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Total Factor Productivity & the Quality of Social Institutions: Institutional Complementarities as Key Drivers of Balanced Innovation

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Jobs & Incomes in the Dawning Era of Intelligence Robots

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DG ECFIN's Fellowship Initiative 2018-2019 "The Productivity Challenge: Jobs and Incomes in the Dawning Era of Intelligent Robots" has solicited contributions examining current and possible future productivity developments in Europe. In view of possible hysteresis effects after the crisis and in the general context of ageing populations and globalisation, the aim has been to re-examine the ongoing trends and drivers and to identify policies to tap fully the potential for inclusive productivity growth. The fellowships have been awarded to prominent scholars in the field to interact with staff in ECFIN and other Commission colleagues, and to prepare final reports on specific research questions within this general topic.

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Directorate-General for Economic and Financial Affairs

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Abstract

We suggest a macro-socioeconomic framework that stresses the relevance of systemic features of national growth models for productivity outcomes to allow for highlighting national peculiarities. A prominent feature of domestic growth models are institutional settings that vary from case to case but where some key institutions are characteristic for particular groups of economies. We label such groupings as productivity regimes. The term social institution refers to a broader array of analytical concepts, which have in common that they focus on regular patterns of behaviour of economic actors that result in structural features as well as of normative beliefs or narratives held by individuals and collectives that account for these regularities. Our analysis makes use of such a concept of social institutions but adds a much more comprising list of variables that make up critical social institutions, which guide economic processes and eventually produce particular outcomes.

JEL Classification: O30, O40, P51.

Keywords: National growth models, productivity regimes, total factor productivity, quality of social institutions, Huebner.

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1. INTRODUCTION

When Robert Solow in an article in the New York Book Review from July 1987 stated 'you can see the computer age everywhere but in the productivity statistics', he could not know that his quip became the *productivity puzzle* for the next 30 years or so. Since this intervention, a meaningful debate has started about the relatively low impact of the type of new technologies that are driving current innovation processes. This debate generated a large body of literature, but so far no broadly accepted analytical explanation emerged. In a slight modification of a summary by the McKinsey Global Institute (2018), we suggest distinguishing five systematic camps within the debate. A *first* camp somehow doubts the empirical findings of a slowdown of productivity. The argument put forward says that productivity generated by current new technologies is challenging to measure and that traditional statistical methods fail to take actual productivity gains into consideration. Chances are, thus, that there is no puzzle at all. A *second* camp takes a macroeconomic perspective and argues that a shortage of demand and investment in the post-financial crisis low-interest-rate situation constrains economic growth, and as a result limits, productivity growth Productivity has slowed down but not due to problems with technologies or innovations. A *third* camp takes the opposite view and argues that the type of current innovations is not as transformational as basic innovations of the past and lacks the substantial impact on productivity. According to this view, the productivity slowdown is best explained by the characteristics of today's innovations. A *fourth* camp questions such an interpretation, and argues regarding the experience with past basic innovations that computerisation and digitalisation need time until the productivity potential of various applications is being exploited: Current innovations have a highly disruptive quality that plays out over time. A *fifth* camp follows this line and adds that it not only needs sufficient adjustment time but also, and critically, it needs 'good' social institutions to unlock the productivity potential of the current wave of technologies.

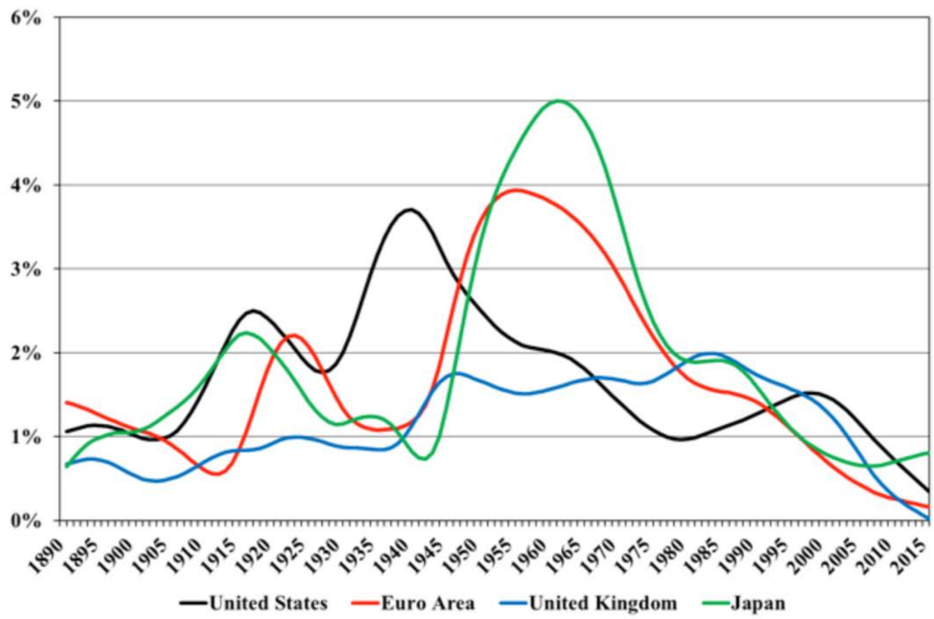
Our project is part of the fifth camp. We suggest a macro-socioeconomic framework that stresses the relevance of systemic features of national *growth models* for productivity outcomes to allow for highlighting national peculiarities. A prominent feature of domestic growth models are institutional settings that vary from case to case but where some key institutions are characteristic for particular groups of economies. We label such groupings as *productivity regimes*. The term social institution refers to a broader array of analytical concepts which have in common that they focus on regular patterns of behaviour of economic actors that result in structural features as well as of normative beliefs or narratives held by individuals and collectives which account for these regularities. Institutions in this sense are seen mainly as norms and regularities which are deeply enshrined the behaviour of actors. In the varieties and diversity of capitalism-literature institutions are more widely conceptualised and try to capture the types of institutions that guide interactions of actors. Following Amable (2003) vital social institutions are identified in the literature by the kind of product market competition, labour market institutions, the financial sector and corporate governance, social protection, and the educational system. Particular national institutional configurations guide in this perspective idiosyncratic economic decisions and processes that result in differing economic outcomes across a spectrum of institutional configurations, i.e. varieties of capitalism. Whereas Amable suggests the existence of five kinds of capitalisms, our approach is not so much interested in the number of diverse varieties of capitalisms than in the effort to identify institutional configurations that are beneficial or detrimental to productivity performance. Still, our analysis makes use of such a concept of social institutions but adds a much more comprising list of variables that make up critical social institutions which guide economic processes and eventually produce particular outcomes. By looking into the potential complementarities of social institutions, we suggest differentiating distinct *productivity regimes* that come with different productivity outcomes.

2. PRODUCTIVITY ON DECLINE - THE BIG PICTURE

Whether indicated as output per worker hour (labour productivity) or as total factor productivity, empirical findings show a long-term reduction in productivity across the OECD-economies. In the case of the US, labour productivity (real GDP per hour worked) between 1950 and 1973 was on annual average 2.6%, went down to 1.7% for the period 1973 to 1995, recovered to 2.2% between 1995-2007, and sank to .4% in the period 2007-2016. The situation is not better for the EU-15: In the period after WW (1950-1973) average annual growth of labour productivity was stunning 4/9% that then sank to 2.5% between 1973-1995. The recovery was relatively mild with 1.5% average yearly growth between 1995 and 2007, only to move down to .4% between 2007 and 2016 (The Conference Board 2019).

The development is similar for total factor productivity. In case of the well-documented US-economy Gordon (2016) made the convincing case of a secular decline of annual average rates of total factor productivity, by comparing the development since the 1970s with the period of the 1930s to the 1970s. This finding has been replicated by and large by several studies (Craft 2016). A long view on the EU, today's Euro area economies, Japan and the UK shows that after the end of catching-up to the technology leader, the contenders moved on the US trajectory which was already on a downward movement.

Graph 1: **Average annual growth rate of TFP (%), smoothed indicator (HP filter, λ = 500), whole economy**



Source: Bergeaud et al. (2016a)

Long-term, TFP moved in large swings and eventually came to a halt, respectively experienced a significant slowdown in the mid-2000s, with the Euro area-economies experiencing the sharpest reductions in TFP growth dynamics (Bergeaud/Cette/Lecat 2017). Van Ark/Jäger (2017) take a closer look onto the productivity performance of an EU-12 group (Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Italy, Netherlands, Spain, Sweden, UK) and divide the period 2002-2015 into three subperiods, namely the period before the Financial Crisis (2002-2007), during the crisis (2008-2010) and post-crisis (2010-2015). In the first period, TFP grew by an annual average of .5%, then shrunk to -1% in period two, and more or less kept stagnant with .2% in sub-period three. Weak TFP performance is not a new phenomenon but has been the 'Achilles' heel' (Van Ark/Mahony/Timmer 2008) of European economies since the 1990s, as the core economies were unable to make use of the latest types of technological innovations.

Our calculations of growth rates of labour productivity and TFP are run for the period 2000 to 2016. As is to be expected, labour productivity as well as total factor productivity experience steep declines with the global financial crisis 2008. Based on our data, labour productivity slowdown after the crisis very much is driven by total factor productivity problems (see also Aznar/Forth/Mason/O'Mahony/Bernini, 2015). A comparison of the performance of both indicators of the EU-28 and EU-15 shows a slightly more positive picture for the whole EU due to the still relatively good performance of catching-up economies which continue to benefit from value chain-integration and trade with frontier economies and also from mobilising backwardness effects. Starting from relatively low levels of productivity comes with the chance to grow on an annual base quicker compared to economies which already are on a relatively high productivity level. As soon as one excludes the new members and looks only at the core EU-15, it is evident that the performance is worse (see graph). In other words, productivity weakness is more pronounced in the more developed market economies of the EU. And yet, an even more disaggregated view on productivity performance that looks at individual countries shows a high level of variance, across the EU-28 and also within the group of EU-15 (see annex 1).

EU-economies all have to deal with their productivity problems. There is not a single case that would be exempt from this trend. However, there is still variance which we capture by creating three groups of economies. For the purpose of distinguishing productivity performance of the EU-28, we look into the development of TFP for the periods 2000 to 2007 and 2008 to 2016. The Global Financial Crisis can be seen as the critical divide as it splits the EU into three groups. A first group that shows a slight recovery of TFP rates after the crisis. Despite recovery processes, it still holds that TFP rates are below previous levels. A second group that shows more or less stagnant growth rates on a shallow level. And a third group, consisting of only one case – Greece - that shows a steep decline in the course of the crisis and then only a slight improvement to close to a zero rate. This implies a further falling back. Those groups should not be seen as stable entities, though. Given the actual productivity performance, it sounds reasonable to expect that some countries from group 2 may join Greece over time., and thus create a binary development. At this point, data suggest that productivity divergence continuous to be a defining trait of the overall weak recovery processes across the EU-28 (see also van Ark/Jäger 2017).

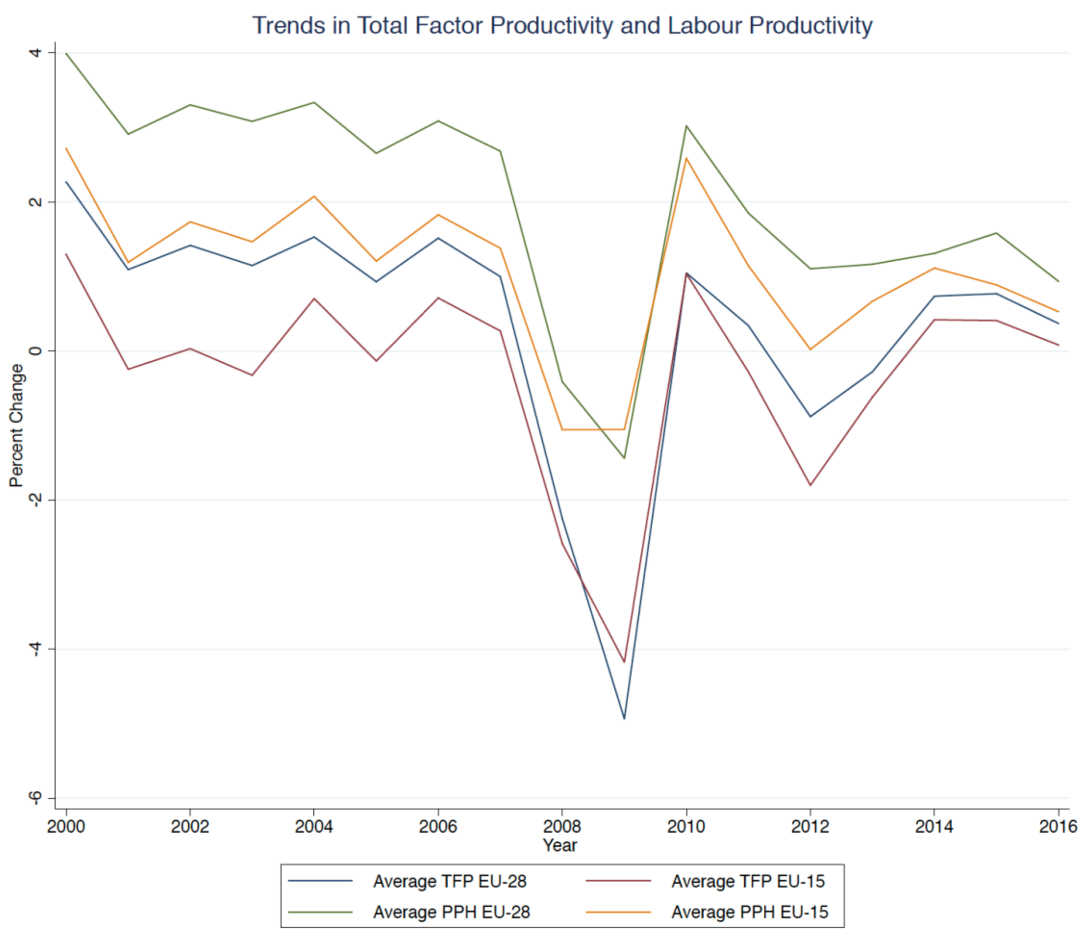
Table 1: **Clusters of Productivity Performers**

Productivity Performance Groups

Group 1 slow recovery	Group 2 Stagnation	Group 3 Falling Behind		
Lithuania				
Netherlands				
Sweden	Finland	Greece		
France	Cyprus			
Germany	Portugal			
Denmark	Austria			
Belgium	UK			
	Poland			
Czech Republik	Malta			
Slovakia	Italy			
Romania				
Luxembourg				
Slovenia				
Estonia				
Spain				
Latvia				
Hungary				
Croatia				
Bulgaria				
Ireland				

The acknowledgement of such variance is critical when it comes to policy recommendations as special constellations need to be taken into consideration. The first group, for example, consists of a pretty varied number of national economies, in terms of the level of economic development as well as in positions within the tech-composition of output. We try to accommodate those differences by analysing a set of institutional variables that are more or less pronounced across the sample (see section 4).

Graph 2: **Trends in Total Factor Productivity and Labour Productivity, 2000 – 2016**



Within the overall picture of stagnating TFP growth hides a variety of cases that differ in many respects, not only in terms of performance but also in terms of their internal setup. Before moving directly into our analysis, we take as a next step a look into the rich literature provoked by the productivity slowdown to get an understanding of the various explanations.

3. LITERATURE REVIEW

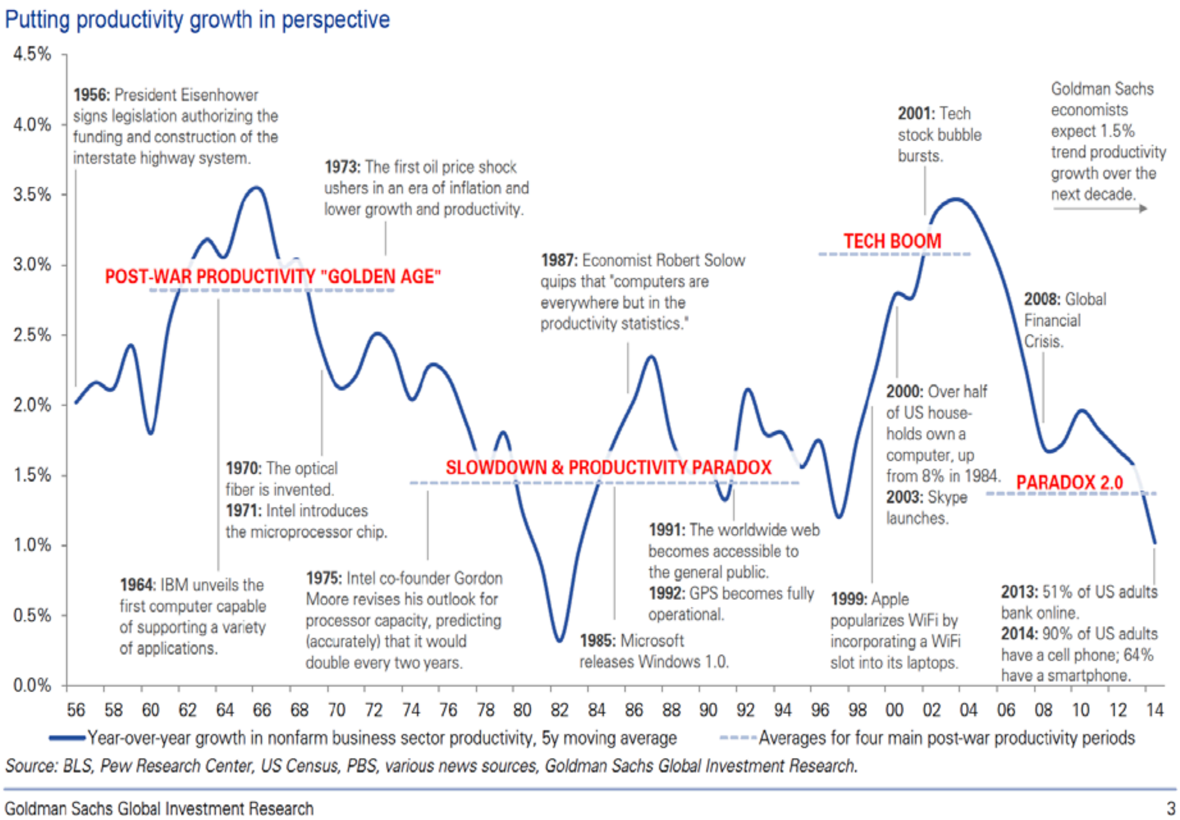
3.1. RELEVANCE OF PRODUCTIVITY

According to the neoclassical growth accounting framework, labour productivity and its growth are determined the growth rate of the capital intensity and by Total Factor Productivity (TFP). Capital intensity indicates how many capital goods are used for production activity per worker. An increase in capital intensity is labelled as capital deepening. In other words, capital intensity captures the change in the relative relationship between capital and labour inputs that affects labour productivity. Total Factor Productivity is in this framework a residual that captures changes in output not attributable to the inputs of capital and labour. In the literature, this is interpreted as an indicator of innovation. Everything else constant, an increase in labour productivity results in an increase in output, usually measured in GDP. Such an increase then widens the distribution space between profit claims, wage claims, and the portion claimed by the state in the form of taxes. Reversely, if labour productivity and TFP come to a halt or even show a lower speed of increase compared to the past, societies suffer - relatively spoken - from smaller distribution spaces. To illustrate the problem: With an annual growth rate of 2 %, labour productivity doubles every 35 years. An annual rate of solely .5% implies that it needs 140 years for productivity to double. In other words, a more extended productivity slowdown is a relevant economic and social event.

Stagnating or even negative growth of labour productivity can be seen as a drag on output growth, assuming that the quantity of input of labour and capital stays put. The current interest in factors that explain the behaviour of labour productivity was sparked by the observation that labour productivity took a trend dive at a time when computer and algorithms started to become ubiquitous. One would have expected that the introduction of a whole variety of innovative technologies would have catapulted labour productivity on a higher plateau where it would move along with high speed. In particular, the ongoing digitisation of economic activities was supposed to lift productivity to new heights. And yet, empirical data show that such expectations were disappointed. Instead, the group of developed market economies experienced negative labour productivity trends over the last 20 years or so. How can this be explained and what can politics undertake to turn around underlying processes? So far, the so-called productivity puzzle generated an enormous production of analyses but no clear-cut answer to the problem. This section presents an overview of the main arguments put forward. The intention is to get insight on critical variables that then help as in our effort to sample indicators for integrative analysis of the role of complementary institutions for productivity growth.

The slowdown of productivity generated a lively debate about the reasons for this phenomenon. The two poles of this debate are characterised by *techno-pessimism* and *techno-optimism*. The techno-pessimistic literature got a massive push by the impressive study of the US growth history by Gordon (2016) where he introduces the empirically-supported argument that the last wave of technical innovations did not live up to the hype as they come with low impact on productivity, in particular, compared to previous fundamental innovations which triggered long-lasting productivity effects. The availability of ‘Great Inventions' made room to the ‘new normal' of modest productivity rates. Distinguishing productivity growth periods within a political event and innovation framework is another way to illustrate the secular weakness of the most recent wave of basic innovations (see graph 2). This framing suggests that productivity growth is not directly tied to innovation activities. Instead, one can argue, it seems that the steady flow of basic innovations goes hand-in-hand with decreasing productivity growth rates. On a more positive note, one can make the argument that political and economic shocks trigger innovation activities that then are getting translated into periods of accelerated productivity rates. Rather than being endogenous, the argument is that productivity improvements are triggered by exogenous events. Such an interpretation is not helpful when it comes to policy considerations, though.

Graph 2: **Productivity Growth in Perspective**



The opposite pole of the debate argues with a productivity-J-curve which is seen typical for General Purpose Technologies (GPTs): In the tradition of Bresnahan and Trajtenberg (1995) such GPTs are engines of potential growth which only unfold their potential if complementary investment, tangible and intangible, are made and if firms are willing and able to radically transform their organisations (Brynjolfsson/Rock/Syverson 2018). Such complimentary investment needs time and often is the outcome of protracted economic and political search processes. As a consequence, radical innovations may not show up in productivity improvements for a long time. Looking at the time pattern of productivity spillovers Venturini (2019) states on the base of patenting data that the time delay also holds for fourth industrial revolution technologies like big data and artificial intelligence.

Economic policy can support but also interfere with innovation search processes. Whereas complementary public investments are often mentioned as pre-requisites for private innovation activities, only seldom discussed is the public role in regards to delaying and postponing technological upgrading (see as an exemption Acemoglu/Moscona/Robinson 2016). However, given that innovation processes potentially lead to destruction processes where established products and production processes are becoming obsolete, actors are demanding public support to keep companies and employment in operation. McGowan/Andrews/Millot (2017) for example, make the case that state policies that keep firms or even whole sectors for social policy reasons in the market despite economic obsolescence results in slow sectoral change that puts negative pressure on productivity: “The results show that the prevalence of and resources sunk in zombie firms have risen since the mid-2000s and that the increased survival of these low productivity firms at the margins of exit congests markets and constrains the growth of more productive firms. Controlling for cyclical effects, cross-country analysis shows that within-industries over the period 2003-2013, a higher share of industry capital sunk in zombie firms is associated with lower investment and employment growth of the typical non-zombie firm and less productivity-enhancing capital reallocation. Besides limiting the expansion possibilities of healthy incumbent firms, market congestion generated by zombie firms can also create barriers to entry and constrain the post-entry growth of young firms". This observation can be read in a way that state policies can be highly contradictory: On the one side, public innovation policies try to generate or support fundamental innovation activities employing direct and indirect subsidies, tax policies and the like. On the other hand, state policies can hinder the unlocking of established growth paths by putting forward structural conservation policies which have adverse effects on productivity performance.

The picture is getting even messier if one steps down on the firm level. Empirical data suggest a widening gap in productivity performance between technology leaders and technology laggards where the latter pull down aggregate productivity growth (Andrews/Criscuolo/Gal 2017). Technology leaders also do much better in terms of R&D as Veugeler (2018) shows: “…in most sectors there is a high degree of concentration among a few top companies in research and development spending. R&D spending is much more concentrated than in sales and employment. In 2015, for example, the top 10 per cent biggest spenders on R&D, accounted for 71 per cent of the R&D spending of the 2500 companies that spend most on R&D”. Such an uneven development further tends to cement the divergence in productivity as laggards are more and more losing out to the top tier firms. As substantial as such findings are, however, we are not following this level of disaggregation and rather keep our analysis on the macro-level.

3.2. MUCH ADO ABOUT NOTHING? - THE MISMEASUREMENT CAMP

One of the first responses to the observed slowdown in productivity made the argument that the slowdown is more a statistical artefact than empirical reality as the way productivity is being measured comes with its deficits that lead to an underestimation of actual productivity. As Hatzius (2015) puts it: "…a significant part of the slowdown reflects growing measurement error in the IT sector. In theory, the IT contribution to growth might be understated either because of an inability to capture nominal GDP—e.g., because of shifts in retail distribution channels from malls to the internet that is only incorporated in official surveys with a lag—or because of an overstatement of IT price changes. In practice, price measurement is likely to be the more important issue". In this line of thinking price indices that are critical to measuring real output are distorted due to (i) the slowdown in IT hardware prices, (ii) the improper calculation of quality-adjusted prices for IT products, and (iii) the lack of including the quality of new products into the output measures. When it comes to IT related products, hardware as well as software, then it is well known that quality improves rather quickly. Quality improvements can come in the form of accelerated speed of processors, more computing power, more storage, or also in all kind of improved and/or new software that has direct or indirect effects on productivity. Dealing with this kind of improvements in terms of calculations adequate prices is a difficult task for statisticians.

In today's debate, it is widely accepted that statistical methods are not up to the challenges provided by digitalisation and related new products and services. This also holds in regards to intangible capital that is even harder to include established statistical accounting practices. However, it is also widely accepted that mismeasurement practice does *not* imply that there is no slowdown in productivity. Mismeasurement is not taking away the productivity problem. Bryne/Fernald/Reinsdorf (2017) tried to make proper price adjustments for the case of the US and came to the result that average labour productivity for the period 1995-2004 was slightly higher than officially reported. The period 2004-2014, though, showed according to their calculations an even stronger slowdown compared to official figures. In other words, efforts to overcome the mismeasurement result in strengthening the finding of a slowdown of productivity. Syverson (2016) makes the most persuasive case against the mismeasurement hypothesis by conducting four separate empirical analyses. First, he shows that the productivity slowdown can be observed over a large number of economies where productivity and thus the input of IT-innovations is measured differently. Second, his review of the research literature on the positive income effects of new technologies cannot explain the actual size of the loss of income due to the reduced dynamic of productivity. This loss can be calculated as the difference between actual output and the output that would have occurred in case of the productivity trend before the slowdown. Third, an analysis of the IT-sectors that produce IT goods and services shows on average higher productivity rates than other sectors but by far not multiple higher rates as expected. Fourth, the observation of a higher Gross Domestic Income than Gross National Income indicates a measurement problem of its own that could be interpreted as an indicator that workers are getting paid for products and services that are given away for free or for undervalued prices. However, this gap as existing long before the slowdown of productivity and seems to indicate more the rise of the profit share.

Statistical methods are not (yet) up to the challenge provided by the current type of new technologies. Thus, one can argue that statistical findings underestimate the effects of new technologies on productivity. However, those methodological problems do not at all support an argument that the slowdown of productivity is a statistical illusion. For example, the IMF (2018) states that only 10 to 20 per cent of the reduction in labour productivity may be explained by mismeasurement. Barnett et al. (2014) state that a maximum of a quarter of productivity slowdown in the UK can be accounted for by statistical problems. In the case of Germany, the Institute for the World Economy in Kiel (IfW 2017) argues that measurement problems do not significantly contribute to explaining the productivity slowdown. Haskel/Westlake (2017) in their highly influential study ‘Capitalism without capital - the rise of the intangible economy' provide an insightful discussion of the mismeasurement hypothesis only to conclude that the neglecting of intangible investment does not explain the negative trend of productivity. All this suggests that the slowdown is an empirical fact that needs an explanation beyond statistical problems.

3.3. DEMAND SIDE: SECULAR STAGNATION-HYPOTHESIS AND MORE

In the tradition of Solow's growth accounting framework, capital accumulation and improvements in the efficiency of usage of factors of production are critical drivers of long-term economic growth. Improvements in efficiency are labelled as Total Factor Productivity (Multifactor Productivity) which is within this analytical framework a residual variable. Capital deepening implies the introduction of new machinery into the existing capital stock, i.e. it adds new investment to the capital stock. As a matter of fact, in the wake of the global financial crisis of 2008 we see - as could be expected - an abrupt slowdown in private investment. What is surprising, though, is the slow recovery of investment activities of the private sector. Only in 2014, OECD-economies saw a return of private business investment to the level of 2008. This has implications for productivity performance. Across the OECD and the euro area, trend productivity growth slowed on average by 0.4 pp annually between 2007 and 2015, most of which - according to an OECD study - can be explained by slower growth in capital per worker (Guillemette et.al. 2016). Slow economic growth due to deleveraging efforts on the side of the private sector continued for quite a while despite aggressive monetary policies in form of drastically reduced key interest rates to the lower zero bound and quantitative easing measures. Sluggish post-financial crisis economic growth, so Blanchard/Lorenzoni/L'Huillier (2017)), is the outcome of pessimistic expectations about future economic growth that holds back capital good investment, and thus the introduction of new technologies into the capital stock. However, it is well-known that sluggish investment growth has a more extensive history: The average share of investment in GDP has been falling significantly over a long period in economies like Japan, Germany, and the UK and has remained constant in such economies as the US and France. All of those economies experienced in different manners a long-term slowdown of labour productivity (Fiedler/Gern/Jannsen/Wolters 2019). And yet, the degree of adverse productivity effects due to falling or stagnant investment differs. A most prominent case for the hysteresis effect of the Global Financial Crisis is the UK where the literature concludes that the magnitude of negative impacts, exacerbated by strict austerity policies, was probably in the range 3.8 to 7.5 per cent of GDP. The dragging Brexit situation seems to add another component of uncertainty to this and may further reduce the growth potential and thus keep the UK on the very bottom of the OECD when it comes to productivity effects (Crafts 2019).

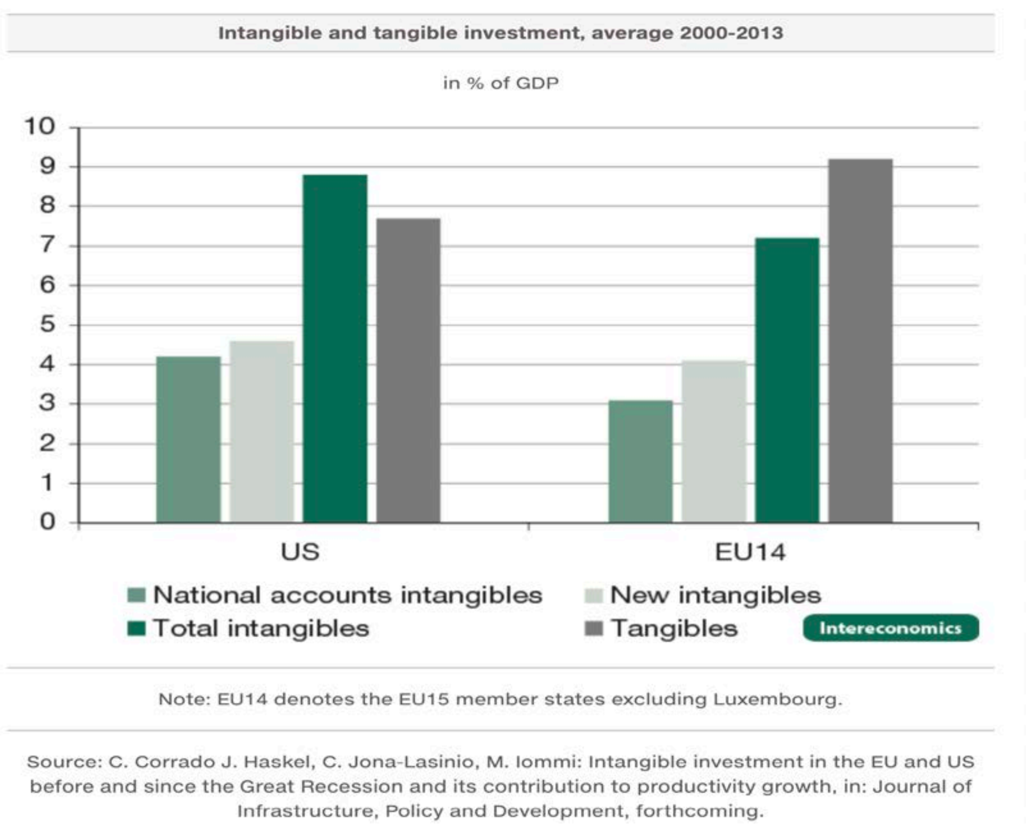
Byrne/Oliner/Sichel(2013) and Adler et al. (2017) argue that the modest improvements in productivity due to new technologies have been crowded-out by factors, like the aftershocks of the Global Financial Crisis and what they call ‘TFP hysteresis’: Increasing political and economic uncertainty made firms more cautious in regards to investment and triggered a move away from high-risk -high return activities. Slowing global trade and stalling growth in global value chains have contributed to weak productivity performance (Lileeva, 2008; De Loecker, 2007; United Nations, 2017). Others make the point that the adverse credit supply performance after the outbreak of the Global Financial Crisis reduced labour productivity, wages and the capital intensity of production at the firm level (Franklin/Rostom/Thwaites 2015). That constraint credit supply can generate a misallocation of resources has also been shown for the UK by Riley/ Bondibene/Young (2015). That financial frictions have negative effects for productivity performance has been demonstrated by Duval /Hee Hong/Timmer (2017) who use rich cross-country, firm-level data set for their analysis. They conclude (i) firms that entered the crisis with weaker balance sheets experienced a decline in total factor productivity growth relative to their less vulnerable counterparts after the crisis; (ii) this decline was more substantial for firms located in countries where credit conditions tightened more; (iii) financially fragile firms cut back on intangible capital investment compared to more resilient firms.

The productivity slowdown started long before the Global Financial Crisis. Hence, the latter should not be seen as the cause of the slowdown but as a factor that may explain why the stagnation seems to continue. Negative expectations about the economic future are contributing to holding back further capital deepening. As Ollivaud/Guillemette/Turner (2018) put it: “Much of the recent weakness in the growth of the capital stock can be explained by an accelerator response of investment to the negative demand shock following the financial crisis. Those countries experiencing the most severe downturns have also suffered the most marked slowdown in capital stock growth. This suggests the operation of an important hysteresis-like effect over the post-crisis period, whereby continued weakness in demand has led to a deterioration in potential output via weaker growth of the capital stock. As Thum-Thysern/Voigt/Bilbao-Osorio/Maier/Ognyanova (2017: 5)) put it: "Undoubtedly, Europe needs investments in order to return to a long-term sustainable growth path: investment is indispensable for stimulating technological progress and increasing productivity, which are, in turn, widely acknowledged as the main drivers of long-run growth and catalysts for the competitiveness of firms and the entire economy". And yet, investment is by far not the whole story behind the productivity slowdown.

3.4. MOVING TOWARDS AN INTANGIBLE ECONOMY?

Knowledge creation and diffusion, as well as fundamental changes in organisational structures firms and the technology-push for new skills, have become trademarks of emerging structures of production and

Graph 3: **Intangible and Tangible Investment 2000-2013**



consumption. The rise of inputs like software, databases, algorithms, intellectual property rights, brand, as well as organisational change-innovations is often summarised under the label intangible capital. Analyses suggest that this type of investment has become critical for productivity, and even more crucial than traditional physical investment (Crouzet/ Eberly 2018). Following Haskel/Westlake (2017), intangibles capital is characterised by the 'Four S's": sunk, spillovers, scalable, synergies: intangible capital can be easily scalable. For example, a transportation company like Lyft and Uber operate with algorithms that allow them to serve more customers than a traditional company that needs to invest in physical capital like cars to deal with more customers. The production of intangible capital comes with significant sunk costs as this type of capital is more difficult to sell, unlike a machine that may no longer be needed. Intangible capital generates significant spillover, as other economic actors can make free use of intangible capital invested by a technology leader. Finally, intangible capital creates potential synergies with other intangible assets so that one intangible asset can become even more valuable when combined with another intangible. Efforts to measure this type of investment are manifold, most prominently by the OECD which speaks of knowledge-based capital. Rather than treating such investments as intermediary products, they are treated as investment proper. Available data indicate that knowledge-based capital has increased continuously and that in some cases, most prominent in the US, this type of investment grew over timer much stronger than fixed investment (OECD 2013). Graph shows that the US leads an EU-14 group of economies in terms of intangible investment as share in GDP. Data for the US, Germany, France, and Italy show that France leads the group, followed by Germany, and Italy and the US are close on par in 2013 (Wolf 2018). Andersson/Saiz (2018) present data that over the last ten years the growth rate of intangible investment outpaced the annual rate of tangible investment. Those illustrations insinuate a strong movement towards the build-up of intangible capital over time.

Corrado/Hulten/Sichel (2006) were first to explore the role of intangible capital for economic growth and productivity and demonstrated that productivity is positively influenced by investing in intangible capital. Since a large number of studies reported that a significant (and in some cases increasing) part of labour productivity growth can be explained by the rising share of intangible assets (Byrne/Corrado 2017). In their growth accounting exercise for the core of EU-economies, Thum-Thysen et al. (2017) can show that intangible capital is critical for output growth but makes the most crucial contribution in combination with an increase of physical capital as both can be seen as complementary components of capital deepening. (see also Piekkola 2011). Unlike physical capital, intangible assets are much less interest-sensitive and thus less exposed to monetary policy. Moreover, intangible capital by nature is less collateralisable than traditional faced capital, with the consequence that conventional financial institutions may be hesitant to provide credit.

Studies on the impact of intangible capital on output growth and productivity use various concepts of 'knowledge capital', and can only make limited use of existing statistical information. National accounting practices differ despite efforts on the side of the OECD to develop common standards. It also needs to be noted that available timelines for intangible capital are relatively short, compared to more traditional indicators covered by accounting practices (Nakamura 2009). And yet, a steady convergence in the literature emerged for the argument that intangible capital is critical and maybe even the significant factor driving productivity.

3.5. CHANNELS OF PRODUCTIVITY

The endogenous growth literature time ago established the insight of a close link between innovation activities and productivity performance: The rate of technological progress depends from innovations, i.e. product innovations, process innovations as well as from new domestic and international markets. Some of those innovations stem from fundamental basic innovations that are closely tied to active research and development (R&D) investments of the private and the public sector. Others are spillover-effects of economic activities on a form or sectoral level, where competitors can free ride and/or where firms learn from experiences with customers. Profit-driven investments in R&D are by definition risky as at the time of investing nobody knows the outcome of those expenditures. As a consequence, innovation activities may not move ahead in an optimum manner. State policies can contribute to some degree to hedge those private risks. At the same time, economic policy also can support innovation via its education policies, its approach towards economic globalisation, and employing taxation, industrial policies, and the like (Hall 2019). The innovation literature usually proxies innovation activities of an economy by R&D expenditures measured as share in GDP. Empirical findings indicate that R&D is a critical driver of long-term productivity performance but are not conclusive about the ways R&D contribute to productivity improvements. Castellani/Piva/Schubert/Vivarelli (2018), for example, conclude that US-firms have a much better capacity to translate R&D activities into productivity gains. Such findings indicate that more variables need to be taken into consideration when it comes to explaining the effects of R&D on productivity.

The Schumpeterian-strand of endogenous growth literature was instrumental in introducing a range of mechanisms that are guiding and characterising innovation activities. For example, it has been demonstrated that productivity in the form of TFP is not only driven by R&D-investment of one national economy but also by R&D expenditures of relevant trading partners of this country (Coe/Helpman 1995). The closer trading links, the higher the probability of spillover effects. This observation seems to hold even more for the case of global value chains: firms that are participating in global value chains, directly and indirectly, benefit from technological advances of technology leaders. However, there are quite some heterogeneities at the country and firm levels. For catching-up economies, trade liberalisation appears to have positive innovation effects that drive productivity. In the case of mature economies, export opportunities and access to imported intermediate goods tend to encourage innovation (see Shu/Steinwender 2019). Moreover, open markets for goods and services provides and incentives for companies to reach beyond domestic markets which then generates learning processes in terms of marketisation, design and the like that may result in product and process improvements, and thus in productivity improvements (see Melitz/Trefler 2012). Peters/ Roberts/Van Anh Vuong (2019) can demonstrate for the case of Germany that firms which export above the industry-average are more innovation-active than firms below the industry export-average.

The role of open markets and technology leaders for catching-up processes has recently been shown by Gordon/Sayed (2019) who found that EU-10 productivity growth can be interpreted as a catching up to the technology leader US. This catching-up occurred over particular

periods, with robust EU-10 productivity growth in the period 1950-72 which represents a delayed adoption of the inventions that propelled US-productivity growth in the first half of the 20th century. The period 1972-95 then shows an imitation of the US performance of the period 1950-72. The period 1995 to

2015 follows according to this study the slowdown of US productivity over the same period. Similar results are reported by Amirkhalkali/Dar (2019) for 27 OECD-economies over the period 2000 to 2015.

Technological leadership can be found on the firm level. Studies who analysed the productivity performance of technology leaders and technology laggards come to the result that technology leaders show strong and far above-average growth of productivity: Between 2001 and 2013, firms at the global frontier have become relatively more productive, with their productivity increased at an average annual rate of 2.8% in the manufacturing sector, compared to an improvement in the evolution of labour productivity of just 0.6% for non-frontier firms. This pattern of divergence is even more pronounced in the market services sector" (Andrews/Criscuolo/Gal (2016). This finding indicates a strong technology and thus productivity gap that seems to grow over time. The creation of 'global super firms' may indicate weak market-driven spillover effects and trends towards oligopolies which may act as a brake on innovation activities.

The early endogenous growth literature (Lucas 1988) identified human capital as an endogenous driver of productivity. Knowledge embodied in human capital is an integral part of innovation activities. If we distinguish in the tradition of Schumpeter between innovation and invention, then it is apparent that it needs ingenious skills to come ups with inventions. Latter is of no further relevance, though, as long as they are not turned into innovations, i.e. into product or process innovations which have practical usages: "As long as they are not carried out into practice, inventions are economically irrelevant. And to carry any improvement into effect is a task entirely different from the inventing of it, and a task, moreover, requiring entirely different kinds of aptitudes" (Schumpeter 1934: 88). Both activities need the input of particular types of skilled labour, which eventually need to be generated by an education system that trains and supports productivity-relevant skills (Griliches 2000). Empirically supported arguments fundamentally question this perspective that we have entered a period where the low hanging innovation fruits are already taken and where innovation activities experience the fate of decreasing returns. Rather than running out of ideas, as Gordon (2016) seems to suggest, it appears that the costs of extracting insights have increased sharply over time): "In other words, the innovation bang for the R&D buck (or 'research productivity') has declined. In an accounting sense, therefore, low productivity growth in the economy is a direct consequence of research effort failing to increase fast enough to offset declining research productivity" (Bloom/Jones/Van Reenen/Webb 2017).

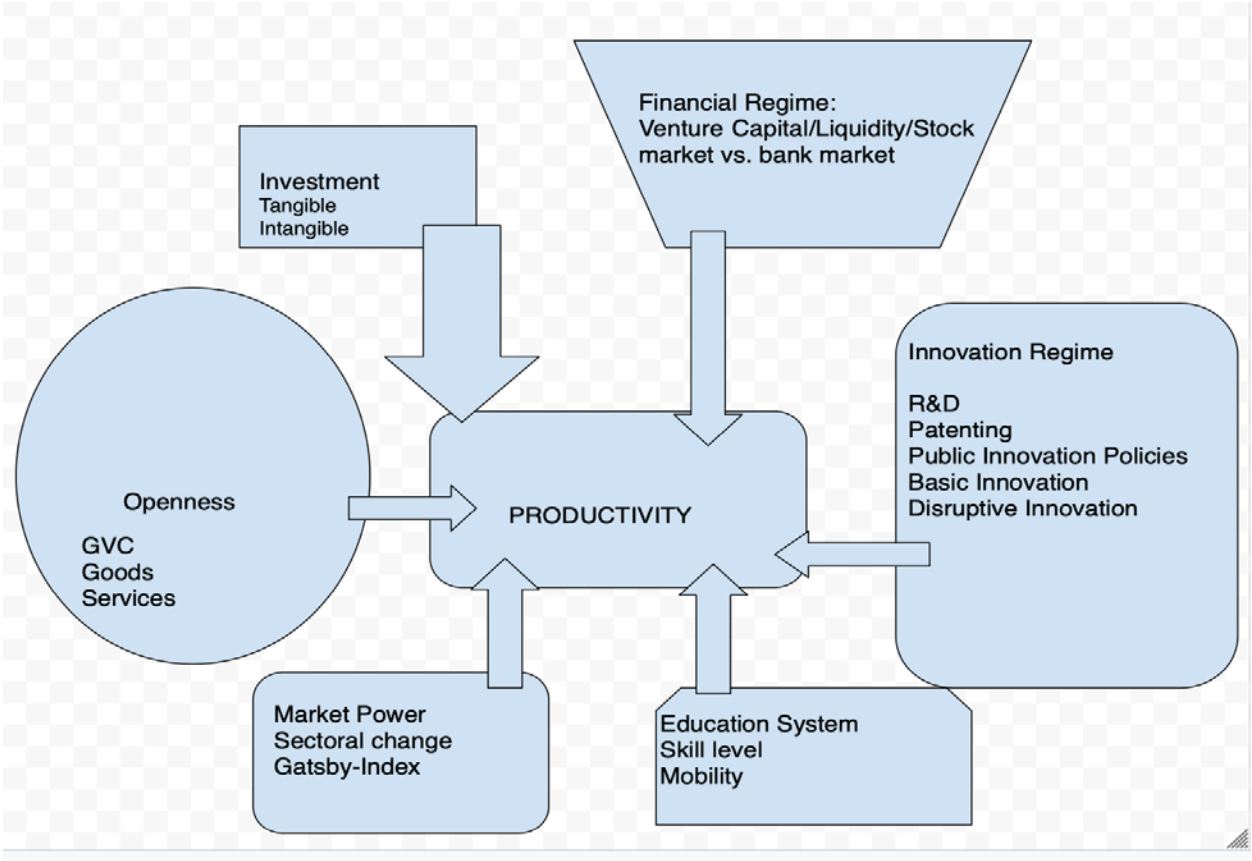
4. PRODUCTIVITY REGIMES AND INSTITUTIONAL SETTINGS

4.1. FIRST RAPPROCHEMENT

Against this background of controversies in the analytical as well as in the empirical literature on the productivity puzzle, we suggest a different route that suggests looking into the institutional settings of innovation activities of national growth models. Producing and utilising knowledge are highly complex activities which are operating in particular institutional environments which are consisting of a variety of institutions that make institutional settings of national economies rather unique. Not all capitalist market economies work in the same way. Institutions shape economic developments and outcomes in direct and indirect ways. In the early 'varieties of capitalism'-literature (VoC) based on Hall/Soskice (2001) it was suggested that the two types of capitalism – liberal market economies and coordinated market economies – differ in particular in terms of innovation activities. Whereas liberal market economies are driven by radical innovations that fundamentally change social and economic dynamics, the type of coordinated market capitalism is prone to incremental innovation activities. Radical innovation activities shift the paradigm and path of economic growth and are thus disruptive. Incremental innovation activities move along a given path, and only slowly if at all lead to path change (Hübner 2009). The VoC-approach found a wide reception and since has moved far beyond the initial two-type classification (Amable 2003; 2018) but still kept the main underlying idea alive that institutional settings, as well as the degree of complementarity of institutions, are key to explain national growth paths and their outcomes.

The VoC-literature complemented, at least to some reasonable degree, insights from the earlier literature on national innovation systems which were defined by one of the foremost scholars of this approach as '…the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies' (Freeman. 1987: 1). National innovation systems differ in many ways, not least in their institutional settings and also in innovation outcomes. The literature on national innovation systems takes a relatively narrow view on innovation activities and stresses, in particular, the interplay between public R&D efforts, universities and the overall political-economic environment of national economies.

Our approach takes a rather pragmatic turn. What we want to explore is, in a first step, the productivity performance of economies, respectively groups of economies. In a second step, we intend to figure out which institutional settings are best suited to deal with sustainable productivity growth. For this purpose, we are started looking at a number of variables that are mentioned in the literature as crucial drivers of productivity. Graph gives a *general idea* of our efforts. The boxes include variables that are seen as critical for explaining the productivity performance of countries. An obvious candidate is the development of investment where we see most critical the share of intangible capital in overall investment, respectively in GDP. The expectation is that the higher the share of intangible assets, the better the productivity performance.



Technologies are getting diffused via various trade channels which we capture with an openness index (X/Y + M/Y) with the expectation that more open economies are doing better than less open economies. We include a more nuanced index provided by the EU, called index of the economic impact of innovation to catch sectoral processes of innovation. The innovation regime, as mentioned, is of importance and we are looking onto this variable by patenting behaviour as well as by R&D expenditures. R&D is included in a new index variable provided by the EU that aggregates several innovation-related variables. Innovation activities need to get funded, not only by firm-internal but also by firm-external sources. We focus on venture capital and its availability, following the literature where venture capital is seen as critical for the emergence of disruptive innovations. The creation and even more so the usage of innovations is closely tied to the skill levels of the working population which we proxy with a number of available indicators, including the share of STEM workers (science, technology, engineering, and mathematics) in the working population. Innovation activities on the high-end pole seem to go hand in hand with winner-takes-all outcomes, and we try to capture this relation by using Gini-coefficients. Product and process innovation only can have an impact on productivity if they are part of the processes of ‘creative destruction', and this requires sectorial change. Governments, even ones favouring innovation policies, are potentially in a bind as they also need to represent sectors which are under high market exit pressure. As a result, we may see the emergence of ‘zombie firms. The more governments try to save obsolete sectors, the more successful they are in social policy outcomes, and the less they are in improving productivity. We use data on zombie firms to proxy resistance of sectorial change that puts downward pressure on productivity.

Based on this general idea of regularities and pattern that drive and shape national innovation activities, we started to evaluate a vast range of empirical indicators for our independent variables. This research was immediately confronted with the problem that by far not all indicators were available for all our cases and a sufficient period. Fortunately, we could make up critical data deficiencies by making use of a data set put together by the European Commission for its 'State of the Innovation Union" report (EC 2013). Still, we had to omit a few cases (see below).

4.2. PRODUCTIVITY REGIMES

Our notion of productivity regimes is grounded in the literature of varieties of capitalism which itself has quite a long history, going back to the work of French economists which contributed to what became known as *école de la régulation* (Aglietta 1979; Boyer 1986; Hübner 1989). In this tradition, an accumulation regime refers to a regular configuration of macroeconomic variables in a particular country and at a specific time. For an accumulation regime to become firmly established, it needs to be complemented by a mode of régulation – a set of social norms, pattern and rules which constrain and guide economic actors. The coherence of an accumulation regime and its mode of régulation then define the path of development as well as economic outcomes. Parallel to this analytical effort emerged the notion of technological regimes, introduced by Nelson (1993) and Patel/Pavitt 1994), which stresses the relevance of particular (industry-specific) institutional factors for innovation activities.

Our analysis connects with those types of approaches by looking onto productivity regimes, i.e. national institutional settings that guide and generate innovation activities and eventually productivity outcomes.

The second half of the 1990s experienced an upswing in labour productivity and total factor productivity, in particular in the US. The improved productivity performance of the US was widely explained by its economic and moreover by its institutional comparative advantage when it comes to radical innovation processes. What quickly was labelled as 'New Economy' was a configuration that included labour market flexibility plus liquid and risk-oriented financial industry (venture capital and stock market) plus dynamic innovation system with close industry-university ties plus an innovation-oriented entrepreneurial class. This configuration became the benchmark for state policies until the financial bubble of this type of New Economy burst in 2001 (Hübner 2006). One consequence, in policy terms as well as in terms of adequate analytics, was to moving away from benchmarking and looking more concrete on national particularities of innovation processes. The idea of the US being the ideal model for accelerated productivity performance was further undermined by the empirical fact of a secular productivity slowdown since the early 2000s which resulted in the notion of the slowdown as the 'new normal' Crafts 2018).

We are interested in particular national institutional configurations of pattern and regularities that guide and shape productivity performances which we label as national productivity regimes. Rather than going for a conventional econometric analysis that would calculate the significance of the contribution of several variables we are opting for a methodology that allows the identification of *sets of institutional complementarities* as well as their potential mutually enforcing ties. Following a similar procedure by Boyer (2004) in his analysis of national growth regimes in times of accelerated innovation processes, we are making use of the fuzzy set-approach introduced by Ragin (1989). Doing so requires the identification of a number of critical variables that are seen as relevant for the productivity performance of economies. For our sample of the EU-28, we could heavily draw on new data provided by the European Commission (2013), additionally to other sources (see Annex 2). Most prominent were two indexes that capture (i) the knowledge intensity of national economies and (ii) the economic impact of innovation activities. We translated quantitative data along with a range of variables into qualitative data and then presented them in a comprehensive truth table. Each variable is averaged over the EU-28, and this average is the threshold for the creation of a Boolean notational scheme where economies above the threshold for each variable receives a value of '1' and variables for economies below the threshold receive a value of '0'. For some variables, we defined quantitative ranges that allowed us to assign Boolean values to each range of those variables (see Table). Those values are then run in a conventional statistical model for detecting significant institutional combination for each country. [1]

This procedure allows us to identify particular institutional configurations (productivity regimes) which drive individual productivity outcomes. Each economy has a productivity regime, but not all productivity regimes are equal. As our results show, they differ in the way and the degree to which they generate and make use of innovations. Moreover, our modelling outcomes indicate that only a minority of productivity regimes are potentially supportive for making productive use of the current and next generation of GPTs. Additionally, it needs to be stressed that none of the national productivity regimes produces outcomes that would be close to the performance of previous periods.

[1] For a few countries, we could not find sufficient data for our variables across a reasonable period of time, and thus we decided to take them out of our N-sample. This includes Bulgaria, Croatia, Cyprus, Estonia, Latvia, Luxembourg, Malta, Romania, and Spain.

Table 4: **Truth Table**

Country	FDI Investment (F)	Intangible Investment (R)	Openness (H)	Income Inequality (I)	Internet Use Share (J)	Economic InnovaBon Index (K)	Knowledge Intensity (M)	Venture Capital (O)	Private Investment (G)	Hitech Employment (Q)	ProducBvity Growth (A)
Austria	0	1	0	0	1	1	1	0	1	-	0
Belgium	1	1	1	0	1	1	1	0	0	1	1
Bulgaria	-	-	0	1	0	0	0	1	0	0	1
Croa2a	-	-	0	-	0	1	-	1	1	-	1
Cyprus	-	-	1	1	0	1	1	1	1	0	0
Czech Republic	0	1	1	0	0	1	1	0	0	0	1
Denmark	0	1	0	0	1	1	1	0	1	1	1
Estonia	0	-	1	1	1	1	1	1	1	-	1
Finland	0	1	0	0	1	1	1	0	1	1	0
France	1	1	0	1	1	1	1	1	1	1	1
Germany	1	0	0	0	1	1	1	1	0	1	1
Greece	0	0	0	1	0	0	0	0	1	0	0
Hungary	0	0	1	0	0	1	1	0	1	0	1
Ireland	1	1	1	1	0	1	1	1	0	0	1
Italy	1	0	0	1	0	-	0	1	0	1	0
Latvia	0	-	0	1	0	0	0	1	0	-	1
Lithuania	0	-	1	1	0	0	0	1	0	0	1
Luxembo urg	0	-	1	1	1	1	1	1	0	-	1
Malta	-	-	1	-	0	0	1	1	1	-	0
Netherlan ds	1	1	1	0	1	1	1	1	1	-	1
Poland	0	-	0	1	0	0	0	0	0	0	0
Portugal	0	0	0	1	0	-	1	0	0	0	0
Romania	-	-	0	-	0	-	0	0	0	0	1
Slovakia	0	0	1	0	0	-	0	1	0	0	1
Slovenia	0	1	1	0	0	-	1	1	0	0	1
Spain	1	0	0	1	0	-	-	1	0	1	1
Sweden	0	1	0	-	1	-	1	1	0	1	1
United Kingdom	1	1	0	1	1	-	1	1	0	1	0

F- FDI; R – Intangible investment; H- openness (X+M as % of GDP); I – income inequality; J - Internet user share; K – Economic Innovation Index; M-Knowledge intensity; O -Venture capital; G private overall investment; Q – high tech employment share

Some of our independent variables turned out to be not relevant within the context of institutional settings. This holds for income inequality and also for the impact of a deferred change via zombie firms. This result of our exercise does not automatically mean that both variables are irrelevant as both indicators were either not covered very well in terms of data availability or were too highly aggregated.

Our modelling suggests three types of productivity regimes across the EU: a *Knowledge-Technology-oriented Productivity Regime* (KTPR), a *Low-Tech Productivity Regime* (LTPR) and a *Dependence Regime* (DPR). A regime is seen as powerful the more mutually enforcing institutions are existent. It is exactly the degree of completeness as well as of complementarity that makes productivity more or less successful Our three productivity regimes follow a descending level of completeness. Accordingly, these types differ in productivity performance as well as in their institutional configurations. The KTPT comes in three versions which are based on small but relevant differences:

KTPR1 = F * G * M * O * K * Q * R

KTPR2 = F * M * O * Q * K * R

KTPR = G * J * O * M * K * R

KTPR 1 describes the case of *France* that sees over time a stable institutional configuration that combines critical institutional pattern which drives productivity outcomes. The French economy is well positioned in terms of the knowledge intensity of its economic structure (R & D; skill level; sectoral specialisation domestically as well as internationally and inward as well as outward FDI) as well as in regards to the index of the economic impact of innovation activities. Moreover, those variables are tied in significant ways with access to venture capital and the provision of intangible investment within a process of capital deepening. KTPR 2 shows a similar institutional configuration but lacks in a dynamic private investment process that would enhance capital deepening. This configuration fits over time the cases of *Germany*, *Belgium* and *Sweden. KTPR 3* differs by having robust overall internet access and usage of the population which also indicates a widespread skill in the use of new technologies on the side of consumers. *Finland* and *Denmark* are the t wo prominent cases. All three versions of a KTPR share a range of commonalities, not least a critical role of intangible investment. Given the institutional pattern of all three regimes, one can expect that those economies are relatively well positioned for the current and future generation of GPTs.

The LTPR is presented by

LTPR = -K * -G * -Q,

a configuration with negative self-reinforcing institutions. The low level of economic innovation impact (patents, the share of employment in knowledge-intensive activities in manufacturing and services, share of new or improved products in overall turnover) and relatively weak private investment dynamic results in overall stagnating productivity performance. This regime consists of economies like *Greece*, *Portugal*, *Italy* and also the *UK*. Given this weakness, one can conclude that those economies are not well positioned for successful adjustment and catch-up processes in times of the introduction of GPTs. The case of the UK is a particularly interesting case as it shows a feeble productivity performance, which seems to be driven by weak private investment dynamics in the aftermath of the Financial Crisis and the Brexit referendum. Strong employment in combination with low productivity rates makes this regime rather weak.

The DPR consists of a group of economies with unstable institutional configurations (*Belgium, CZR, Hungary, Ireland, Lithuania, Netherlands, Slovakia, Slovenia*) but which have in common that they all show critical levels of openness. Openness is sometimes combined with vigorous knowledge intensity, sometimes with strong FDI performance, and sometimes with a high economic impact of innovations. Productivity performance very much seems to depend from open markets for goods and services as well as for foreign direct investment. Based on more disaggregated literature we assume that the integration in cross-border value chains plays an important role. Rather than a distinct regime, this type of institutional configurations is a flexible regime characterised by a small number of mutually enforcing institutions. A small set of domestic institutions interact in this regime successfully with the level of openness of the economy.

5. PRODUCTIVITY REGIMES AND POLICY IMPLICATIONS

Europe has a productivity problem, as do other economies. Even though there are weak indications for a mild productivity recovery, the fact is that it is a far cry from the productivity performance of the ‘golden age' of capitalist growth after WW II. This is the more puzzling given the rapid technological changes that occurred in the last twenty years or so. Our analysis showed that the way productivity is ‘being created' differs within the group of EU-economies. Not all productivity regimes are equal. Rather than identifying convergence, we can observe further divergence. If only some of the many predictions of coming technological innovations prove to be correct, then it is implied that divergence tendencies are even becoming stronger as already weak productivity of today will not be able to keep with innovation leaders. The result would then be more inequality.

It is well-known that innovation policies are a crucial part of dealing with the productivity puzzle, and our analysis confirms those findings. The general rule holds that the weaker the institutional configuration of a national productivity regime, the weaker its productivity performance. Innovation, though, is a fickle subject. Getting engaged in innovations activities means by definition to deal with risk and more so with uncertainty: It is never clear at the outset whether research and development activities pay off. This is one of the reasons why not all firms are equally research-oriented and why it needs public policy initiatives to avoid potential market failure.

A usual recommendation calls for throwing more money onto innovation activities: "Europe's innovation deficit does not stem from a lack of ideas or a lack of start-ups. Our problem is the lack of scale-up," so, for example, Pascal Lamy, former head of the World Trade Organization. “We have to invest in and promote innovative ideas that can be rapidly scaled up.” Science Europe states in its report of March 2018 ‘Recommendations on Funding Investment, Research and Innovation, SMEs, and the Single Market After 2020', "…that the total combined EU, national, and private investment in research and innovation in Europe needs to be higher for the EU to strengthen its competitive position in the creation of knowledge and to become a beacon of scientific excellence. Europe currently does not lack excellence or potential for innovation, it lacks funding…". There is no doubt that research and innovation activities are costly and require public as well as private investments. Currently, the EU is not up to the challenge. Its R&D intensity, measured as R&D expenditures as % of GDP, was 2.07% in 2017. The same indicator for China showed 2.06%; for Japan 3.28%, a stunning 4.22% for South Korea, and the US 2.76%. And yet, a purely quantitative assessment of innovation activities is not sufficient when it comes to policy recommendations. The EU Commission report ' Lessons from a Decade of Innovation Policy ' (EC 2013) concluded that support for public-private collaborations within the framework of concrete program-based initiatives is a promising way to improve productivity performance. The same report also stressed, though, that national innovation systems seem to be instead path dependent and only slowly moving towards more promising innovation strategies. Rather than being learning entities, they tend to be resilient to change in situations of grand challenges.

Edler/Fagerberg (2017) distinguishes three types of innovation policies. (i) Invention-oriented policies which focus on their policy instruments on the invention process, and leave the usage and the diffusion of inventions to markets. (ii) System-oriented policies concentrate on features, of national innovation systems and the interplay of sub-features as well as on particular critical component of national innovation systems. (iii) Mission-oriented policies try to come up with solutions for well-defined public problems or short-comings. The slowdown of productivity can be seen as such a short-coming that needs to be addressed along the whole process of innovation activities, from the basic research and invention phase to the eventual innovation and diffusion phase. As a consequence, what is needed is a comprehensive approach to innovation policies.

Improving productivity performance is critical for any future improvement of living standards of citizens. However, even a drastic and sustainable improvement in productivity is no guarantee for a 'rising tide lifts all boats'-outcome. Productivity analyses on the firm-level found that innovation leaders earn somewhat skewed rates of return and that the industry leader benefits from innovation rents which go beyond usual first-mover advantages. The outcomes of such processes can be less innovation and a higher degree of income inequality due to winner-takes-all structures (Furman/Orszag 2018). The same holds in regards to employment and more so the composition of employment skills. An increase in productivity can but must not automatically increase employment. This can be illustrated by calculations of potential productivity effects of autonomously-driving cars. For the US it is calculated that the current number of motor vehicle operators of 3.5 Mio would get reduced to 1.5 Mio for ten years. This would result in an annual productivity push of 0.17 % (Brynjolfsson/Rock/Syverson 2017). Productivity improvement and shrinking employment, ceteris paribus, would go hand in hand.

Research indicates that GPTs offer productivity opportunities which emerge only over time. A McKinsey Global Institute analysis of 25 key technologies over the last 50 years comes with a range from 8 to 28 years that is needed until commercial availability is assured. Making use of existing GPTs as well as of the next generation of GPTs requires adequate productive regimes that are up to the challenges ahead. Our analysis demonstrated that productivity regimes of EU-economies on average are not prepared for the problems. Quite a number are incomplete productivity regimes that lack complementarities between crucial institutions.

Our analysis of productivity regimes hints to a number of policy recommendations, some of which are more general and some of which are more specific.

1. Macroeconomics matters. Productivity performance needs strong and stable private investment which drives capital deepening. Private investment depends on favourable national and international environments and foremost from political certainty and robust positive expectations. The most successful productivity regime is one that combines specific institutional features with positive investment processes, confirming the argument that capital deepening requires substantial private investment.

2. Open trade and foreign investment regimes are critical. A situation of rising protectionism and 'trade wars' undermines the viability of existing cross-border value chains and slows down learning processes via technology imports. Trade in goods and services and probably even more so the free flow of foreign direct investment fosters technology transfers that often are substitutes for underperforming or constrained sub-institutions of national productivity regimes. Openness is not only critical for the DPR but also for the other types of productivity regimes as our analysis strongly hints to the relevance of international specialisation on knowledge-intensive industries. The free flow of such activities is a driving force for the KTPR. Trade with data and overall digital trade needs to be supplemented in international trade agreements.

3. Productivity regimes are the more successful, the more 'complete' they are. In his respect policy-maker need urgently to address R&D efforts as this is critical when it comes to making use of GPTs, and in particular when it comes to economy-wide diffusion processes. Currently, the EU is underperforming in regards to its target and more so in comparison with leading competitors. The problem is even more severe in terms of national performances within the EU, where the differences between innovation leaders and innovation laggards are high and getting more pronounced over time.

4. Productivity performance is closely tied to the skill composition of the active workforce: The higher the skill level, the more positive the impact on productivity, under the condition of a relatively high specialisation on knowledge-intensive economic activities. Not all EU-economies are in the same way endowed with adequate education systems. Current GPTs will turn over time in a large number of applications that all will require the ability for skill upgrading and lifelong learning, individually as well as collectively. In regards to the next generation of GPTs. Trajtenberg (2019) makes the case that governments need to get prepared for those fundamental challenges by revamping its education approaches towards emphasising analytical, creative, interpersonal and emotional skills. This is a steep task that requires transformative policies on the side of governments and education agencies, from kindergarten to universities.

5. Intangible investment is a crucial part of the KTPR and seems to strife knowledge-intensive activities. The 'unlocking investment in intangible assets' (Thum-Thysen/Voigt/Bilbao-Osorio/Maier/Ognyanova 2017) requires policy actions like tailoring tax schemes to make the

investment in intangibles more attractive and also, see (4), via skill training that allows the proper use of intangible assets. At the same time, intangible capital is defined by its network externality effects and thus requires reforms of competition policy rules that deal with potentially turns towards monopolistic market structures.

6. Access to sufficient venture capital and thus a liquid and risk-oriented financial structure is an institutional feature of KTPR1 but is missing in other productivity regimes. Venture capital is a feature that provides in particular firms which deal with intangibles a potential source of funding. Intangible capital, in contrast to physical investment goods, has no adequate collateral and thus allows no access to regular bank credit funding. The build-up of a liquid and transparent venture capital industry is helped by government policies that regulate this industry and injects trust into venture capital activities.

7. The economic exploitation of GPTs requires a rather holistic policy approach. It seems reasonable to argue that policies that follow the logic of established innovation trajectories are not well prepared to deal with disruptive changes. And yet, not all innovation-driven changes are by definition disruptive. It is the mix of incremental and disruptive technological processes that need to be managed by productivity regimes. Productivity regimes across the EU differ in their managing capacity, and it may need additional support from the EU-level to upgrade less developed productivity regimes. Moreover, given that improvements in productivity enlarge the distribution space of economies, it needs a *new social contract* to organise a distribution pattern that turns around the current winner-takes-all structures, and that also slow down innovation activities. Such a contract can be precipitated employing competition laws, tax policies as well as by providing learning opportunities via training sabbaticals for employees within flexible labour budgets.

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ANNEXES

Annex 1

Total Factor Productivity Labour Productivity (Per Hour)

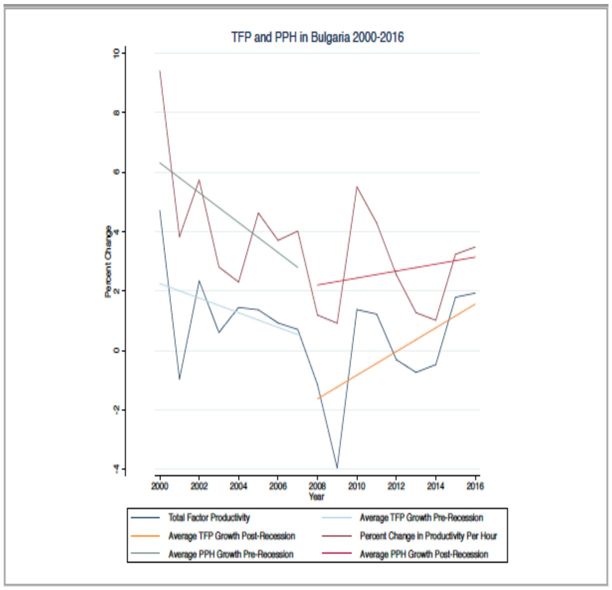
Data for per cent changes in total factor productivity and output per hour worked were taken from the Conference Board (https://www.conference-board.org/data/economydatabase/)

Labour productivity per hour was recoded to reflect per cent changes in output per hour worked relative to the previous year.

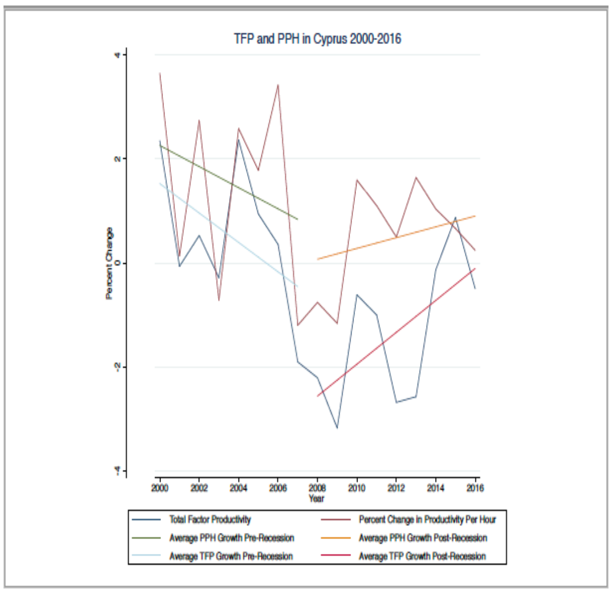
The graphs illustrating changes in total factor productivity and output per hour worked for each country were created in the same method. The charts present the trends for both these variables over time; we examine the years 2000-2016. We present linear growth predictions for both variables before and after the 2008 financial crisis. This was done to illustrate varied growth and recovery periods across the EU-28. We created linear projections of the trend lines based on the given data. We present linear predictions for the years 2000-2007, marking productivity before the financial crisis, and present predictions from subsequent analysis of productivity changes for the years 2008-2016.

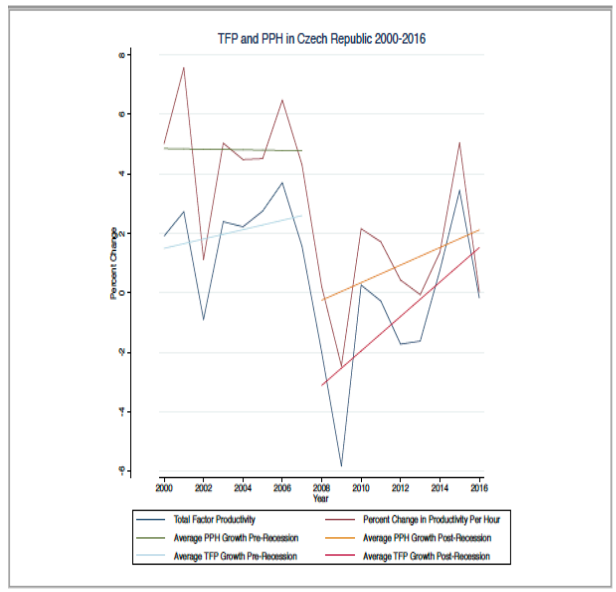
The graphs illustrating changes across the EU-15 and EU-28 use a similar methodology to country-level charts. In this case, we determined the average changes across the EU-15 (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom) and EU-28, respectively.

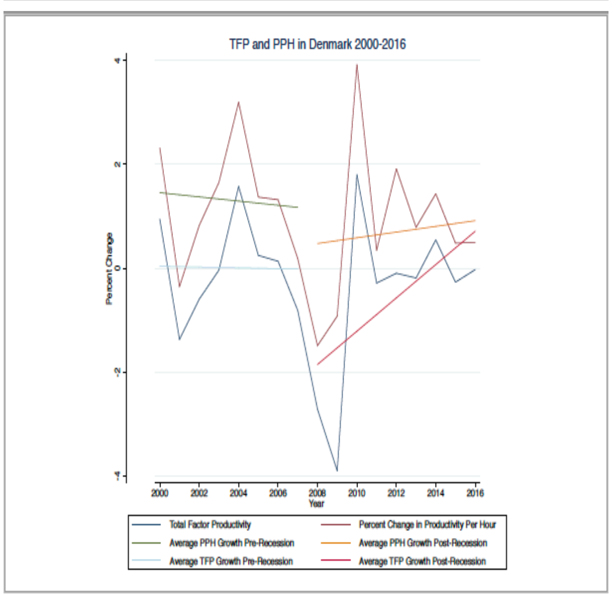
The following charts depict national performances across the EU-28.


TFP and PPH in Bulgaria 2000-2016
Percent Change
Year
Total Factor Productivity
Average TFP Growth Pre-Recession
Average TFP Growth Post-Recession
Percent Change in Productivity Per Hour
Average PPH Growth Pre-Recession
Average PPH Growth Post-Recession


TFP and PPH in Croatia 2000-2016
Percent Change
Year
Total Factor Productivity
Percent Change in Productivity Per Hour
Average PPH Growth Pre-Recession
Average PPH Growth Post-Recession
Average TFP Growth Pre-Recession
Average TFP Growth Post-Recession


TFP and PPH in Cyprus 2000-2016
Percent Change
Year
Total Factor Productivity
Percent Change in Productivity Per Hour
Average PPH Growth Pre-Recession
Average PPH Growth Post-Recession
Average TFP Growth Pre-Recession
Average TFP Growth Post-Recession

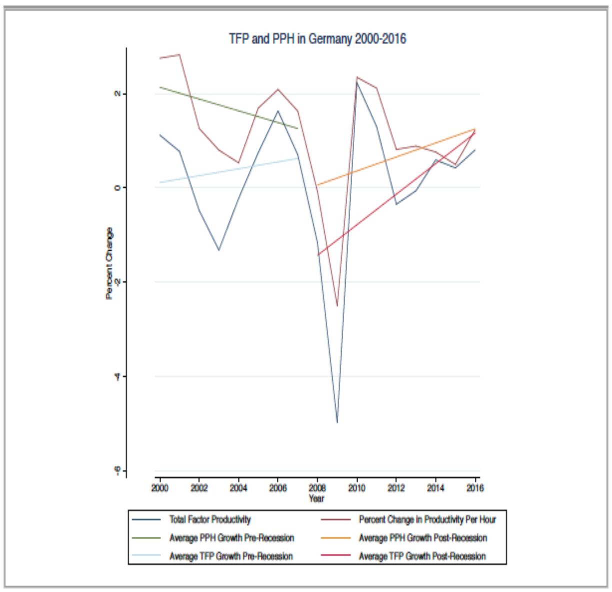

TFP and PPH in Czech Republic 2000-2016
Percent Change
Year
Total Factor Productivity
Percent Change in Productivity Per Hour
Average PPH Growth Pre-Recession
Average PPH Growth Post-Recession
Average TFP Growth Pre-Recession
Average TFP Growth Post-Recession

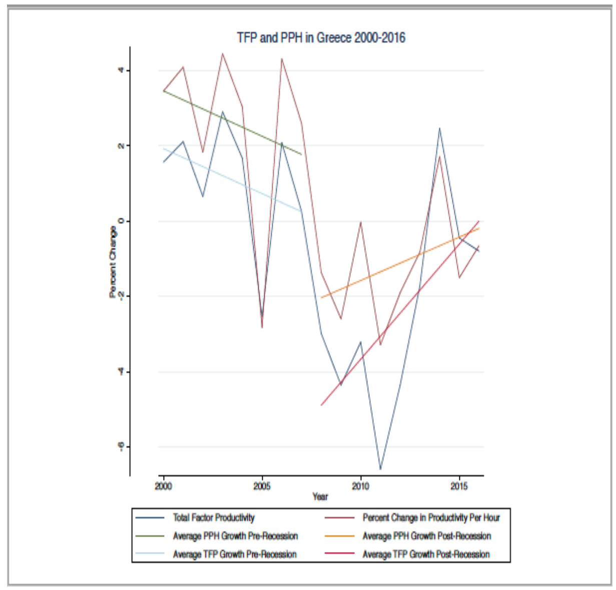

TFP and PPH in Denmark 2000-2016
Percent Change
Year
Total Factor Productivity
Percent Change in Productivity Per Hour
Average PPH Growth Pre-Recession
Average PPH Growth Post-Recession
Average TFP Growth Pre-Recession
Average TFP Growth Post-Recession


TFP and PPH in Estonia 2000-2016
Percent Change
Year
Total Factor Productivity
Percent Change in Productivity Per Hour
Average PPH Growth Pre-Recession
Average PPH Growth Post-Recession
Average TFP Growth Pre-Recession
Average TFP Growth Post-Recession


TFP and PPH in Finland 2000-2016
Percent Change
Year
Total Factor Productivity
Percent Change in Productivity Per Hour
Average PPH Growth Pre-Recession
Average PPH Growth Post-Recession
Average TFP Growth Pre-Recession
Average TFP Growth Post-Recession

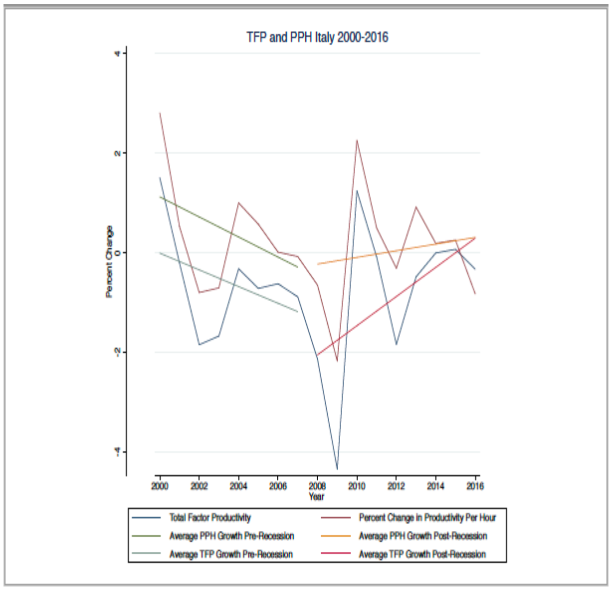

TFP and PPH in France 2000-2016
Percent Change
Year
Total Factor Productivity
Percent Change in Productivity Per Hour
Average PPH Growth Pre-Recession
Average PPH Growth Post-Recession
Average TFP Growth Pre-Recession
Average TFP Growth Post-Recession


TFP and PPH in Germany 2000-2016
Percent Change
Year
Total Factor Productivity
Percent Change in Productivity Per Hour
Average PPH Growth Pre-Recession
Average PPH Growth Post-Recession
Average TFP Growth Pre-Recession
Average TFP Growth Post-Recession


TFP and PPH in Greece 2000-2016
Percent Change
Year
Total Factor Productivity
Percent Change in Productivity Per Hour
Average PPH Growth Pre-Recession
Average PPH Growth Post-Recession
Average TFP Growth Pre-Recession
Average TFP Growth Post-Recession


TFP and PPH in Hungary 2000-2016
Year
Total Factor Productivity
Percent Change in Productivity Per Hour
Average PPH Growth Pre-Recession
Average PPH Growth Post-Recession
Average TFP Growth Pre-Recession
Average TFP Growth Post-Recession

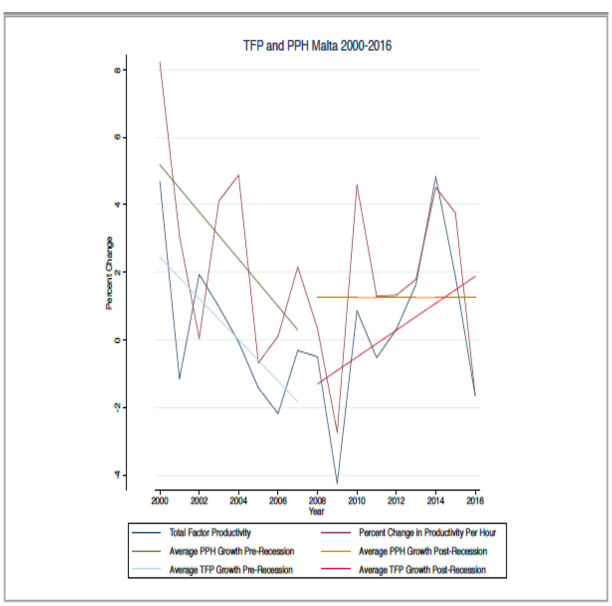

TFP and PPH in Ireland 2000-2016
Percent Change
Year
Total Factor Productivity
Percent Change in Productivity Per Hour
Average PPH Growth Pre-Recession
Average PPH Growth Post-Recession
Average TFP Growth Pre-Recession
Average TFP Growth Post-Recession


TFP and PPH Italy 2000-2016
Percent Change
Year
Total Factor Productivity
Percent Change in Productivity Per Hour
Average PPH Growth Pre-Recession
Average PPH Growth Post-Recession
Average TFP Growth Pre-Recession
Average TFP Growth Post-Recession

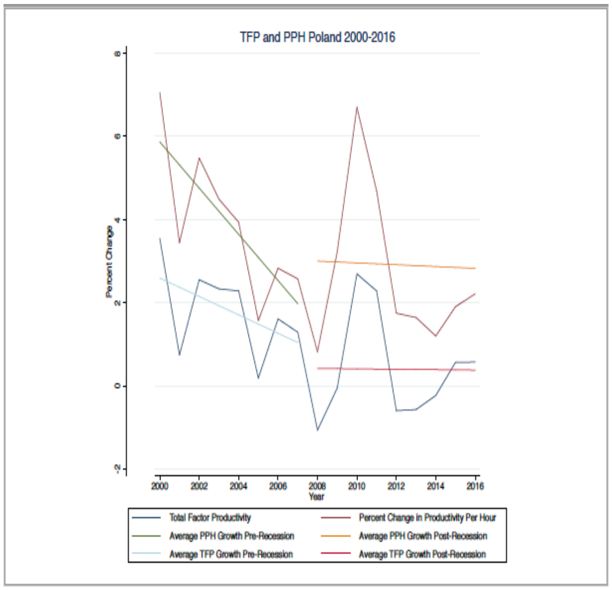

TFP and PPH in Latvia 2000-2016
Percent Change
Year
Total Factor Productivity
Percent Change in Productivity Per Hour
Average PPH Growth Pre-Recession
Average PPH Growth Post-Recession
Average TFP Growth Pre-Recession
Average TFP Growth Post-Recession

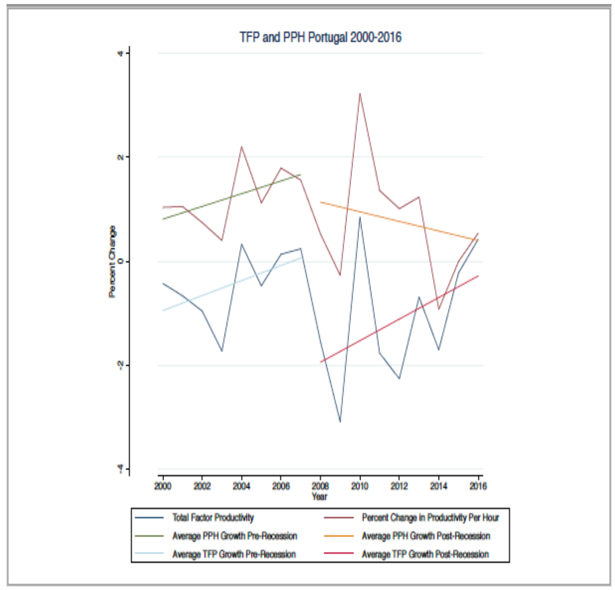

TFP and PPH Lithuania 2000-2016
Percent Change
Year
Total Factor Productivity
Percent Change in Productivity Per Hour
Average PPH Growth Pre-Recession
Average PPH Growth Post-Recession
Average TFP Growth Pre-Recession
Average TFP Growth Post-Recession


TFP and PPH Luxembourg 2000-2016
Percent Change
Year
Total Factor Productivity
Percent Change in Productivity Per Hour
Average PPH Growth Pre-Recession
Average PPH Growth Post-Recession
Average TFP Growth Pre-Recession
Average TFP Growth Post-Recession

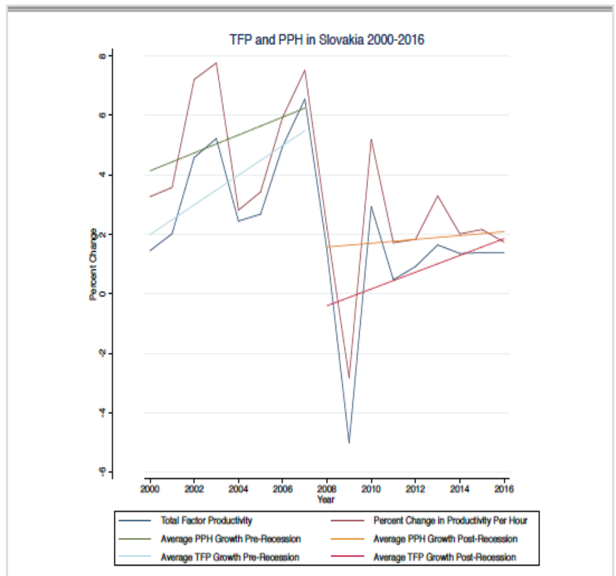

TFP and PPH Malta 2000-2016
Percent Change
Year
Total Factor Productivity
Percent Change in Productivity Per Hour
Average PPH Growth Pre-Recession
Average PPH Growth Post-Recession
Average TFP Growth Pre-Recession
Average TFP Growth Post-Recession

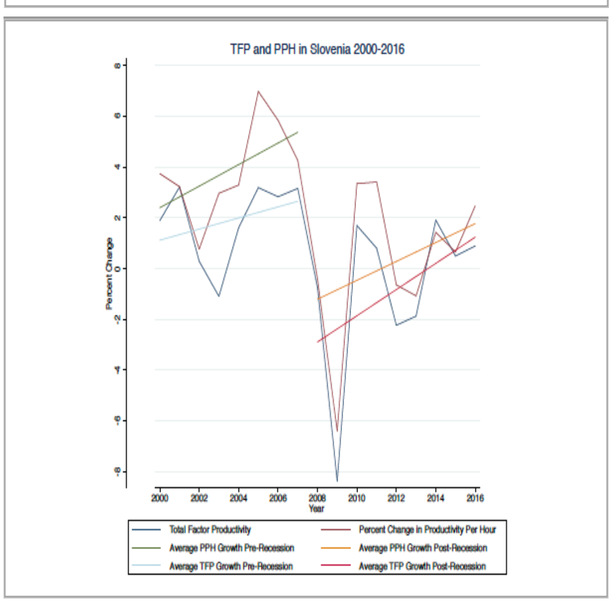

TFP and PPH Netherlands 2000-2016
Percent Change
Year
Total Factor Productivity
Percent Change in Productivity Per Hour
Average PPH Growth Pre-Recession
Average PPH Growth Post-Recession
Average TFP Growth Pre-Recession
Average TFP Growth Post-Recession

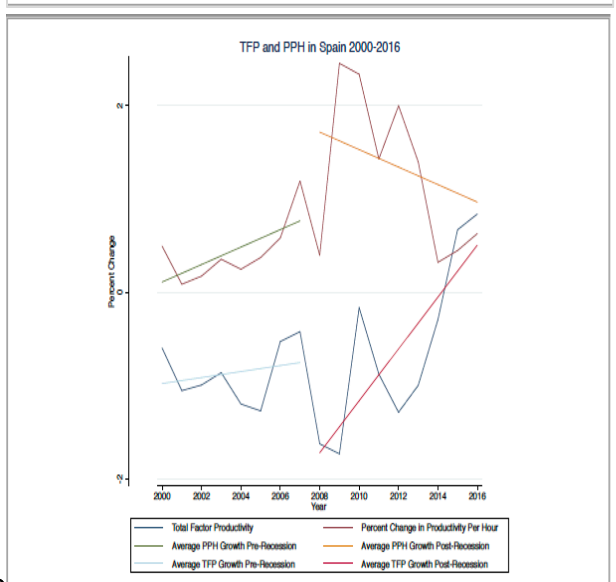

TFP and PPH Poland 2000-2016
Percent Change
Year
Total Factor Productivity
Percent Change in Productivity Per Hour
Average PPH Growth Pre-Recession
Average PPH Growth Post-Recession
Average TFP Growth Pre-Recession
Average TFP Growth Post-Recession

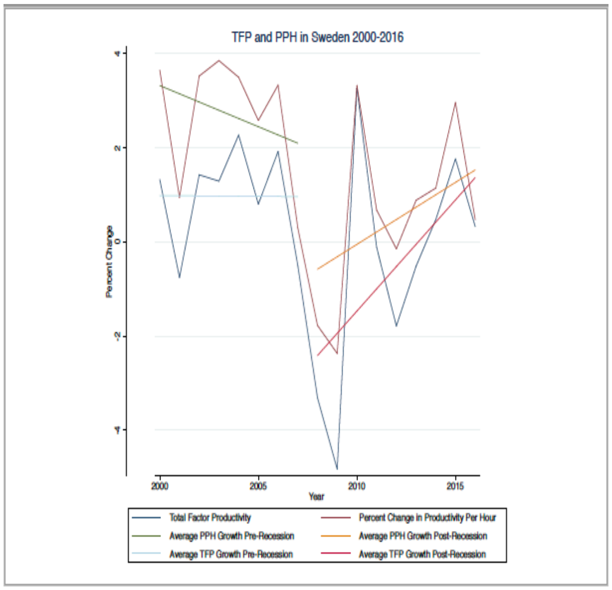

TFP and PPH Portugal 2000-2016
Percent Change
Year
Total Factor Productivity
Percent Change in Productivity Per Hour
Average PPH Growth Pre-Recession
Average PPH Growth Post-Recession
Average TFP Growth Pre-Recession
Average TFP Growth Post-Recession

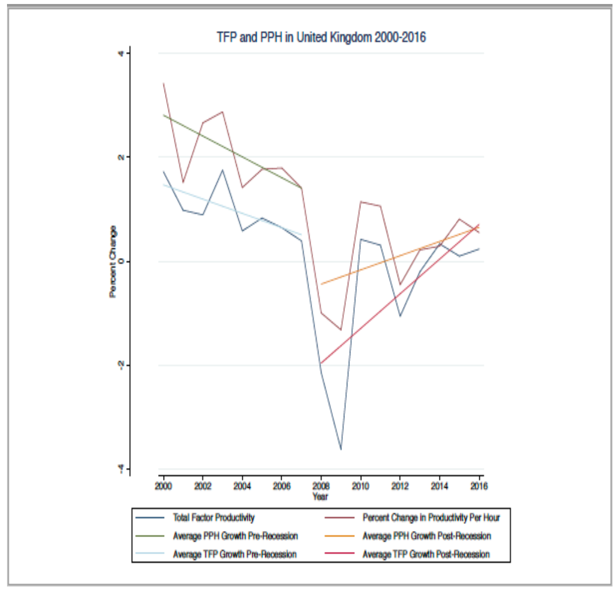

TFP and PPH Romania 2000-2016
Percent Change
Year
Total Factor Productivity
Percent Change in Productivity Per Hour
Average PPH Growth Pre-Recession
Average PPH Growth Post-Recession
Average TFP Growth Pre-Recession
Average TFP Growth Post-Recession


TFP and PPH in Slovakia 2000-2016
Percent Change
Year
Total Factor Productivity
Percent Change in Productivity Per Hour
Average PPH Growth Pre-Recession
Average PPH Growth Post-Recession
Average TFP Growth Pre-Recession
Average TFP Growth Post-Recession


TFP and PPH in Slovenia 2000-2016
Percent Change
Year
Total Factor Productivity
Percent Change in Productivity Per Hour
Average PPH Growth Pre-Recession
Average PPH Growth Post-Recession
Average TFP Growth Pre-Recession
Average TFP Growth Post-Recession


TFP and PPH in Spain 2000-2016
Percent Change
Year
Total Factor Productivity
Percent Change in Productivity Per Hour
Average PPH Growth Pre-Recession
Average PPH Growth Post-Recession
Average TFP Growth Pre-Recession
Average TFP Growth Post-Recession


TFP and PPH in Sweden 2000-2016
Percent Change
4
2
0
-2
-4
2000
2005
2010
2015
Year
Total Factor Productivity
Percent Change in Productivity Per Hour
Average PPH Growth Pre-Recession
Average PPH Growth Post-Recession
Average TFP Growth Pre-Recession
Average TFP Growth Post-Recession


TFP and PPH in United Kingdom 2000-2016
Percent Change
4
2
0
-2
-4
2000
2002
2004
2006
2008
2010
2012
2014
2016
Year
Total Factor Productivity
Percent Change in Productivity Per Hour
Average PPH Growth Pre-Recession
Average PPH Growth Post-Recession
Average TFP Growth Pre-Recession
Average TFP Growth Post-Recession

Annex 2

Variable: Knowledge-intensity of the economy (Structural change of economy)

This index comprises eight compositional structural change indicators which are organised into five dimensions:

- o The R&D dimension measures the size of business R&D (as a % of GDP) and the size of the R&D services sector in the economy (in terms of total value added; source: WIIW calculations using OECD, Eurostat, WIOD and national sources)
- o The skills dimension measures changing skills and occupation in terms of the share of persons employed in knowledge-intensive activities (both in manufacturing and service sectors considered where on average at least a third of the employees have tertiary graduates; source: Eurostat)
- o The sectoral specialisation dimension captures the relative share of knowledge-intensive activities (in terms of value added; source WIIW calculations using OECD, Eurostat, WIOD and national sources)
- o The international specialisation dimension captures the share of the knowledge economy through technological (patents) and export specialisation (revealed technological and competitive advantage) and
- o The internationalisation dimension refers to the changing international competitiveness of a country in terms of attracting and diffusing foreign direct investment (inward and outward foreign direct investments).

The eight indicators in the five pillars have been normalised between 10 and 100 using the min-max method and taking into consideration three-time points simultaneously. The five pillars have also been aggregated to a single composite indicator of structural change using the geometric average to provide an overall measure of country progress in this area.

Source: Group of Research on the impact of the Innovation Union (GRIU), RTD-JRC/IPSC Ispra): Composite Indicators measuring structural change, monitoring the progress towards a more knowledge-intensive economy in Europe, 2011.

Variable Index of the economic impact of innovation

The index is composed of five indicators of the Innovation Union Scoreboard 2013:

- PCT patents applications per billion GDP (in PPS€) - the number of PCT patent applications filed under the PCT, at international phase, designating the European Patent Office (EPO). Patent counts are based on the priority date, the inventor's country of residence and fractional counts. (Eurostat/OECD)
- Employment in knowledge-intensive activities (manufacturing and services) as % of total employment - number of employed persons in knowledge-intensive activities in business industries. Knowledge-intensive activities are defined, based on EU Labour Force Survey data, as

all NACE Rev.2 industries at a 2-digit level where at least 33% of employment has a higher education degree (ISCED5 or ISCED6) (Eurostat)

- Contribution of medium and high-tech product exports to trade balance – see below
- Sales of new to market and new to firm innovations as % of turnover - the sum of the total turnover of new or significantly improved products, either new to the firm or new to the market, for all enterprises (Eurostat - Community Innovation Survey)
- Knowledge-intensive services exports as % total service exports - exports of knowledge-intensive services are measured by the sum of credits in EBOPS (Extended Balance of Payments Services Classification) 207, 208, 211, 212, 218, 228, 229, 245, 253, 260, 263, 272, 274, 278, 279, 280 and 284 (UN/Eurostat)

Source: European Commission (2013).

Annex 3

Fuzzy set methodology

This study employed the fuzzy set methodology as outlined by Ragin (2005). This was done in order to determine whether certain configurations of social institutions led to increased national productivity across the EU-28. Fuzzy set methodology is used to determine whether combinations of variables yield a specified outcome. More importantly, it can be used to determine whether certain conditions are necessary for the implementation of an outcome variable. Using a fuzzy set methodology, we sought to examine the effects of different variables on the outcome variable; namely, increased productivity.

Fuzzy methodology uses Boolean logic, whereby all variables must be given values ranging from 0 – 1, with 0 denoting no membership, and 1 denoting full membership for the function in question. The collected data was thus modified to fit the assumptions of Boolean notation. We did so by ensuring all the data thus ranged in value from 0 to 1. Our method required that we first create categorical variables with the raw data, then configure these variables to the parameters of Boolean notation. The initial categorical variables were determined based on the literature, and on the performance of the EU-28 in general. The categorisation of variables determined the membership of each observation in the specified set. In this way, we were able to effectively calibrate the difference between observations and set thresholds for membership. Once converted into categorical variables, we were able to transform them into variables that ranged from 0 to 1 using the fuzzy software.

In order to conduct the analysis, we first created a truth table in order to determine whether there were any evident patterns in terms of variables leading to the outcome variable. Observations were either coded as 0 (false) or 1 (true). In this stage, we were able to identify certain patterns we suspected may have an effect on the outcome variable. In conducting the model analysis, we used an yvn test, which compared the y-consistency to the n-consistency and produced results regarding the significance of certain configurations. The robustness was shown through the F-distribution and p-values to determine significance of the highlighted configurations. The selected test compared the y-consistency to the n-consistency. The delineated configurations had significant increases in productivity, as evidenced by the F-distribution and low p-values of 0.000. Thus, we are able to conclude the selected configurations have a significant effect on increasing the country's productivity.

Prepared by Isabella Picui

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