Multilateral Comparisons of Productivity among European Countries
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Abstract
The objective of this multilateral comparison study is to analyse differences between levels of total factor productivity among European countries for the 2000–2012 period. Our results indicate that countries in Western and Central Europe are doing better with respect to the level of productivity compared with Mediterranean and Eastern European countries. Furthermore, we observe that most of the countries experienced increases in their productivity throughout the years. The productivity increases in Western and Central European countries are mainly due to increases in output, while the increases in Mediterranean and Eastern European countries are mainly due to the more efficient use of their inputs. It is important to note that our results suggest that the less productive countries are those with the highest productivity growth. That is, the Mediterranean and Eastern European countries show a faster productivity growth compared with the Western/Central European countries.

Keywords: Multilateral comparisons of productivity, Comparisons across countries and time, Rankings of countries.

1. Introduction
Productivity is considered a key source of economic growth and competitiveness in an economy and consequently affects the well-being of its people. An economy of a country is considered competitive, if it can produce inputs of the same quality as other countries, but at a lower cost.

Studies in the literature are mainly concerned with the productivity gap between Europe and the United States. These studies find that Europe is lagging in productivity and the gap seems to be widening steadily, while showing no signs of narrowing (see Acemoglu, Aghion and Zilibotti, 2006; Kretschmer, 2009; Miller and Atkinson, 2014; Timmer and van Ark, 2005; van Ark, O’Mahoney and Timmer, 2008).

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Most studies suggest that if Europe intends to catch up with the US, it needs to adopt new information and communication technologies (ICT) (Acemoglu, Aghion and Zilibotti, 2006; Colecchia and Schreyer, 2002; Kretschmer, 2009; Miller and Atkinson, 2014; Timmer and van Ark, 2005; van Ark, O’Mahoney and Timmer, 2008), a more flexible approach towards labour, product, and capital markets, and a truly single market across Europe (van Ark, O’Mahoney and Timmer, 2008).

Fagerberg and Verspagen (1996), analysing regional growth in the EU in the post-war period, found that after a slow but steady reduction of differences in gross domestic product (GDP) per capita during most of the post-war period, there are now some signs that this trend is reversing. The study further suggests that the potential for poorer regions to catch up is still there, but that other variables, such as differences in research and development (R&D) efforts, investment support from the EU, industrial structure, and differences in unemployment, have had a diverging impact. It also finds some support for the idea of a Europe at different speeds, with three different growth clubs.

In this study, we compare differences between GDP per capita and total factor productivity among European countries in the 2000–2012 period, and find that Western and Central Europe countries are doing better with respect to their level of productivity and GDP per capita when compared with Mediterranean and Eastern European countries. Furthermore, most of the countries analysed experienced increases in their productivity throughout the years in question. The productivity increases in Western and Central European countries are mainly due to increases in output, while the increases in Mediterranean and Eastern European countries are mainly due to more efficient use of inputs. The data, however, suggests that on average the countries with lower GDP per capita are doing better with respect to productivity growth.

2. Empirical implementation

The economic theory of index numbers provides useful tools that can be used to make multilateral (and bilateral) comparisons. Caves, Christensen and Diewert (1982) developed a methodology for making multilateral comparisons of outputs, inputs, and productivity.

At period $t$, the general expression for bilateral productivity comparisons of country $s$ with a hypothetical country, is:
\[ \ln \lambda_{st} = (\ln Y_{st} - \ln Y_t) - \frac{1}{2} (W_{Kst} + W_{Kt})(\ln X_{Kst} - \ln X_{Kt}) - \frac{1}{2} (W_{Lst} + W_{Lt})(\ln X_{Lst} - \ln X_{Lt}) \]

(1)

where \( Y \) is the output of the country, \( X \) is the input vector (capital \( K \), and labour \( L \)), and \( W \) are the corresponding input shares in total cost. The bar indicates the arithmetic mean (the geometric mean, as it is the average of logarithms) over the total number of countries of the variable or product under the bar and represents the hypothetical country.

Following this, the multilateral productivity comparisons (country \( s \) and \( l \)) at period \( t \) are given by:

\[ \ln \lambda_{slt} = \ln \lambda_{st} - \ln \lambda_{lt} \]

The productivity comparisons are equal to the output differences with the hypothetical country minus the weighted input differences with the hypothetical country. Therefore, productivity difference will be positive if the productivity growth of a country is higher than the productivity growth of the hypothetical country.

The productivity growth for country \( s \) at period \( t \) is defined as:

\[ \ln \delta_{st} = (\ln Y_{st} - \ln Y_{st-1}) - \frac{1}{2} (W_{Kst} + W_{Kst-1})(\ln X_{Kst} - \ln X_{Kst-1}) - \frac{1}{2} (W_{Lst} + W_{Lst-1})(\ln X_{Lst} - \ln X_{Lst-1}) \]

(2)

Using Eq. (1) for periods \( t \) and \( t - 1 \), along with a normalisation of keeping all the variables of the hypothetical country at their values in the base year, we obtain the following growth rate of productivity:

\[ \ln \delta_{st} = \ln \lambda_{st} - \ln \lambda_{st-1} \]

3. Data and empirical results

In order to utilise the multilateral comparison methodology, we focus our analysis on the years 2000–2012 and on the countries of Belgium, Germany, Estonia, Ireland, Greece, Spain, France, Italy, Cyprus, the Netherlands, Austria, Portugal, Slovenia, Slovakia, and Finland. We obtained data from several Eurostat and European Commission publications.

The variables used are GDP, total hours worked, investment, and the compensation of employees. Output quantity is defined as GDP in constant prices. The quantity of labour is defined as the value of labour divided by the price of labour. Employee compensation was used as the value of labour, adjusted to include the self-employed. Capital stock was constructed from investment data in constant prices by using the perpetual
inventory method with a 5% depreciation rate. The value of capital was obtained by subtracting the value of labour from GDP at current prices. Following Christensen, Cummings and Jorgenson (1981) and Jorgenson and Nishimizu (1978), in order to be able to compare countries we require comparable measures of factor inputs and outputs. To achieve comparability in measuring outputs and factor inputs one needs to employ purchasing power parities (PPPs) of output, capital, and labour for all the countries under consideration. Therefore, all price and quantity data are expressed in constant 2000 euros and are PPP adjusted.

FIGURE 1

GDP per capita (PPP adjusted) in 2012

Figure 1 presents the level of GDP per capita (PPP adjusted) for all countries in the last year of our sample, 2012. We can identify two groups of countries moving together. The first group, at the top of the scale, consists of Western and Central European countries (the Netherlands, Austria, Belgium, Finland, Germany, and France) along with Ireland and Italy. The second group of countries, located in the lower middle with respect to GDP per capita, mainly consists of the Mediterranean countries, apart from Italy, and the Eastern European countries.

Table 1 presents the ranking of countries with respect to productivity for 2000–2012 relative to the hypothetical country, which has been normalised to be equal to 1. Reading this table vertically shows the productivity level of each country in a given year, while reading this table horizontally shows the productivity change of a country over time.
TABLE 1

<table>
<thead>
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</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>1.214</td>
<td>1.169</td>
<td>1.200</td>
<td>1.189</td>
<td>1.208</td>
<td>1.184</td>
<td>1.196</td>
<td>1.214</td>
<td>1.196</td>
<td>1.158</td>
<td>1.175</td>
<td>1.350</td>
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<td>France</td>
<td>1.195</td>
<td>1.214</td>
<td>1.268</td>
<td>1.248</td>
<td>1.219</td>
<td>1.232</td>
<td>1.261</td>
<td>1.261</td>
<td>1.230</td>
<td>1.227</td>
<td>1.254</td>
<td>1.251</td>
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<tr>
<td>Germany</td>
<td>1.032</td>
<td>1.040</td>
<td>1.014</td>
<td>1.059</td>
<td>1.073</td>
<td>1.086</td>
<td>1.117</td>
<td>1.142</td>
<td>1.141</td>
<td>1.095</td>
<td>1.145</td>
<td>1.248</td>
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<tr>
<td>Netherlands</td>
<td>1.096</td>
<td>1.100</td>
<td>1.128</td>
<td>1.118</td>
<td>1.114</td>
<td>1.173</td>
<td>1.192</td>
<td>1.226</td>
<td>1.234</td>
<td>1.197</td>
<td>1.184</td>
<td>1.275</td>
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<tr>
<td>Austria</td>
<td>0.902</td>
<td>0.886</td>
<td>0.900</td>
<td>0.913</td>
<td>0.933</td>
<td>0.942</td>
<td>0.990</td>
<td>1.011</td>
<td>1.021</td>
<td>0.999</td>
<td>1.029</td>
<td>1.124</td>
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<tr>
<td>Finland</td>
<td>0.902</td>
<td>0.912</td>
<td>0.921</td>
<td>0.922</td>
<td>0.984</td>
<td>0.996</td>
<td>1.031</td>
<td>1.108</td>
<td>1.104</td>
<td>0.999</td>
<td>1.034</td>
<td>1.099</td>
</tr>
<tr>
<td>Italy</td>
<td>0.800</td>
<td>0.818</td>
<td>0.783</td>
<td>0.776</td>
<td>0.776</td>
<td>0.790</td>
<td>0.799</td>
<td>0.814</td>
<td>0.823</td>
<td>0.786</td>
<td>0.834</td>
<td>1.037</td>
</tr>
<tr>
<td>Ireland</td>
<td>0.737</td>
<td>0.760</td>
<td>0.789</td>
<td>0.829</td>
<td>0.878</td>
<td>0.892</td>
<td>0.892</td>
<td>0.901</td>
<td>0.876</td>
<td>0.916</td>
<td>0.933</td>
<td>0.986</td>
</tr>
<tr>
<td>Slovenia</td>
<td>0.675</td>
<td>0.675</td>
<td>0.666</td>
<td>0.679</td>
<td>0.711</td>
<td>0.766</td>
<td>0.829</td>
<td>0.881</td>
<td>0.871</td>
<td>0.766</td>
<td>0.793</td>
<td>1.009</td>
</tr>
<tr>
<td>Spain</td>
<td>0.855</td>
<td>0.862</td>
<td>0.881</td>
<td>0.882</td>
<td>0.883</td>
<td>0.886</td>
<td>0.896</td>
<td>0.910</td>
<td>0.924</td>
<td>0.928</td>
<td>0.923</td>
<td>0.981</td>
</tr>
<tr>
<td>Cyprus</td>
<td>0.579</td>
<td>0.577</td>
<td>0.597</td>
<td>0.612</td>
<td>0.643</td>
<td>0.669</td>
<td>0.693</td>
<td>0.719</td>
<td>0.770</td>
<td>0.766</td>
<td>0.754</td>
<td>0.867</td>
</tr>
<tr>
<td>Slovakia</td>
<td>0.410</td>
<td>0.435</td>
<td>0.476</td>
<td>0.499</td>
<td>0.499</td>
<td>0.530</td>
<td>0.581</td>
<td>0.667</td>
<td>0.718</td>
<td>0.700</td>
<td>0.746</td>
<td>0.820</td>
</tr>
<tr>
<td>Greece</td>
<td>0.523</td>
<td>0.555</td>
<td>0.601</td>
<td>0.630</td>
<td>0.663</td>
<td>0.644</td>
<td>0.666</td>
<td>0.674</td>
<td>0.679</td>
<td>0.677</td>
<td>0.651</td>
<td>0.832</td>
</tr>
<tr>
<td>Portugal</td>
<td>0.585</td>
<td>0.588</td>
<td>0.586</td>
<td>0.589</td>
<td>0.596</td>
<td>0.632</td>
<td>0.644</td>
<td>0.658</td>
<td>0.661</td>
<td>0.658</td>
<td>0.676</td>
<td>0.733</td>
</tr>
<tr>
<td>Estonia</td>
<td>0.510</td>
<td>0.526</td>
<td>0.559</td>
<td>0.593</td>
<td>0.620</td>
<td>0.657</td>
<td>0.683</td>
<td>0.731</td>
<td>0.714</td>
<td>0.680</td>
<td>0.708</td>
<td>0.681</td>
</tr>
</tbody>
</table>

FIGURE 2

Productivity differences in 2012
Table 1 shows that there are some variations with regard to the productivity ranking of the countries. However, four countries (Belgium, France, the Netherlands, and Germany) are always at the top of the ranking. The last five countries in the ranking are also always the same: Portugal, Cyprus, Greece, Estonia, and Slovakia.

Figure 2 shows the productivity differences of all countries to the hypothetical country for the 2012 period. In 2012, the Western and Central European countries did better when compared with the hypothetical country, while the Mediterranean and Eastern European countries did worse. We observe three convergent groups: at the top of the scale we have the Western and Central European countries of Belgium, France, Germany, the Netherlands, Austria, and Finland; in the middle and close to the hypothetical country we find Italy, Ireland, Slovenia, and Spain; and lastly on the scale (of the ranking) are Cyprus, Slovakia, Greece, Portugal, and Estonia.

The results are different between GDP per capita and productivity level. With respect to GDP per capita (labour productivity) we observe two groups of convergent countries, while when total factor productivity is considered (capital also included) there are three convergent clubs. In both cases the Western and Central European countries are performing better.

Looking at Table 1 (each row), we can also observe how the productivity of each country changes throughout the years analysed. Most of the countries experienced an increase in their productivity in all years being considered. Productivity increases or decreases (changes) are essentially associated with changes in output and total inputs, as total factor productivity is constructed as output growth minus a weighted average of the growth of inputs. The productivity increases in the Western and Central European countries are mainly due to increases in output, while the increases in the Mediterranean and Eastern European countries are mainly due to more efficient use of their inputs.

Boosting productivity is critical to each country’s future economic welfare (well-being). Raising productivity growth rates is crucial for European countries, especially Mediterranean and East European countries if they are going to catch up with Western and Central European countries. It is important to note that our results suggest that the less productive countries (relative to the hypothetical country) are the countries with the most productivity growth. Figure 3 shows the average productivity growth rate for the 2000–2012 period. From Figure 3 we can observe that productivity growth is highest in Slovenia, followed by Slovakia, Greece,
Cyprus, Ireland, and Estonia, the countries with the lowest productivity levels.

**FIGURE 3**

*Average productivity Growth % (2000-2012)*

Looking at the empirical evidence, Miller and Atkinson (2014) suggest that one way to increase productivity growth is through investment in ICT. The countries, industries, and firms that do invest in and use ICT reap significant benefits. The lack of gains that are observed in Europe and individual European countries is mainly due to a lack of investment in ICT capital.

**5. Conclusion**

In this study we make multilateral comparisons for a set of European countries for the 2000–2012 period. We find that Western and Central Europeans countries are doing better with respect to the level of productivity and GDP per capital when compared with Mediterranean and Eastern European countries. The Netherlands, Belgium, Germany, and France are the most productive countries, while the least productive countries are Portugal, Greece, Cyprus, Estonia, and Slovakia.

Most of the countries experienced increases in their productivity throughout the years. The productivity increases in the Western and Central European countries are mainly due to increases in output, while the increases in the Mediterranean and Eastern European countries are mainly due to the more efficient use of their inputs.
Countries with lower GDP per capita have grown faster in terms of productivity in the 2000-2012 period. If other countries want to catch up with the Western and Central European countries, making productivity growth the centre of their economic policy is vital. One possibility for countries to increase productivity is by encouraging the adoption and use of ICT capital, a topic which will be addressed in future research.

References


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