kohl, 2016; Pereshybkina, Castillo Conde, & Kalyesubula, 2017; Ślusarczyk, 2018).

### *3.2.8 Intangible capital and productivity*

Intangible capital comprises three major groups of factors that can support productivity growth: 1) computerised information (computer software, computerised databases); 2) innovative capital (which mainly incorporates R&D, but also other innovative expenditure); and 3) economic competencies (brand equity, firm-specific human capital, and organisational structure). It was defined by Corrado, Hulten & Sichel (2006) and has since been intensively studied in relation to both firm and aggregate performance.

Overall, estimates of intangible capital investment show that some countries invest a similar proportion in intangibles as in tangibles (e.g. USA); otherwise, the share of intangible investment is around 5 to 13 percent of GDP, depending on the country and year) ("CoInvest Project," 2012; Corrado, Hulten, & Sichel, 2009; Fukao, Miyagawa, Mukai, Shinoda, & Tonogi, 2009; Innodrive, 2008; van Ark, Hao, Corrado, & Hulten, 2009), while on average between 2000 and 2013 the level of intangible investment was 9.2 percent in the EU-14 (Jona-Lasinio & Meliciani, 2018).

Early estimates of intangible capital's impact on aggregate productivity growth suggest that intangible capital contributed up to one-third of productivity growth. For example, in the USA, total labour productivity growth between 1995 and 2006 was 2.96 percent, intangibles in total contributed 0.83 of a percentage point to total labour productivity growth. The contributions in other countries were also significant, ranging from around one-quarter to around one-third of total labour productivity growth (Corrado, Hulten, & Sichel, 2009; Fukao et al., 2009; van Ark et al., 2009). Recent estimates by Jona-Lasinio and Meliciani (2018) show that between 2000 and 2013 the contribution of intangibles to total factor productivity growth was from 14 percent (Denmark) to 30 percent (Netherlands) and even slightly higher in Spain, Finland and the UK (e.g. 33%). According to the authors, the overall decline in labour productivity growth is mostly the result of the TFP slowdown, and not tangible and intangible capital.

Piekkola (2011) summarised certain key results of the Innodrive study on the impact of intangibles on European performance. First, if intangibles are considered as an investment type and not as costs, GDP increases by 5.5 percent. The differences between European countries (studied between 1995 and 2006/2008) are substantial, but convergence is observed, primarily high-income countries with a comparatively smaller share of intangible capital have been investing more, which the authors see as a move towards the knowledge economy and convergence. With regard to convergence, the authors also observe a link between FDI and intangible capital growth, primarily increasing R&D and organisational capital. This is further confirmation of FDI's impact on firm performance that is also linked to international linkages and intangible capital by Jona-Lasinio and Meliciani (2018), who provide selected results on global value chains' impact on intangible capital and find a significant and positive relationship between GVC participation and productivity which they attribute to specialisation in the most productive activities, technology transfer, knowledge spillover, and competition.

Roth and Thum (2013) also find a positive and robust relationship between intangible investment and labour productivity growth, in addition stressing that intangibles explain a large share of the unexplained variance in labour productivity growth since the unexplained variance decreases even by 51 percent. The relationship is stronger between 1995 and 2000 than between 2000 and 2005. Corrado et al. (2018) investigate the period between 2000 and 2013, finding that during the crisis intangible investments were relatively resilient, while tangible investment fell. Intangible investment also bounced back relatively fast.

While the components of intangible capital are linked to firm productivity, the results of empirical work show that all components of intangible capital are positively related to productivity growth, but the size of the contribution (similarly as the size of investments in a certain component) depends on the economy's structure and development. Innovative property and economic competencies account for the biggest shares of intangible capital. For example, in Japan intangible investment in innovative property alone between 2000 and 2005 was 6 percent of GDP, while in manufacturing it reached 11 percent of GDP (produced by those same sectors). Very high innovative investment levels were also recorded in Canada (5%) and the USA (5.5%) (Miyagawa, 2010). The contribution of innovative property to total productivity growth in many countries represents the most pronounced contribution of intangible capital to labour productivity growth. For example, in Germany between 1995 and 2006 innovative property contributed 0.23 of a percentage point of the 0.38 of a percentage point that intangibles in total contributed to labour productivity growth, which is around 60 percent. In Austria, Czech Republic, Slovakia and Denmark, the contribution was around half of the total contribution of intangibles, resulting from the comparatively high role of manufacturing (van Ark et al., 2009). Given that R&D has long been connected with productivity growth, the new intangible approach basically confirms the research done so far (Griffith, Redding, & Reenen, 2004; Hall & Mairesse, 1995; Wakelin, 2001), but in a more systematic and detailed manner as innovative property is systematically defined and measured more broadly than just R&D expenditure (as also stressed by Roth and Thum (2013)).

The investment and contribution of economic competencies to labour productivity growth in some economies is also significant, again depending on the structure and development of the economy. For example, van Ark et al. (2009) shows that in 2006 intangible investment in economic competencies was 5.5 percent and 5.8 percent of GDP in the UK and the USA, respectively. In France, Germany, Italy and Spain, the figure ranged between 1.9 percent and 3.3 percent, which is significantly lower. In terms of the contribution to labour productivity growth, the contribution again varied, contributing to about half of the total contribution of intangibles in the UK (total labour productivity growth was estimated at 3.06%, intangibles contributed 0.69 and competencies 0.36 percentage points). On the other hand, the contribution of competencies in Spain was even negative. On average in the nine investigated EU economies, competencies contributed around 20 percent of intangibles' total contribution.

In relation to the mechanism, economic competencies have three important components (brand equity, firm-specific human capital, which is built by on-the-job training  and job-related education and organisational structure). ICT was already used in the 1990s and early 2000s similarly as R&D expenditure to (in the case of ICT) to assess the impact of new technology and the knowledge economy on growth. For example, Wiel (2001) studied the Dutch ICT impact on productivity and shows that ICT-intense industries experienced significantly higher productivity growth, like in other OECD countries. Similarly, Dahl, Kongsted and Sørensen (2011) study productivity in Europe in the 1990s and find that, despite the generally declining productivity growth, the slowdown was more pronounced in non-ICT-intense sectors. Inklaar, O'Mahony & Timmer (2005) examined ICT (and non-ICT) capital deepening in France, Germany, the Netherlands, the UK and the USA between 1979 and 2000. The results show the contribution made by ICT to sectoral growth is higher in the USA, but the contribution was increasing and the non-ICT contribution was decreasing. Like Wiel (2001), Jorgenson, Ho & Stiroh (2008) also study US productivity growth and find that between 1995 and 2006 about half of the TFP growth can be explained by ICT deepening.

With regard to organisational structure, organisational innovation is one of the components measured by CIS (Community Innovation Survey) and shown to impact productivity. As Polder, Leeuwen, Mohnen & Raymond (2010) argue based on Dutch data, between 2002 and 2006 organisational innovation is complementary to process innovation and according to their findings. If process or product innovation is accompanied by organisational innovation, the productivity impact is stronger, and it is also stronger if all three types (product, process and organisational) are involved. Similarly, Lynch (2007) finds a positive relationship between organisational innovation and profit as well as organisational innovation and productivity (Black and Lynch (2004)). Organisational innovation was defined broadly, including HRM approaches such as teamwork, different forms of training, re-engineering, information exchange etc. Besides these, the studies show a positive link with external focus and broader networks (proxied by exports, multi-plant firms etc.), where the positive link is explained through learning. This could also be linked to the aforementioned open innovation model (H. W. Chesbrough, 2003). In relation to organisational structure, managerial practices are also important. Bloom and van Reenen (2010) established a model to capture management practices and show a strong relationship between productivity and sales, management and worker ability as well as wages. (Bender, Bloom, Card, Van Reenen, & Wolter (2017) further study the relationship on a rich micro-data set for Germany. The findings show that variation in productivity largely results from the best paid human capital in the firm (managers). Better-managed firms recruit and retain more qualified (higher human capital) workers. After acknowledging and controlling for human capital, management practices remain a significant contributor to productivity.

From an economic point of view, brands can be defined as intangible assets of firms (Corrado & Hao, 2013) that allow consumers to differentiate between products, as well as enable firms to launch new products and expand markets (Morgan & Rego, 2009). They contribute to firms' growth through a dynamic interaction with other business activities, which in turn affects the value of brands (Clayton & Turner, 2000). In developed economies, the productive role of brands is in line with the role of innovations, although international standards do not include brand equity in national accounts. Brand investments are positively correlated with the level of economic development (Chang & Chan-Olmsted, 2005; Corrado & Hao, 2013; O'Donovan, Rae, & Grimes, 2000).

For prospective, existing and past customers, product/service brand equity equals brand awareness, brand preference, image and loyalty (Keller (2003), Aaker (2010), Bei and Cheng (2013). A distinction between product/service brands and corporate brands is needed since corporate brands have a multi-stakeholder rather than a customer orientation (Balmer & Gray, 2003). Marketing's domain includes direct control over all activities that have a significant impact on customer acquisition and retention and therefore the functions of sales, customer service, new product development and pricing should be treated as part of marketing (Sheth & Sisodia, 2002). In marketing literature, productivity is specifically related to the accountability of marketing communication expenditures (e.g. advertising, sales promotions) and is defined as "the optimally weighted ratio of marketing outputs (sales level, sales growth, and corporate reputation) to marketing communication expenditure (advertising media spending in broadcast, print, and outdoor and sales promotion expenditure)" (Luo & Donthu, 2006, p. 71). Capital market players regard the efficient use of advertising budgets as valuable information, meaning that an input–output relation that is superior to competitors is also rewarded by the capital market in terms of abnormal returns (Raithel, Scharf, Taylor, Schwaiger, & Zimmermann, 2011).

In the intangibles framework of Corrado, Hulten and Sichel (2009), brand equity is part of economic competencies and refers to advertising effects that go beyond short-term sales promotions. Firms' advertising investments include advertising in paid, owned and earned media (Burcher, 2012) alias purchased and in-house brand investments (Corrado & Hao, 2013). Conventional measures of brand investments mostly include what companies paid for advertising (estimated at about USD 625 billion in 2019 according to *Global Ad Spend Forecasts* 2019) and disregard spending on social media and strategic marketing that are generally developed in-house (owned media and earned media). The future direction of work in the area of brands and productivity depends on the following: (1) a deeper economic understanding of branding and its interaction with other intangible assets; (2) improved knowledge regarding the rate at which investments in brand depreciate; and (3) data about investments in brands that include paid, owned and earned media (social media communication), together with market-mediated purchased services (Corrado & Hao, 2013).

### *3.2.9 Sectoral and firm characteristics and productivity growth*

Blow, other factors that can impact firm productivity are discussed, primarily firm size, ownership and sectoral aspects. In 2016 in the EU-28, large firms, which account for 0.2 percent of all firms, created 43 percent of all value added and engaged 33 percent of all employees. Large firms contribute a disproportionately big share of value added in the economy, but does that also mean that size is positively related to productivity? The studies that relate productivity and productivity growth to firm size explain the positive relationship via several channels. First, firm efficiency is related to size. Larger firms can utilise resources more efficiently, divide work, specialise, and work processes can be organised better. On the other hand, as (Leung, Meh, & Terajima, 2008b) claim, larger organisations are more rigid, managerial efficiency is lower, they are also less open and more hesitant to take risks. These authors on the other hand add that larger firms benefit from ICT use, invest in labour training, can afford more R&D, and engage in more innovation. Large firms are also more capital intensive due to lower cost of capital and their different market and product focus, including more customisation and centring on a niche. Their estimates for Canada in comparison to the USA show the

Canadian lag may be attributed to the size distribution difference, although the causes for the wide productivity gap at the lower and upper tails of the distribution vary.

Firm size is another determinant of productivity and firm level and thus firm size distribution matters for productivity at the aggregate level. A substantial study by Yang (2012) and published by the World Bank investigated 45,000 companies in over 100 economies. It showed that larger firms are more productive, pay higher wages and offer more formal training. The last two are either a reflection or also a cause of productivity. The results reveal that large firms have three times higher productivity, double the wages while the share of large firms offering formal training is twice the level among large firms than in smaller firms. Overall, about two-thirds of large firms offer formal training. There are some exceptions to this rule, the differences are smaller in Eastern Europe and central Asia (possibly also linked to transition problems) and are even higher in some parts of Africa.

Firm size is expected to impact firm productivity positively for a number of reasons. (Leung, Meh, & Terajima, 2008a) claim that labour productivity initially depends on productive efficiency, which depends on a firm's ability to use better, more modern technologies, its organisation and other factors that determine how well the firm exploits its inputs as well as the presence of possible increasing returns to scale. Labour productivity also depends on the intensity of using other resources, where a higher intensity of capital use in comparison to labour increases labour productivity. The authors empirically show that the difference in the employment distribution across firm size explained 20 percent of the US–Canada gap in sales per employee and even 50 percent of the productivity gap in manufacturing in the 1990s.

In theoretical and empirical explanations of what makes it important to understand size, productivity differences feature first, namely, larger firms do more R&D and are more innovative. For example, in 2018 Siemens invested EUR 5.6 billion in R&D, and had 41,000 employees in R&D and was by then granted 65,000 patents ("Siemens – R&D indicators 2018," 2019). This is about eight times the amount invested in R&D by the whole of Slovenia (SURS, 2019). Primarily, the literature suggests that larger firms exploit or use more total factor productivity enhancing factors, including having more R&D and also introducing more innovation (Shefer & Frenkel, 2005). They claim large firms tend to invest more in R&D than do small ones.[8] Larger firms can disperse risk associated with innovations and inventions more easily, as supported by Revilla & Fernández (2012) who show that large firms have an advantage when property rights protection is limited or cooperation within a value chain is an important source of innovation opportunity. Choi and Lee (2018) show that in Korea firm size was positively linked to R&D, and also new and incremental innovation in all types, including multidimensional combinations of product and process innovation.

The size of firms is also linked to the quantity and quality of human resources. Larger firms have a wider pool of experts, allowing them to be more efficient in teambuilding, better exploit the complementariness among experts, more complementary and specialised competencies are available, firms can also invest more in people,

[8] Not all literature finds a positive link between firm size and productivity. In the 1980s, (Cohen, Levin, & Mowery, 1987) show on a US example »overall firm size has a very small, statistically in- significant effect on business unit R & D intensity«, but it does affect the probability of conducting R&D.

optimise human resource management, chiefly on-the-job training and continuous education. Larger firms are often more attractive employers, can appeal to talent and more often build and invest in developing their core group of employees. Several studies address these linkages.

Shefer & Frenkel (2005) suggest that besides firm size, organisational structure, ownership type, industrial branch and location impact firm productivity. As concerns ownership, the literature mainly investigates differences between state and private ownership, domestic and foreign, as well as insider and family ownership. A broad spectrum of literature generally shows that private ownership is more efficient than state ownership, that foreign ownership can be dominant over domestic, and that insider ownership can cause the bargaining power to tilt the goal function away from profit, although insider ownership also brings some positive effects. The debate on the impact of state ownership is old and was particularly vibrant in the 1980s and 1990s following the debate on the need to privatise transport, utilities, for example in developed countries. Ehrlich et al. (1994), for instance, show that state ownership can in the longer run lower productivity growth and the decline in costs. Iwasaki et al. (2018) study a big set of transition companies in Russia and find that government has a negative impact on management and firm performance, and that private ownership is superior to state. But they admit the results also depend on the type of private ownership. The smallest positive impact is observed in the case of domestic outsider investors, smaller than foreign and insider (primarily managerial ownership is positive).

With regard to family ownership, many studies find it is related to lower productivity and also provide an explanation. For example, Larraz, Gene & Sánchez (2017) study a considerable sample of Spanish firms and show that family-owned ones are less productive, which they attribute to lower capital intensity and lower staff monetary renumeration. Barth et al. (2005) attribute the lower productivity of family-owned firms to family management since their results show that in the case management is hired from outside, firms with family ownership are equally productive. Barbera and Moores (2013) study differences between family and non-family ownership and establish that with family-owned firms the contribution of labour is significantly higher and that of capital significantly lower, concluding that once these differences are accounted for, the differences in total factor productivity between family-owned and other firms disappear.

The discussion of foreign ownership's impact on productivity generally reveals that in many cases foreign-owned firms are more productive. Theoretically, foreign firms are more productive following the OLI paradigm (ownership-location-internalisation advantages), which combines the ownership-specific advantages with their transfer to foreign countries – which in combination with host-specific advantages produce superior results in comparison to domestic firms (Damijan, Kostevc, & Rojec, 2015; Dunning, 1988; H. Dunning & Lundan, 2008). Javorcik (2004) explains that countries have attempted to attract foreign investors due to the knowledge spillovers and productivity impacts. The study of the Lithuanian experience identifies positive spillover effects also between foreign affiliates and domestic suppliers in the case domestic-owned suppliers are present in the chain. Similarly, Schoors and Tol (2002) find that foreign firms perform better than domestic firms and also had a positive spillover effect in Hungary. This experience is seen not only in transition economies, but elsewhere as well (e.g. (Benfratello & Sembenelli, 2006) for Italian firms under US ownership, (Griffith, 1999) studied domestic UK ownership in comparison to US and German-based foreign ownership and found differences in productivity with US ownership).

Firm age also appears in the literature as one of the determinants of productivity. De Kok et al. (2006) claim the productivity of new firms is below average, while the productivity growth of new, emerging (but surviving) firms is above average. The authors add that during the first years the productivity level increases, while the productivity growth rate is concave and decreases over time. For established firms, those older than 10 years, according to the authors the relationship between age and productivity is less clear. Coad, Holm, Krafft and Quatraro (2018) provide two views on the evolution of productivity with age. The first is ecological and linked to firm maturation, maturation of processes and changes within the firm, firm routines and liabilities as it passes through different life-stages: "*newness, adolescence, age, senescence and obsolescence*". The authors also stress an evolutionary approach which focuses on learning and selection – firms "*must either learn or exit*". In the context of learning, innovation in relation to firm age impacts firm performance. According to Huergo and Jaumandreu (2004), new-born firms have higher rates of productivity growth (similarly to surviving firms in the (Coad, Holm, Krafft, & Quatraro, 2018) context), but these growth rates slowly decline and converge to average. Nonetheless, above-average growth persists if firms innovate where the authors primarily stress process innovation. The importance of learning and innovation in relation to corporate governance and firm age is also studied by Bianchini, Krafft, Quatraro and Ravix (2015) who show that younger firms are more prone to a short-term focus than long-term (riskier) innovation. This is in line with Coad, Segarra & Teruel (2016) who study the relationship between innovation and firm age in Spain. They show that young firms benefit more from successful innovation, but also lose more in case of being unsuccessful, pointing to innovation being riskier for young firms.

Besides age, there are sectoral differences in productivity. Already during the 1990s (Biema & Greenwald, 1997) asked "What is preventing a productivity revival in the U.S. economy? Clearly, the manufacturing sector cannot be blamed". The authors observed that between 1970 and 1990 in the USA the share of service employment increased, yet productivity growth in the services sector was lower than in the manufacturing sector. The non-tradable vs. tradable dilemma on how to drive competitiveness, quality and innovation has been long present in the literature and the laggard growth of non-tradable (which services more often are in comparison to goods) is stressed in the Balassa-Samuelsson effect (e.g. (Asea & Mendoza, 1994; Ito et al., 1997; Samuelson, 1964)). (Dabla-Norris et al., 2015) claim that stagnant and declining TFP growth at the aggregate level can result from slower human and physical capital accumulation, slower sector-specific innovation and structural shifts to less productive sectors. Structural transformation, according to these authors, is driven by technological change and accompanied by efficient labour allocation. But globalisation has meant developed economies have lost some highly productive sectors (Pisano & Shih, 2012), while economies have shifted away from agriculture and manufacturing into services. Some of these services are high-value-added, knowledge-intense services (ICT, for example), although Dabla-Norris et al. (2015) claim that personal services (hotels, restaurants, social and personal services) and non-market activities (public administration, education, health etc.) have gained in labour shares in most developed economies, while productivity growth has been much lower. These sectors also are more protected from competition and, while ICT has boosted productivity in all sectors, the comparative effect was lower in these sectors and also accompanied by less complementary innovation. Overall, the authors stress that the non-market, personal and business services "were the heaviest drags in terms of TFP growth for many countries" (Dabla-Norris et al., 2015).

# 4 CHALLENGES FOR FUTURE RESEARCH

European Union and other developed countries have struggled with declining productivity growth and sluggish productivity growth in comparison to emerging economies. Apart from the declining productivity growth, the productivity gap between the EU and the USA measured by output either per worker or hour remains significant, despite the decline. This also applies to the productivity gaps between EU economies. The slowdown in productivity growth has become even more apparent after the recent crisis when the sluggish contribution of the supply-side determinants has been exacerbated by the negative impact of the demand-side contributors. As a result, the productivity puzzle has become a vital issue discussed in the literature and particularly among policymakers at different levels.

The key question is how to boost productivity growth. Unfortunately, productivity is the outcome of a complex list of factors, some depending on developments and characteristics in the business environment, including macroeconomic trends, while others depend more on firms themselves. Externally, factors such as the institutional environment in the broadest context, macroeconomic characteristics, the technological and business environment in general, international linkages of the economy, financial markets, macroeconomic, industrial and social policies, and many other factors influence the firm's performance as outside determinants that shape the behaviour of companies. This behaviour constitutes the firm-specific factors. In addition, firm-specific factors that influence company behaviour and productivity growth are labour and human capital (i.e. the qualities and structure of human capital), R&D, capital, the composition of capital, allocation of resources, new technologies, intangible capital, and other. The endogenous loop of demand- and supply-side factors create a path-dependent loop, leading to higher productivity and ultimately quality of life.

*Table 4: A summary of the determinants of productivity*

| Determinants of productivity | |
|---|---|
| External (environmental) determinants | Internal (firm-level) determinants |
| Institutions | Capital and composition of capital |
| Macroeconomic environment | Resource allocation |
| International trade, exchange rates, FDI | Labour and human capital |
| Technological environment | Ageing |
| Access to finance and financialisaton | R&D |
| Financialisation in the economy | Trade and global value chain participation |
| Policies | Industry 4.0 |
| | Intangible capital |

Source: Own.

The previous chapter highlighted (selected) key variables or groups of variables and their links to productivity determinants with productivity growth. Only a comprehensive understanding of the fundaments can produce policy solutions able to improve future productivity growth – of both existing and new growth determinants. Therefore, this paper also highlights future research challenges, which principally include:

(1) Theoretical challenges: establishing strong theoretical foundations for the research into the impact of new productivity determinants
(2) Methodological challenges: where needed, contributing to the preparation of measurement and data collection or highlighting the use of existing registry and survey data to define measurements of the new productivity growth determinants
(3) Empirical analysis: investigating the link between the »old« and »new« productivity growth determinants and defining their contributions to growth
(4) Preparing policy implications in order to support productivity growth and catching up

In relation to theoretical challenges, theory has already extensively linked productivity with its most common determinants such as labour, human capital, capital and technology. Or, to use the words of Mayhew and Neely (2006) when claiming that policymakers focus extensively on five drivers of productivity: *"investment, innovation, skills, enterprise, and competition*". Two further accents are given. First, there is excessive focus on investments that are too broadly defined. Second, it is also very important to understand the *" (...) long and complex chain of causation*" (...). To understand that complexity, the theory, methodology and empirical research must revisit the 'black box' of the organisation. Further, the black box of productivity addresses not just the organisation as such but also the "long and complex chain of causation".

Future research should thus first focus on preparing the theoretical foundations for providing solid working models for investigating the complex links between the factors within the organisation because it is often the nature of the linkages, cooperation, that causes losses in efficiency. Second, new theoretical models/foundations should also encompass (and link) new drivers of productivity. These primarily include the investigation of:

1) New technologies (Industry 4.0). In this context, new theory should not only examine the nature and level of such investment, but link the investment with the 'black box' of the organisation to understand fully the motives for or against such investment, how the technology is incorporated and which impacts were expected;
2) Global value chains (GVCs), the position of companies in global value chains, the stability of the relations and the nature of the relations, what makes companies participate in such chains (price or quality competition, firm-specific assets/skills etc.) and the impact of GVC on companies in the broadest sense (impact on other investments, skills, learning, tech transfer etc.). While trade is extensively investigated, there is no theory of GVC and its link to productivity.
3) The role of ageing, especially also at the firm level and include the age dimension in the human capital (or firm-specific human capital as part of intangible capital) dimension.

4) Intangible capital. Intangible capital could be considered extremely important for understanding the black box of the organisation, especially due to its economic competencies components which incorporate firm-specific human capital. But while intangible capital as it is measured at the moment represents a significant leap forward in understanding the nature of productivity, considerable space for research remains:
    a. Extending the intangible capital with new aspects, which are intangible in nature, but related to the aforementioned new technologies and GVC.
    b. Developing a theoretical foundation (relying on many concepts from business literature) that would efficiently link intangible capital to productivity and also help explain the nature of the organisation (such as managerial practices (Bloom & Van Reenen, 2010)).

While the theory itself is important, an empirical link between the assumed productivity determinants and actual firm-level productivity must also be examined. Data are needed for this purpose. While existing registry and survey data provide extensive sources, they are not necessarily best suited for researching into additional productivity factors. To be able to examine the role of these factors, several research challenges must be resolved:

1) operational definitions should be developed of each new category, a definition that would be internationally accepted and at the same time be very clear and thus represent a foundation for developing the measurement scale;
2) existing registries must be examined to work out which existing data sources can be used, and which aspects are not captured by the data;
3) preparing new measurement approaches (preferably with the cooperation of relevant institutions) for those data that are uncaptured, testing the methods and preparing a standardised (international) approach/standards for measurement while keeping in mind the future purpose of the data.

Empirical analysis is often conducted at a stringent econometric level which is, of course, necessary to correctly and properly capture the effects. Yet the results should always be interpreted and evaluated in context and it is here that, to fully understand the results, a wide discussion also considering the business/managerial foundations of the theoretical background would often be useful. This in particular would also help bring the results closer to policymakers and decision-makers in firms where such results, especially those that open the black box, should be efficiently disseminated in order to achieve the desired impact and help raise productivity.

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