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Factors affecting the productivity of European Economies

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Abstract

The 2008 financial crisis in Europe highlighted the importance of productivity growth as a vehicle to economic growth and stability. This paper estimates and compares productivity growth in European countries. It also investigates factors that directly or indirectly affect productivity growth with a view to reaching policy conclusions. The data used in the analysis are drawn from Eurostat, European Commission, OECD, and World Bank sources, and cover the period 1995-2014.

We find that productivity growth exhibits substantial variation over time. Cross-country differences in productivity growth are also observed, indicating changes in the countries' competitiveness. To explain the observed productivity differences, we apply simple regression analysis to link productivity growth with factors found in the literature to be among the main drivers of productivity growth: Research and Development (R&D) and Patents; Foreign Direct Investment (FDI); Information and Telecommunications Technology (ICT); and human capital, as measured by gross enrolment ratios in primary, secondary and tertiary education. The results obtained suggest that R&D expenditures and the number of patents have a positive and statistically significant effect on productivity growth. Thus, both process and product innovations contribute to the growth of an economy. The effect of ICT capital on productivity growth is also positive and significant, as is the effect of human capital - as measured by people entering tertiary education.

These findings conform to those prevalent in the literature, suggesting that to increase their productivity and, thereby, enhance competitiveness and economic growth, the EU countries should initiate reforms to promote R&D and encourage investment in ICT and human capital. Such reforms should be designed around measures creating new business opportunities, while tackling anti-competitive product and labour market regulations.

Keywords: Productivity, Competitiveness, Growth Accounting, EU Economy

1. Introduction

Productivity is a measure of economic efficiency. More specifically, it shows how effectively inputs (labour and capital) are converted into output, and is commonly defined as the ratio of a volume measure of output to a volume measure of inputs (Schreyer, 2001). This paper estimates and compares productivity growth in European countries. It also investigates factors that directly or indirectly affect productivity growth with a view to reaching policy conclusions.

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Productivity measures may refer to one or all factors (inputs) used in production. Labour productivity is the most commonly used measure of single factor productivity and is defined as the volume of output per unit (e.g. hours) of labour. Single factor productivity measures are easy to calculate, but may not be representative of the overall productivity of an economy or firm because they are influenced by the intensity of use of other factors. For instance, with given technology, the labour productivity is affected by the quantity and/or quality of capital.

Total Factor Productivity (TFP), also known as multi-factor productivity, avoids the ambiguity arising from the dependence of the productivity of one factor on the output contribution of other factors, as it measures the part of output growth that is not influenced by the output contribution of any factor. Thus, TFP growth reflects phenomena such as advances in general knowledge, advantages of particular organisational structures or management techniques and reallocation of resources to more productive uses. Throughout this paper, the use of the term productivity refers to TFP, unless stated otherwise.

Productivity growth is a vehicle to economic growth and stability. Low productivity not only jeopardises the economic and financial stability of individual countries, but can also hinder the functioning of an economic union, like the euro area, as a whole (ECB, 2012). In contrast, high productivity reduces average costs and product prices, thereby, reducing inflationary pressures and making the economy more competitive.

Productivity also affects employment, investment and consumption. Blinder and Baumol (1993) argue that nothing contributes more to combating poverty and to the country's ability to finance education, public health, environment and the arts than high productivity. Furthermore, increases in productivity are associated with higher technical change (OECD, 2011; Grilliches, 1988), real cost savings in production (Harberger, 1998) and higher efficiency - due to movements towards best practice, in order to achieve maximum amount of output that is physically achievable with current technology and given inputs (Diewert and Lawrence, 1999).

The 2008 financial crisis in Europe highlighted the importance of productivity growth as a vehicle to economic growth and stability. In general, it is acknowledged that in the light of increasing international competition and the looming danger of a new financial crisis, the pressure on policy makers in Europe to develop strategies fostering growth is felt most. Thus, raising productivity is crucial for Europe to prosper. The question is how can this be best achieved? To answer this question, one needs to know the factors that influence productivity and, consequently, economic growth.

There is a vast literature considering variables that might affect productivity. For instance, Syverson (2011) studies factors that can have a direct effect on productivity at the micro level; and factors that can influence productivity indirectly, by enhancing producers' operating environment. Among the factors that directly affect productivity are the managerial practice or talent, quality of human and physical capital, Information and Communications Technology (ICT) capital, Research and Development (R&D), product innovation and learning by doing. The indirect drivers of productivity include, among others, knowledge spillovers, market competition, flexible input markets, financial development, tax policy, market regulations and foreign direct investment (Isaksson, 2007; Bart van Ark, 2014; Eichler et. al., 2006; Havik et. al., 2008; Syverson, 2011).

Due to data limitations, the analysis in this paper focuses on a subset of the aforementioned determinants of productivity; namely, R&D and patents (capturing process and product innovation, respectively), ICT, human capital and foreign direct investment. The next section presents a literature review. Section 3 describes the methodology and data used in the empirical analysis. Section 4 reports the results obtained from this analysis. Section 5 concludes the paper.

2. Literature review

2.1 Innovations

There is a long literature linking innovations with productivity growth. Innovations can be product or process specific. Both can be viewed as generation of new knowledge. However, knowledge cannot be measured directly so it is proxied by several indicators such as R&D expenditure as a percentage of GDP, the proportion of the labour force with secondary and tertiary education and patent counts (Eichler et. al., 2006; Stiroh, 2001; Moreno and Surinach, 2014; Mohnen and Hall, 2013; Isaksson, 2007).

Probably the most studied indicator of process innovation is R&D expenditures. In a review of the determinants of total factors productivity growth, Isaksson (2007) indicates that while taking place mostly at the individual firm or industry level, R&D ultimately promotes overall economic growth through enhancing the productivity of the economy at large. The author also states that the effect of R&D on productivity can be domestic or generated from international spillovers. In both cases, the impact of innovation on productivity is positive and significant.

The positive and statistically significant effect of R&D on productivity growth, in general, echoes throughout the empirical literature. In addition, some studies highlight certain aspects or details of this effect.

• Guellec and van Pottelsberghe de la Potterie (2001), breaks down the effect of R&D on productivity growth into three sources: domestic business research, public research and research undertaken by other countries. The results based on data from 16 OECD countries between 1980 and 1998, show that all three sources of R&D are important for productivity growth.

• Moreno and Surinach (2014), using various indicators provided by the Community Innovation Survey, conclude that the impact of R&D on productivity varies with the type of innovation carried out. Along similar lines is the finding by Mohnen and Hall (2013) that the effect of R&D-induced innovation on productivity is difficult to separate from the effects of other types of innovation.

• Eichler et. al. (2006), using data from the IBC database for 120 European regions that cover the period 1990 to 2003 find that the effect of R&D on productivity growth appears to be smaller compared to the human capital effect. Perhaps, this result is due to (un-modelled) dynamics, in the sense that the effect of R&D on productivity growth may take longer to materialise than the effect of human capital.

R&D is an observable component of the overall innovation efforts undertaken by firms/countries and - in addition to process – it can also generate product innovations. If productivity is thought of as units of quality delivered per unit of input, it can be enhanced by product innovation (Syverson, 2011; Lentz and Mortensen, 2008; Balasubramanian and Sivadasan, 2011 using patent data). In empirical investigation, product innovations are approximated by the number of patents.

Balasubramanian and Sivadasan (2011) link detailed and broadly based US data on firms patenting with production activities. They find strong evidence that new patents are associated with increases in firm size, scope and productivity. Furman and Hayes (2004), using data on 23 OECD countries, obtain similar results for the period 1978-1999. Also, Chen and Dahlman (2004) in their study show the importance of knowledge creation (measured in terms of the number of patents) for productivity growth using 80-90 countries for the period 1960-2000. Abdih and Joutz (2005), using US time-series data, find a positive long-run relationship between productivity and the stock of knowledge proxied by patents.

2.2 Human Capital and ICT

As regards the role of human capital in productivity, the literature is mostly consisting of studies that tie education, training and overall experience to productivity growth (Syverson, 2011). Eichler et. al. (2006) find that education is positively and significantly associated with the productivity of European regions. Isaksson (2007) suggests that human capital, as measured by the level of education, has a significant effect on productivity because it determines the economy's capacity to carry out technological innovation. For developing countries, in particular, it also plays a role in adopting, adapting and implementing foreign technology.

Isaksson (2007) finds that empirical results tying human capital with productivity and economic growth vary in terms of statistical significance, magnitude, and sign of the estimated parameter. For instance, human capital in the form of employee training is shown to significantly increase the productivity of firms (Bartel, 1992 for the US; Barret and O'Connell, 1999 for Ireland). Furthermore, human capital is found to: (i) have high marginal returns in countries where it is scarce; and (ii) complement technology insofar as firms are encouraged to train their staff to acquire the skills needed for adopting new technology (Isaksson, 2007).

Information and Communication Technology (ICT) capital is another factor found in the literature to affect productivity growth, and has been the subject of intense study (Syverson, 2011). In general, the results document a spectacular productivity growth in ICT-producing industries and modest changes in ICT-using industries. In both cases, ICT capital appears to play an important role in explaining productivity growth over the last couple of decades[1]. Miller and Atkinson (2014) argue that to raise productivity Europe must move to more ubiquitous adoption of ICTs by organisations throughout the European economy. Overall, the ICT's effect on productivity varies across countries, industries and firms. Nonetheless, it is clear that investing in ICT reap significant benefits (Jorgenson et.al, 2005; 2008; Stephen et.al, 2007; van Ark et.al., 2008; Stiroh, 2001).

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[1] The European Central Bank (ECB, Occasional Paper 53, 2006) examines productivity developments in the euro area and the US over the period1980-2005. It finds that since mid-1990's labour productivity growth has fallen in the euro area but rose in the US. The decline labour productivity growth in the euro area is mainly attributed to lower ICT capital deepening and lower total factor productivity growth.

According to Miller and Atkinson (2014), encouraging ICT should be a policy priority in Europe, especially in ICT-using sectors. They argue that getting the full potential of ICT requires organisational redesign and better management techniques; and suggest that the regulation of product, labour and land markets in Europe raises the cost of ICT investments and slows down market forces that encourage firms to adopt productive practises. The EU tax policy is not helping either: the high taxes imposed on ICT products lower consumption and, thereby, business adoption of ICT.

2.3 Other drivers of productivity growth

Foreign Direct Investment (FDI) is also considered as a potential contributor to productivity growth. Isaksson (2007) argues that FDI is encouraged by governments because it is viewed as a channel for the transfer of advanced technology across countries. The FDI-growth link, however, is generally ambiguous because the transfer of advanced technology can generate both positive and negative externalities (through knowledge spillovers and barriers to competition, respectively). Some, empirical studies point to a positive relationship between FDI and growth, e.g. Keller and Yeaple (2003) in US firms for the period 1987-1996 and Griffith et.al. (2003) in UK firms for the period 1980-1992. Isaksson (2007), however, suggests that the positive effect of FDI on productivity growth is observed in industrialised but not in developing countries.

Investigated in the literature are also variables that affect productivity growth indirectly, i.e. by creating an environment in which producers are encouraged to invest in the productivity-inducing factors mentioned in the previous sub-section: R&D, human capital and ICT. Such an indirect driver of productivity growth is income and company taxes. In general, taxes on investment and highly qualified employees are found to have a negative effect on productivity growth (Eichler et. al., 2006)[2].

Product and labour market regulations are also found in the literature to function as indirect drivers of productivity growth with a mixed - positive and negative - effect (Eichler et. al., 2006; Havik et.al, 2008; Syverson, 2011).

• Labour market regulations have a positive impact on productivity growth, but their precise effect depends on the type of regulation. For instance, minimum wage regulations affect only the less qualified labour.

• Product marker regulations, generally, have a negative effect on productivity growth.

• Financial market regulations appear to hamper productivity growth when they are anti-competitive (Havik et. al. 2008).

Finally, openness to trade is reported in literature to have a positive and statistically significant effect on productivity growth and competitiveness. Thus, countries pursuing greater outward orientation experience faster economic growth (Isaksson, 2007). The gains from productivity growth are argued to come from trade-induced specialisation that exploits comparative

[2] In particular, high income taxes on highly qualified employees appear to have a strong negative impact on productivity; much stronger than the corresponding impact of company taxation.

advantages and heightened competition (Syverson, 2011; Amiti and Konings, 2007; Fernandes, 2007; Verhoogen, 2008).

2.4 The current situation in Europe

Achieving sustainable growth is especially challenging in Europe. As is firmly established in the literature, gains in productivity and competitiveness is a prerequisite for economic growth and stability. Yet, productivity and competitiveness in the EU is weakened by both internal and external factors: the internal factors include the high cost of the business environment due to an ageing and relative expensive labour force, weakened innovation and high debt levels; the external factors include the inability of the financial system to attract enough investment.

In its annual report, the European Commission (2017) claims that boosting investment is crucial for businesses to grow and innovate. Thus, removing barriers to financing investment is considered crucial for promoting productivity and competitiveness[3]. Adopted by the European Commission is also the so called 'smart specialisation strategy' (McCann and Ortega-Argiles, 2011). This strategy embraces the argument by Moreno and Surinach (2014) that from a policy perspective not only R&D efforts but also important for generating innovations are embeddedness of agents in local networks and the degree of connectedness with the outside word.

Social conditions, as well as reform implementation remain uneven across the EU. The ECB (Working Paper 1431, 2012) examines the extent to which productivity convergence is present among euro area countries. The results suggest that, while a small productivity convergence is observed at the sectoral level, the same does not appear to be takeing place at the aggregate level. The unprecedented inflow of refugees and asylum seekers has created tension among EU member states (European Commission Annual reports, 2016, 2017) and disagreement about ways to promote the social and labour market inclusion of migrants.

The EU has the potential for growth but needs to initiate reforms designed around measures promoting the creation of new business opportunities that encourage firms to invest more, thereby increasing their productivity and competitiveness. The European Investment Bank (EIB, 2011) stressed that Europe's need for productivity growth has become more pressing than other problems, such as large debt and slowdown in labour supply, faced by the EU economies. Included among the EIB suggestions are the following.

- Governments should design and implement measures to embrace domestic and international competition by dismantling anti-competitive product market regulations, especially in services.

- Increasing private and public R&D should feature high on the policy agenda and their effectiveness should be enhanced by removing overly protective patent systems.

- Education attainment and quality as well as life-long learning should be fostered, and more emphasis should be put on ICT investments.

[3] Isaksson (2007) claims that policies aimed at capital accumulation can never go wrong: the more capital workers have the more they produce. Also, more recent vintages of (and better quality) capital tend to be more productive

• Productivity enhancing resources require lower employment protection and stronger incentives for regional and sectoral mobility.

It should be emphasised here that policy measures take time to deliver the intended results in terms of productivity growth. In particular, this time often exceeds the period for which politicians are elected. Thus, in cases where the policy measures are unpopular, the future positive effects should be clearly explained and convincingly communicated to stakeholders and the population at large[4].

3. Methodology and Data

The methodology used in the empirical investigation of productivity growth here is based on the so-called Growth Accounting approach, first developed by Solow (1957). This approach is widely used by economists to measure the contribution of different factors of production (labour and capital) to economic growth, and to indirectly compute the rate of technological progress. Here, we present the basic features of this methodology. A technical description is given in the Appendix.

Growth Accounting decomposes the growth of total output into the part attributed to observed changes in factor usage and the part not attributed to these changes. The latter part is known as the Solow's residual and is taken to represent increases in productivity, as it represents increase in output with the same amounts of inputs. A common finding resulting from the application of this technique to data is that the observed economic growth in a country (or firm) cannot be fully explained by changes in the growth of the stock of capital and labour force.

Application of the Growth Accounting methodology requires data for the prices and quantities of both output and inputs. In the context of the present study, the relevant data are drawn from several publications of the Eurostat and the European Commission. The data cover the period 1995 to 2014[5].

The variables used for our analysis are:

- gross value added in current and constant (2000) prices,
- number of employees (total and self-employed),
- total hours worked (man hours for total and the self-employed),
- investment in current and constant (2000) prices, and
- compensation of employees.

[4] Additionally, regions are not self-contained. The economic development of a region might be influenced by political decisions in other regions (Eicher et.al. 2006).

[5] The countries included in our analysis are: Belgium, Bulgaria, Czech Republic Republic, Denmark, Germany, Estonia, Ireland, Greece, Spain, France, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Hungary, Malta, Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden, UK, Norway, Switzerland and Iceland.

For the construction of the output variable, we use the value added in current and constant prices. The latter is considered as the quantity of output. The price of output is obtained by dividing the output in current with the output in constant prices.

For labour, the data required for the application of the Growth Accounting methodology are, again, price and quantity. The compensation of employees is used as the value of labour, adjusted to include the self-employed. Having the value of labour and hours worked (again, adjusted to include the self-employed) the price of labour is obtained, which is then expressed in 2000 prices. By dividing the labour value by the labour price we obtain the quantity of labour in 2000 prices.

Investment, in current and constant prices, is used to construct the capital stock. The value of capital is obtained by subtracting the value of labour from the value added (all at current prices). To get the stock of capital the perpetual inventory method is applied, where the initial (1996) capital stock from the European Commission data and a constant depreciation rate of 5% are used.

As shown by Christensen et. al. (1981) and Jorgenson and Nishimizu (1978), to compare countries a suitable measure of factor inputs and output is required. To achieve this comparability one needs to employ purchasing power parity (PPP) adjustments to the output, capital and labour of the countries under consideration. Therefore, all price and quantity data in our sample are in 2000 prices and PPP adjusted.

For the variables that might influence productivity, we have drawn data from OECD, World Development Indicators (WDI) and Eurostat for the countries in our sample. We have collected data for variables, including R&D expenditure as a percentage of GDP, FDI net inflows and outflows as a percentage of GDP, Gross enrolment ratios in primary, secondary and tertiary education, the number of patent applications, and ICT expenditure as a percentage of GDP.

4. Empirical analysis

4.1 Descriptive statistics

Table 1 shows the productivity growth of each country in our sample by time intervals: 1996-1999, 2000-2004, 2005-2009 and 2010-2014; and for the whole sample period 1996-2014 (last column). The last row of the table (labelled 'mean') reports the productivity growth of a hypothetical country that consists of all the countries in our sample. As such, it indicates the time variation in the overall productivity growth in the European countries in the sample and serves as a benchmark for cross-country comparison.

The results in Table 1 suggest that productivity growth exhibits substantial variation over time. This variation appears to be relatively high among countries most hit by the 2008-2009 financial crises (Greece, Spain and Ireland) and some Eastern European countries (e.g. Romania and Bulgaria). It also seems to follow a similar pattern across countries. For instance, productivity increase is observed in all counties during 1996-1999 (except for the UK and Czech Republic), 2000-2004, and 2010-2014; and decrease in most countries during 2005-2009. This similarity across countries is reflected in the mean productivity growth of the EU countries under investigation: 1.59, 1.69, -0.35 and 2.72 percent over the period 1996-1999, 2000-2004, 2005-2009 and 2010-2014, respectively.

TABLE 1

Productivity growth by time interval

	1996-1999	2000-2004	2005-2009	2010-2014	1996-2014
Austria	1.40	1.05	0.97	2.19	1.40
Belgium	1.06	1.07	-0.36	2.76	1.14
Bulgaria	1.62	1.82	-1.26	3.88	1.51
Cyprus	1.73	1.01	0.74	2.71	1.54
Czech Republic	-0.23	2.80	1.89	2.64	1.88
Denmark	0.69	0.68	-1.11	2.90	0.79
Finland	2.09	1.33	-0.86	2.03	1.10
France	1.41	0.89	-0.33	1.54	0.85
Germany	1.09	1.25	0.37	2.79	1.39
Greece	4.25	3.00	-0.73	1.32	1.84
Hungary	0.52	2.87	-0.39	2.86	1.51
Ireland	0.11	0.54	-0.58	3.61	0.96
Italy	0.41	0.45	-0.65	3.55	0.97
Netherland	1.44	0.71	0.16	2.61	1.22
Norway	1.15	1.31	-1.97	0.21	0.12
Poland	3.00	0.55	0.89	2.82	1.75
Portugal	2.34	0.87	0.70	3.64	1.87
Romania	2.33	5.50	-7.22	3.98	1.09
Slovakia	1.42	1.63	1.81	2.72	1.92
Slovenia	2.78	5.57	0.58	3.74	3.19
Spain	4.13	0.06	-0.06	1.81	1.35
Sweden	1.78	2.09	-0.78	1.85	1.21
UK	-0.85	1.80	-0.24	2.91	1.00
Mean*	1.59	1.69	-0.35	2.72	1.41

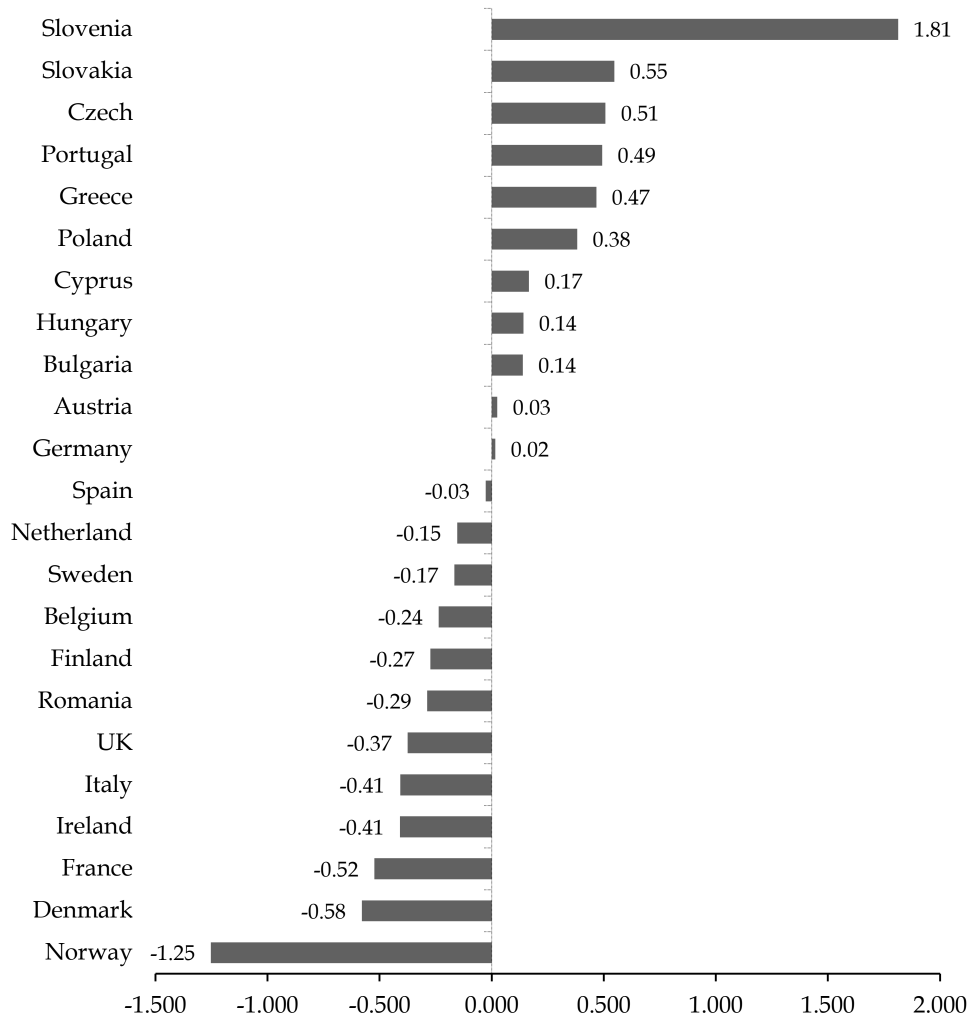
Notes: * The productivity growth of a hypothetical country that consists of all the countries in our sample.

The results reported in the last column of Table 1 suggest that over the sample period 1996-2014, on average, productivity in the EU countries in our analysis increased by 1.41 percent. Cross-country differences in productivity growth over this period are presented in Figure 1 and can be viewed as changes in the countries' competitiveness. Thus, Slovenia appears to be the best performer by far in the competitiveness contest, achieving a productivity increase of 1.81 percentage points between 1996 and 2014. Slovakia, Czech Republic, Portugal, Greece and

Poland also seem to be making gains in competitiveness over the same period. In contrast, Norway appears to be the country suffering the highest loss in competitiveness, followed by Denmark, France, Ireland, Italy and the UK.

FIGURE 1

Differences of productivity growth from the mean (1996-2014)



Of course, in interpreting the results reported in Figure 1, one should not overlook the fact that, in general, gains and losses in competitiveness among EU countries tend to be negatively correlated with the level of GDP per capita. This is because developed countries have less scope to gain from technological fusion than the developed ones; and a given change in output corresponds to higher percentage figure when measured from a low base.

4.2 Factors affecting productivity growth

The descriptive statistics in the previous subsection show a substantial variation of productivity growth across countries and over time. As argued in the literature, there can be a large number of factors behind this variation, and their importance can differ from country to country and from one period to the next. In this section, we apply simple regression analysis to the data to find the importance of some factors that are found in the literature to be among the main drivers of productivity change. The results of this investigation can give rise to conclusions that have policy implications for the EU countries in our sample.

As shown in the Appendix, the first step towards estimating productivity growth (i.e. the output growth not explained by observed changes in factor usage, as described above and in the Appendix) is the specification of a production function that links changes in output to changes in capital and labour inputs. Then, the productivity growth for each country at a given time period is constructed by subtracting from the growth of output the growth of labour and capital inputs.

Having obtained the productivity growth for all the countries in each year of the sample period (1995-2014), regression analysis is performed to estimate the parameters quantifying the effect of R&D, FDI, patents, ICT and human capital (primary, secondary and tertiary gross enrolment ratios) on productivity growth. Time and country dummies are also included in the regression equation to capture country specific and time specific effects on productivity. The results obtained from the estimation are reported in Table 2.

The figures in the first row of Table 2 suggest that R&D expenditures as share of GDP have a positive and statistically significant effect on productivity growth. Thus, increasing the R&D share in GDP results in higher productivity growth rates. As said earlier, the R&D expenditures are used to capture process innovation. To capture product innovations, the number of patents are used. As shown in the second row of Table 2, patents also have a positive and significant effect on productivity growth, but smaller compared to the R&D effect. Thus, based on our empirical results, one can conclude that both process and product innovations have a positive effect on the productivity growth of an economy.

The third row of Table 2 reports the estimated parameter capturing the effect of FDI on productivity growth. This parameter is statistically insignificant, implying that FDI does not influence productivity growth. This is not a surprising result, given that FDI captures knowledge transferred from abroad and, as said in the literature review section, its effect on productivity growth can be positive or negative

The results obtained for the effect of ICT capital on productivity growth are reported in the fourth row of Table 2. As one would expect from the empirical findings in the literature, the effect of ICT on productivity growth is positive and significant. Thus, more ICT capital (more investment in ICT and in ICT adoption) in EU countries can reap significant benefits in terms of productivity and, consequently, competitiveness and GDP growth.

The last three rows of Table 2 report effects of human capital on productivity growth approximated by gross enrolment ratios at different levels of education. The results show that the effect of gross enrolments on productivity growth is (i) negative and significant for primary, (ii) insignificant for secondary, and (iii) positive and significant, for tertiary education. Thus, as more people enter tertiary education the rate of productivity growth increases. This result is consistent with findings in the literature.

TABLE 2

Parameter estimates of factors affecting productivity growth

	Parameter	Standard error
Variables		
Research and Development (R&D)	0.0347**	0.0043
Patents	0.00005**	0.00001
Foreign direct investment (FDI)	0.0013	0.0009
Information and Telecommunications Technology (ICT)	0.0247**	0.0084
Gross enrolment ratio: primary	-0.0015***	0.0008
Gross enrolment ratio: secondary	-0.0002	0.0004
Gross enrolment ratio: tertiary	0.0065*	0.0011
Constant	0.125***	0.0743
Observations	308	
R-squared	0.377	

Note: ***, **, *: statistically significant at .01, 0.05 and 0.1 level, respectively.

5. Conclusions

The EU recognises that gains in productivity and competitiveness are prerequisites for sustainable growth. In this paper we draw data from Eurostat, the European Commission, OECD, and the World Bank to estimate productivity growth in EU countries over the period 1995-2014. The methodology used is the so-called Growth Accounting, where productivity growth is measured as the GDP growth that cannot be explained by the growth of the country's capital and labour inputs.

The estimated productivity growth rates for each country and year in our sample are summarised in a table and a diagram. We find that productivity growth exhibits substantial variation over time that seems to follow a similar pattern across countries. Cross-country differences in productivity growth over this period are also reported and can be interpreted as indicators of changes in the countries' competitiveness; albeit this interpretation merits caution, insofar as productivity growth in less developed countries is measured from a low base and has more room to gain from technological fusion.

Following the descriptive analysis of productivity growth, we apply simple regression analysis to our data in order to answer the question 'which are the factors responsible for the observed changes in productivity growth in different countries?' In these factors we include those found in the literature to be among the main drivers of productivity change: Research and Development (R&D) and Patents; Foreign Direct Investment (FDI); Information and Telecommunications Technology (ICT); and human capital, as measured by gross enrolment ratios in primary, secondary and tertiary education.

The results obtained suggest that R&D expenditures and the number of patents have a positive and statistically significant effect on productivity growth. Thus, both process and product innovations contribute to the growth of an economy. In contrast, FDI does not appear to influence productivity growth, a phenomenon often found in the literature and attributed to FDI having both positive (enhance knowledge) and negative (barriers to competition) effects. Finally, as one would expect from the empirical findings in the literature, the effect of ICT on productivity growth is positive and significant. The same is also true for human capital as measured by people entering tertiary education.

As said in the introduction, our empirical analysis focuses only on a subset of variables that can be potential contributors to productivity growth in an economy. This can give rise to what is traditionally known as omitted variable bias, i.e. the parameters of the variables included in the regression picking up the effect of excluded variables. Thus, more studies are needed to pinpoint how each variable influences productivity growth. Nonetheless, our results conform to those prevalent in the literature, suggesting that to increase their productivity and, thereby, enhance competitiveness and economic growth, the EU countries should initiate reforms to promote R&D and encourage investment in ICT and human capital. Such reforms can be designed around measures creating new business opportunities, while tackling problems such as anti-competitive product and labour market regulations.

Finally, as policy measures to raise productivity can take a long time to produce tangible results, the positive effects of reforms will have to be clearly explained and convincingly communicated to stakeholders and the population at large. This should help overcome the reluctance of politicians to undertake reforms that produce results beyond the period for which they are elected.

Appendix

In the context of Solow's (1957) growth accounting the production function is defined as

$Y = F(K, L, A)$,

where Y is the quantity of output, K is the capital input; L is the labour input and A the level of technology (TFP).

Differentiating with respect to time, dividing by Y and rearranging terms we obtain

$$\hat{y} = \frac{\partial F}{\partial K}\frac{K}{Y}\hat{k} + \frac{\partial F}{\partial L}\frac{L}{Y}\hat{l} + \frac{\partial F}{\partial A}\frac{A}{Y}\hat{A}, \quad (1)$$

where $\widehat{(.)}$ stands for the growth rate, e.g. $\hat{x} = \frac{dX}{dt}/X$.

Then, the rate of TFP change is calculated as the (Solow) residual

$$\hat{T} = \frac{\partial F}{\partial A}\frac{A}{Y}\hat{A} = \hat{y} - \frac{\partial F}{\partial K}\frac{K}{Y}\hat{k} - \frac{\partial F}{\partial L}\frac{L}{Y}\hat{l} \quad (2)$$

Equation (2), however, is impractical, because the marginal product of capital, $\frac{\partial F}{\partial K}$, and labour, $\frac{\partial F}{\partial L}$, are unobserved. To overcome this, we assume that firms maximise profits so that the social marginal products of inputs equal their observed prices.

Then, equation (2) becomes

$$\hat{y} - s_K\hat{k} - s_L\hat{l} = \hat{T} = \frac{\partial F}{\partial A}\frac{A}{Y}\hat{A}, \quad (3)$$

where s_K and $s_L$indicate the output share of capital and labour, respectively.

Moreover, it is assumed that the Solow residual depends on variables z that might influence productivity, and the exogenous technical change. Therefore, (3) can be writen as

$$\hat{T} = \alpha + \beta\,\hat{z}, \quad (4)$$

and, for estimation purposes,

$$\widehat{T_{it}} = a_0 + \sum_i D_i + \sum_t D_t + \beta\widehat{z_{it}} + u_{it}.$$

The TFP growth ($\widehat{T_{it}}$) for each country i and time period t is constructed by subtracting from the growth of output the weighted growth of labour and capital inputs.

The variables vector z_{it} includes the R&D expenditure as a percentage of GDP, patent applications, Foreign Direct Investment, Information and Communications Technology capital and primary, secondary and tertiary gross enrolment ratios. The time and country dummies D_t and D_i, respectively, are included to capture time and country specific effects. F-tests suggest that these effects are jointly significant.

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