Journal of International Business and Economics
June 2014, Vol. 2, No. 2, pp. 33-60
ISSN: 2374-2208 (Print) 2374-2194 (Online)

Published by American Research Institute for Policy Development

A Comparative Analysis of Productivity Measurements for Five European Countries

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Abstract

The last century provided the stage for important changes in the productivity of all industries. The Industrial Revolution together with the several technological revolutions enhanced the growth rhythm of economies by introducing new and improved production means. This article analyses several indicators of productivity for five European countries, during the last decades of the 20th century and the first of the 21st century. The research is based on statistical data provided by *EU KLEMS, OECD* and *The New Maddison Project* and the reviewed period is 1970-2007. The countries that have been the focus of our research are Finland, France, Germany, Greece and Spain. The choice of countries is justified by the need to approach both countries that are well known for their productivity enhancing methods and countries that have entered the race at a later stage. Another reason motivating our selection is the fact that we wanted to include countries from Northern, Central and Southern Europe. The research is based on input-output indexes used to emphasise the productivity of labour and capital and its evolution over the time. The basic research question of the present paper is whether there are largely different methods for computing productivity or we can consider the existence of a single theoretical concept measured in many ways. Subsequently, we wanted to verify whether these measurements reflect different underlying realities or if they are just different representations of the same process.

1. Introduction

Productivity growth has been the goal of all countries over the last century. In this respect, they have developed economic policies and have founded departments and institutions to stimulate economic development.

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The main target was to „achieve the highest sustainable economic growth and employment" in order to „raise the standard of living" for their citizens as stated in Article 1 of the OECD Convention signed in Paris on the 14th of December 1960, which became one of the referential documents for the international system regarding economic development in a changing world. Economic strength and prosperity are considered essential for the attainment of the development goals, for the preservation of individual liberty and for the increasing of general well-being.

This paper captures the growth of productivity in the countries chosen for the empirical analysis as productivity is considered the driving force of economic growth. However, we consider important to mention that there are several approaches, patterns and models used to measure productivity, which makes this initiative rather difficult and susceptible to criticism. For the current research, we have chosen to measure and analyse the development of *gross output/labour input* ratio, *gross output/capital input* ratio, *value added/labour input* ratio, *value added/capital input* ratio.

Another difficulty regarding the issue of productivity is making international comparisons, due to the availability of data and the variety of concepts. As far as data is concerned, we diminished this problem by gathering all the data needed from the EU KLEMS database. Due to its wide country and industry coverage, potential applications of the database vary widely. Given the fact that this database was built by a consortium of 20 countries, this reduces also our concern about the variety of concepts, the members having agreed upon the terminology and definitions.

The present paper does not start as it is often done, with a number of hypotheses. We have a largely descriptive focus intending, as already stated, to analyse comparatively different definitions of productivity and conclude on their heterogeneous nature. The paper will start with a descriptive overview of the countries chosen for the empirical analysis, consisting of the period 1970-2007. Finland, France, Germany, Greece and Spain differ in size, historical background, GDP and, as shown in section 5, also in productivity. We have computed productivity for both labour and capital, in all five countries, using input (number of persons engaged, total hours worked by persons engaged, labour compensation and capital compensation) and output (gross output and gross value added) measurements. The model consists of a few very simple operations: graphical representation of the data, testing the stationarity of the variables and the existing correlation between the variables. These operations will be explained furthermore in section 3, dedicated to presenting the methodology.

2. Literature Review and Measurement Issues

Economic theory often associates the analysis of productivity with weighting and estimating the specific variables, with identifying the factors (causes) that have generated a certain change (increase/decrease) by using adequate methodological tools. Empirical research uses a set of methods and models specifically tailored for the objectives of the research like: (i) collecting a wide spectrum of descriptors, including indexes for measuring gross outputs, value added, labour, capital, intermediate inputs etc.; (ii) multivariate analysis of variables; (iii) choosing the variables that have a significant impact in constructing the productivity model; (iv) multicriterial evaluation of the selected indexes.

Productivity is a "ratio between the result and the means used in order to obtain that result" (Manoilescu, 1986), in general, being taken into account a multifactor productivity obtained by combining labour, capital, energy, materials, innovation, know-how, and other types of resources of a most diverse nature.

A basic definition of labour productivity would present the ratio of value produced by an individual over a given time period, but this is just a starting point, the definition needing to be customized or extended in relation to the field of interest, industry type or the particular objectives sought after by the researcher. The concept of productivity was reinvented over the time in order to better correspond current realities. However, there are some basic principles which have been preserved over the time like the fact that increasing labour productivity basically means a change in the way things are done in order to reduce the number of hours needed for producing a given amount of products.

Labour productivity measured as a function of gross output shows "the time profile of how productively labour is used to generate gross output. Labour productivity changes reflect the joint influence of changes in capital, intermediate inputs, as well as technical, organizational and efficiency change within and between firms, the influence of economies of scale, varying degrees of capacity utilization and measurement errors" (OECD, 2001).

Labour productivity is not necessarily a record of personal knowledge, skills and capabilities of individual workers, neither of the intensity of their workers, but rather the cumulative result of the adequate merger of various types of resources blended by the capacity of the management to identify the most suitable position of each worker and the potential value of each type of resource. Increasing labour productivity means perpetual improvement of the human resources and of the production processes, the focus being ensuring the sustainability of the progress in the most efficient and suitable way.

Capital productivity represents the ratio between the production results and the quantity of capital used for producing it. According to OECD, capital productivity index shows "the time profile of how productively capital is used to generate gross output or value added". As labour productivity did, capital productivity also reflects the influence of economies of scale, varying degrees of capacity utilization and measurement errors. It is important to emphasise the difference between capital productivity and the rate of return on capital, while capital productivity is a physical, partial productivity measure, the rate of return on capital is an income measure that relates capital income to the value of capital stock (OECD, 2001).

Productivity is a central element analyzed at different levels, either at individual level, business, industry or country level. This research has approached productivity from a spatial dimension perspective, considering local productivity as dependent of the national particularities with a given economic specificity.

If economic growth could be achieved only by doing more and more of the same kind of activity, we would eventually run out of raw materials and suffer from unacceptable levels of pollution and nuisance. "Human history teaches us, however, that economic growth springs from better recipes, not just from more cooking. New recipes generally produce fewer unpleasant side effects and generate more economic value per unit of raw material. Every generation has perceived the limits to growth that finite resources and undesirable side effects would pose if no new recipes or ideas were discovered. And every generation has underestimated the potential for finding new recipes and ideas. We consistently fail to grasp how many ideas remain to be discovered. The difficulty is the same one we have with compounding: possibilities do not merely add up; they multiply" (Romer, 2008).

High productivity rates reflect an efficient combination of labour and other production factors. Nowadays, there has been a shift from *being able to produce* to *being able to produce more, better and cheaper,* and in this race for efficiency, productivity stands up as the proper mark for tracing the ups and downs of the production processes, applicable in all fields, not only in industry.

The concept of productivity has surpassed its pure economic meaning having become an index of efficiency and even more. The levels of productivity can bring to our attention both strengths and weaknesses within the system, they emphasise how effective and how efficient an organisation is. They can also constitute starting points in designing the action plans for interventions meant to increase the efficiency of an organisation, or of a department within an organisation. Measuring productivity across industries can reveal which field is more productive in a country and, also, whether a country would benefit more from importing a certain product rather than from producing it.

3. Methodology

In order to assess the contribution of each type of input to the aggregate economic growth, one can apply the growth accounting framework. This methodology has been tailored by Jorgenson and Griliches (1967) and further developed by Jorgenson *et al.* (1987). It is based on „production possibility frontiers where industry gross output is a function of capital, labour, intermediate inputs and technology, which is indexed by time, *T*. Each industry, indexed by *j*, can produce a set of products and purchases a number of distinct intermediate inputs, capital and labour inputs to produce its output" (O'Mahony and Timmer, 2009). The production function is given by:

$$Y_j = f_j(K_j, L_j, X_j, T)$$

The research undertaken within this paper is two folded, first we have analyzed the productivity and economic growth of the five countries and afterwards we have built a comparison between them, based on input-output theory. Evaluating the determinants of the growth process and, also, the various variables and the effects they produce, imposes the use of specific models and methods.

We begin by presenting the definitions of the major indicators used in this paper. We have kept the original names of the indicators, as defined by the EU KLEMS Consortium.

The variables considered are:

GO – Gross output at current basic prices (in millions of euro) representing the goods or services that are produced within an industry and that become available for use outside the production units. This is a gross measure in the sense that it represents the value of sales and net additions to inventories without, however, allowing the purchases of intermediate inputs.

VA – Gross value added at current basic prices (in millions of euro) is a measure obtained by deducing the purchases of intermediate inputs from the gross output.

EMP – Number of persons engaged (thousands), as a total of employees, self-employed and family workers.

HEMP – Total hours worked by persons engaged (millions), as a total of hours worked by employees, self-employed and family workers.

LAB – Labour compensation (in millions of euro) is derived by applying the ratio of hours worked by total persons engaged to hours worked by employees to compensation; more explicit, it is an aggregate variable obtained through adjusting the employment values by age, sex, education and industry.

CAP – Capital compensation (in millions of euro) is derived as value added minus labour compensation (VA-LAB).

Based on the data, we have tried to identify the particularities and overlapping areas of the variables in order to construct a more general and suitable model meant to ease our understanding. An economic/econometric model is the simplified framework of a phenomenon, which removes unnecessary aspects in order to emphasize the content, shape and functioning of a more complex mechanism (Klein et al., 2003). In explaining the essential aspects of socio-economical transformations, economic models sometimes overcome the limits of a pure economic rationale, providing additional information about the analysed cases.

Our model analyzes labour and capital productivity at country level by applying several statistical tests. The first stage of the process consists of realising the graphical representation of the data at macroeconomic level, the existing indicators being designed to provide extensive information about the particular economic sectors and also about the economy of a country as a whole. The overall economy is therefore characterised, in terms of macroeconomic analysis, by output indicators, expressing the status of the results and by productivity indicators, expressing the efficiency of the processes and of the links between them.

After having built the charts we have tested the stationarity of each variable by using KPSS test (Kwiatowski, Phillips, Schmidt, Shin 1992). A further step in our analysis is testing whether there are any correlations between the variables analyzed and if there are, how strong are they. In this respect, we have computed the values for *Pearson's coefficient* and decide whether they highlight the presence of a strong correlation or not. We consider important to emphasize the fact that between variables there are some times more complex interactions, and each variable has the capacity to influence the other variables, that is why identifying the relevant correlations can reduce the error rate. Not knowing the direction and pattern of mechanisms among these variables can hamper the effective economic reporting and planning; therefore it is important to investigate the relationship between these variables.

The research presents also some limitations induced by the availability and comparability of data and time series for the discussed variables, and also due to the fact that the productivity of each type of input is only a partial measure being susceptible to the joint influence of a host of factors. We have tried to respond to these limitations by designing an accurate model and by performing the relevant tests for all the variables considered.

4. Descriptive Overview of the Countries

In 1970, Europe, as well as other countries across the globe, was in crisis. There are several perspectives upon the origins and causes, but one aspect can't be denied: several countries had just agreed upon a ceasefire that put an end to the Second World War.

Recovery takes time and even if there was the experience gained from the First World War, rebuilding meant learning a new lesson. The crisis lasted until the end of the 1970s and in some countries even beyond.

Periods of crisis represent opportunities for actors to stop for a moment and look back at what went wrong. The 70s crisis emphasized the implications of the irrational use of resources and, also, the fact that they are limited in size. This gave rise to several global movements that increased the awareness upon the need to approach together the concerns that go beyond the capacity of only one nation to respond to them.

The European Union was part of these initiatives; it was born shortly after the end of the Second World War and it became a promise of peace and prosperity. It began with an agreement signed by six countries and it developed progressively, today having become a structure with 27 members and three aspiring members.

During the 80s all Western economies entered a liberalization process; this meant a diminishing of the state prerogatives in the field of economics, together with a set of principles and beliefs that became known as *neoliberalism*. It was believed that by allowing everyone to pursue their own goals of prosperity, the society as a whole will reach a higher level of welfare and prosperity. As a consequence, there has been a change of paradigm, the *top-bottom* approach being replaced by the *bottom-up* approach, which reinforced the subsidiarity principle.

In accordance with these principles and a series of common goals, the European Union entered a step by step process targeted at constructing a solid and stable structure that could provide development support to all its members. The countries chosen for our analysis entered the EU at different stages; France and Germany are founders of the Union, Greece entered in 1981, Spain in 1986 and Finland in 1995.

Year 1993 meant the beginning of a new era for the European states, the single market resulting into a movement never seen before of people, goods and services, money and information. The borders of the countries became as conventional as the borders of cities within a country. This was just the initial stage of a process designed to bring together the European countries in order to reach their common goals and face their common problems and fears.

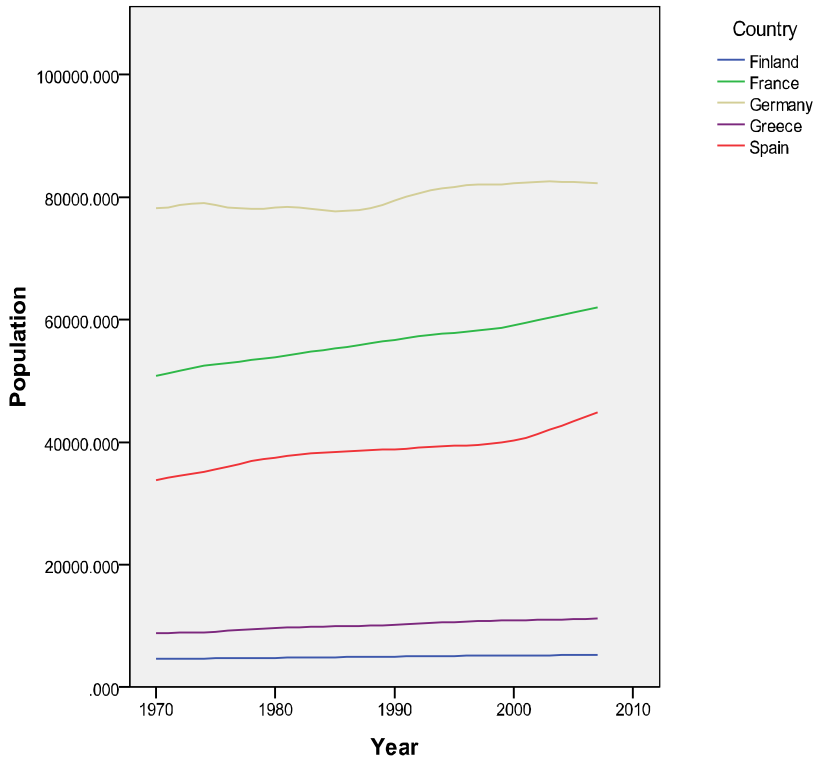
The following stage of this process was the beginning of the Economic and Monetary Union in 1999 which gave the economic and market integration a further stimulus. This process hasn't reached its full maturity but it reached an undeniable progress, the Euro becoming a symbol of the Union and the official currency in 17 countries until now, with plans to become the official currency of all member states at some point.

Finland, France, Germany, Greece and Spain are member states of the European Union and though they share a common currency and a common history - the one of Europe, they present some striking particularities. The present research has been focused on identifying the economic particularities of the five countries, more specific, on identifying the factors that have shaped them differently in the field of economic growth and productivity.

But first, we have addressed certain particularities that need to be taken into account before referring to the absolute levels of productivity. One aspect that needs to be addressed is the size of each country; the chart below presents the trends in population changes in each country over the analysed period, 1970 – 2007. The data was gathered from the OECD Database and it represents thousands of inhabitants.

As we can see, the analyzed countries are quite different, the smallest population belonging to Finland, with the highest value reached in 2007, of less than 5.3 millions. The largest population belongs to Germany that in 2007 had approximately 82.2 millions.

Chart 1: Number of Inhabitants per Country (1970-2007)



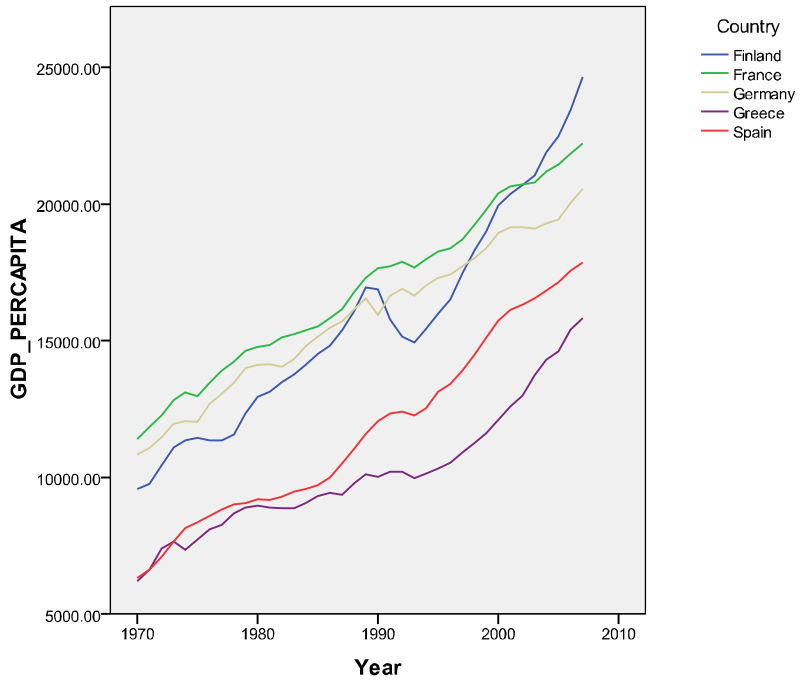
Source: OECD Database, http://stats.oecd.org/#[2]

As far as tendencies are concerned, we can note the fact that all the populations have grown over the analysed period, the smallest nominal growth belongs to Finland while the smallest percentage growth belongs to Germany which has increased its population only by 6% in 38 years. The highest nominal growth belongs to France that has enlarged its population by almost 11.2 million, while the largest percentage growth belongs to Spain which increased its population almost by one third regarding the levels from 1970.

The second differentiating aspect, that needs to be addressed, is the countries' GDP. Given the large differences between the countries' populations, we decided to consider GDP per capita, being more relevant in this particular analysis. The data was collected from the *Maddison Project Database* and the evolution over time is represented in the chart below:

[2] Accessed on the 28th of February 2013

Chart 2: GDP Per Capita per Country (1970-2007)



Source: New Maddison Project Database, http://www.ggdc.net/maddison/maddison-project/data.htm[3]

As we can see, all countries have increased their GDP per capita during the analysed period. Finland presents an interesting development, with a fall at the beginning of the 90s followed by a complete recover by 1997. This regression could be explained by the fall of the Soviet Union, one of the most important economic partners of the country during that period.

The gap between the countries with the highest, respectively the lowest GDP per capita expands by almost 60% during the analysed period. The smallest nominal increase belongs to Greece, 9616$[4], while the highest belongs to Finland, 15074$[5]. Finland shows also the highest percentage growth, 157%, while Germany shows the lowest, 89%.

[3] Accessed on the 28th of February 2013
[4] Constant 1990 USD with Geasy Khamis PPP factor
[5] Idem

The next step in our analysis is to check if there is any correlation between these variables: GDP per capita, Population and Gross Output. Correlation represents the identification of weather a variable depends on another variable through the time continuum it exists in, and also the direction of the dependence. The table below presents the correlations between the selected variables:

Table 1: Correlations between Gross Output, GDP per capita and Population

		Gross Output	GDP per capita	Population
Gross Output	Pearson Correlation	1	.662**	.807**
	P-value (2-tailed)		.000	.000
	N	190	190	190
GDP per capita	Pearson Correlation	.662**	1	.352**
	P-value (2-tailed)	.000		.000
	N	190	190	190
Population	Pearson Correlation	.807**	.352**	1
	P-value (2-tailed)	.000	.000	
	N	190	190	190

**. Correlation is significant at the 0.01 level (2-tailed).

The table presents the values for the Pearson correlations, the significance (p-value) and the number of cases considered. As we can see, there have been considered all 190 cases for each correlation; also, all the results have a high significance, which means that the probability to reject a true hypothesis of independence is 0. Another common aspect is that all relations have positive values for Pearson, which means that they vary in the same direction, if one variable increases, the other one increases as well.

Now, if we look at the values retrieved for Pearson, we can understand also the strength of the correlation. The correlation between gross output and GDP is 0.662, it belongs to the 0.3 – 0.7 interval, which means that it is a positive correlation of medium intensity. The correlation between the gross output and population is even higher, 0.807, which means that it has high intensity.

The correlation between population and GDP is weaker, 0.352; this is not unexpected, given the fact that GDP has already been calculated as a ratio between nominal GDP and population.

Further in our analysis, we sunk deeper, in our attempt to understand the way in which productivity is constructed and measured. We begun by analyzing the productivity as a whole, at country level, using graphical representations for trends, correlations and KPSS test (Kwiatowski, Phillips, Schmidt, Shin 1992) for stationarity.

5. Productivity Measurements and Comparisons

This section discusses productivity at national level, the data including values for 72 industries. The section treats separately labour productivity and capital productivity given the necessity to approach them differently in order to better understand the complexity of the phenomenon.

As presented in the previous section, the countries that we have chosen are quite different though they share a common history. If by now we have discussed just global differences, here we went into more detail in order to better understand the different pathway of each country.

Finland has a strong and knowledge intensive economy based on innovation, the largest sector of the economy is services at 65.7 percent, followed by manufacturing and refining at 31.4 percent. Finland is a modern welfare state that seeks to offer a high standard of education for its citizens that promotes equality among all people, a country with a strong and functional national security social system (CIA The World Factbook).

France has one of the most competitive economies in the world, according to the data from the World Bank being considered the fifth largest economy by nominal figures, the ninth largest economy by PPP figures, and the second largest economy of Europe, following closely Germany, its main economic partner and competitor. The French economy is diversified across all sectors. The government has partially or fully privatized many large companies, including Air France, France Telecom, Renault, and Thales.

However, the government maintains a strong presence in some sectors, particularly power, public transport, and defence industries (European Comission, 2006).

German economy is the largest national economy in Europe, the fifth largest economy in the world in PPP terms, a strong, competitive country with strong economic relations. Germany is a leading exporter of machinery, vehicles, chemicals, and household equipment and benefits from a highly skilled labour force. Like its Western European neighbours, Germany faces significant demographic challenges caused by the rapid aging of its population, associated with the diminishing of its active population. Low fertility rates and declining net immigration are increasing pressure on the country's social welfare system and necessitate structural reforms. Since the age of industrialisation and beyond, the country has been a driver, innovator and beneficiary of an ever more globalised economy. Germany is the second world largest exporter, export accounting for more than one third of the national output (European Comission, 2006).

Greece has a capitalist economy with a public sector accounting for about 40% of GDP and with per capita GDP about two-thirds that of the leading euro-zone economies. Tourism provides 15% of GDP. Immigrants make up nearly one-fifth of the work force, mainly in agricultural and unskilled jobs. Greece is a major beneficiary of EU aid, equal to about 3.3% of its annual GDP. The Greek economy grew by nearly 4% per year between 2003 and 2007, partly due to infrastructural spending related to the 2004 Athens Olympic Games, and in part to an increased availability of credit, which has sustained record levels of consumer spending. Following this period of economic growth and development, in 2009, Greece entered a period of recession caused by a combination of structural weaknesses of the Greek economy coupled with the incomplete economic, tax and banking unification of the European Monetary Union (European Comission, 2012).

The economy of Spain is considered strong despite the recent problems. According to an official report from 2008, Spain is the 13th largest economy in the world and the fifth largest in the European Union based on nominal GDP comparisons. Still, after almost 15 years of above average GDP growth, the Spanish economy began to slow in late 2007. Since the 1990s there have been several Spanish companies that became international, expanding their economic processes beyond the Spanish borders, especially in Latin America.

The economy of Spain is very comprehensive, the past recent years emphasising a development of fields like renewable energies, ITC, machinery, textile, petroleum, etc. Evan if Spain presents itself as a strong, competitive economy, the past few years have raised several challenges for the Iberian economy. Spain, similar to Greece and other countries from the Southern part of Europe, entered the European sovereign debt crisis, mostly, due to long-term loans and the crash of the construction market, which have generated high unemployment, bankruptcy of several companies and major setbacks for many more (European Comission, 2012).

All these countries have their undeniable strengths and striking particularities, but this tells us nothing about how productive their economies are, nor how the different types of productivity impact the economic growth of the country.

5.1. Labour

There are several ways to measure labour productivity; we cannot say that one way is better than the other, but in accordance with the purpose of the measurement, one can choose to calculate as productivity per hour or per employee; it can be calculated by taking into account the gross output or just the value added; it can be also calculated considering the labour compensation. For the sole descriptive purpose of this research, we have chosen to consider all these types of measurement and observe the differences between them. We have used six formulas for the labour productivity determination as presented below:

$$WLGOEMP = \frac{GO}{EMP}$$

$$WLGOHEMP = \frac{GO}{HEMP}$$

$$WLVAEMP = \frac{VA}{EMP}$$

$$WLVAHEMP = \frac{VA}{HEMP}$$

$$WLGOLAB = \frac{GO}{LAB}$$

$$WLVALAB = \frac{VA}{LAB}$$

Where:

GO – Gross Output
VA – Value Added
EMP – Number of persons engaged
HEMP – Number of hours worked by the persons engaged
LAB – Labour compensation

First, we have tested the stationarity of each variable, this stage is essential when dealing with time series. Time series are sets of observations placed and analysed along a single linear dimension, such as time (Diebold, Kilian and Nerlove, 2006). A stationary time-series will present a development over time that varies around a fixed average value, with no significant growth or decline. A trend-stationary (level 1) time-series will have a statistically significant constant growth or decline over the studied time span.

For this purpose, we have used the KPSS test, used for testing the null hypothesis that a time series is stationary around a deterministic trend.

The null hypothesis for KPSS test is "the variable is stationary" and the critical values are: 0.119 for 10%, 0.146 for 5%, 0.176 for 2.5% and 0.216 for 1%. We have tested all the above variables for each countries, the results being presented in the table below:

Table 2: Stationarity Analysis for Labour Productivity

	Finland	France	Germany	Greece	Spain
WLGOEMPTOT	Non-stationary	Level 1 0.209	Level 1 0.153	Non-stationary	Level 3 0.178
WLGOHEMPTOT	Non-stationary	Level 1 0.127	Non-stationary	Non-stationary	Level 3 0.199
WLVAEMPTOT	Non-stationary	Level 2 0.204	Level 1 0.167	Non-stationary	Level 3 0.184
WLVAHEMPTOT	Non-stationary	Level 1 0.141	Level 2 0.176	Non-stationary	Level 3 0.207
WLGOLABTOT	Level 2 0.160	Level 3 0.212	Level 2 0.207	Level 1 0.215	Level 1 0.176
WLVALABTOT	Level 1 0.193	Level 1 0.193	Level 1 0.146	Level 3 0.177	Level 0 0.201

The countries for which KPSS test retrieved a value higher than 0.216 for all lag orders are considered non-trend stationary because the null hypothesis can be dismissed with an error rate smaller than 1%. Spain appears to be the only one that registered a value smaller than the 1% threshold for the 0 lag order, for labour productivity calculated as *value added/labour compensation* ratio, this means that the null hypothesis can still be dismissed but with an error risk a bit higher than 1%.

The other countries have registered values smaller than 1% threshold at the first, second or third level, but none of the test values are high enough to confirm the null hypothesis.

In order to better understand the concept of stationarity and trend-stationarity, we have represented all these types of productivity using line charts:

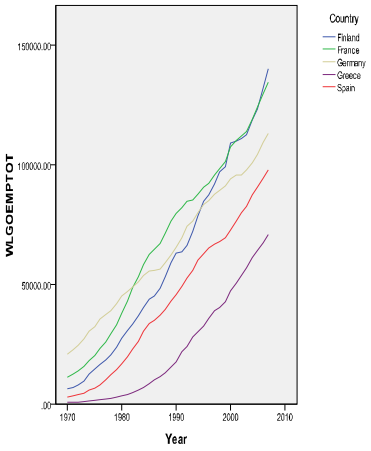


Chart 3: Labour productivity as Gross Output / Number of employees ratio (1970-2007)

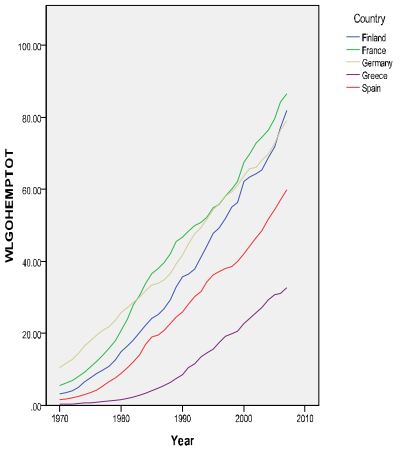


Chart 4: Labour productivity as Gross Output / Number of hours worked by employees ratio (1970-2007)

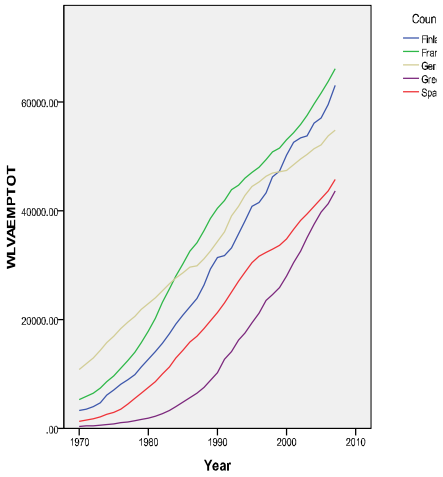


Chart 5: Labour productivity as Value added / Number of employees ratio (1970-2007)

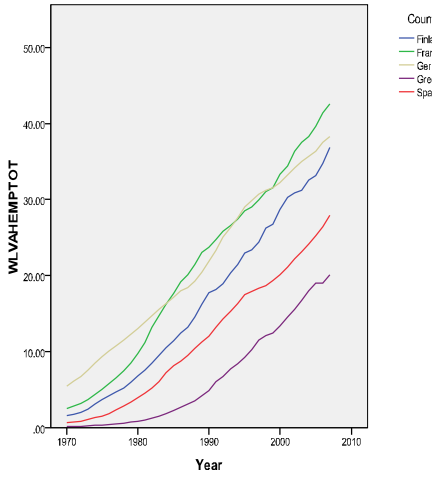


Chart 6: Labour productivity as Value added / Number of hours worked by employees ratio (1970-2007)

The four charts above represent the variation of labour productivity calculated as ratio of gross output or value added and number of employees or number of hours worked by employees. If we dismissed the KPSS tests performed before, we would be tempted to consider labour productivity as being trend-stationary due to the neat lines. Having performed the tests prevents us from reaching this erroneous conclusion. While the developments show growth over the whole time span, the trends are variable showing acceleration and deceleration processes. These will be the focus of further analysis.

The following two charts present labour productivity calculated as ratio of gross output or value added and labour compensation:

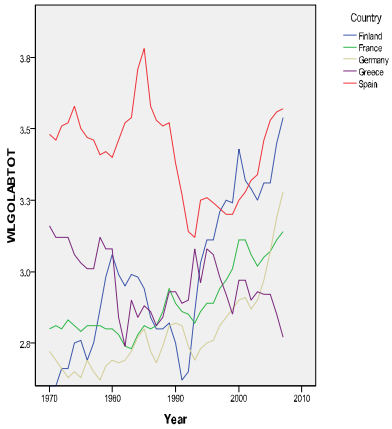


Chart 7: Labour productivity as Gross Output / Labour compensation ratio (1970-2007)

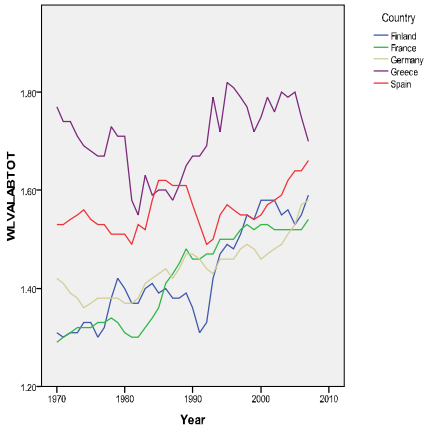


Chart 8: Labour productivity as Value added / Labour compensation ratio (1970-2007)

These two charts emphasise clearly the lack of stationarity and trend-stationarity, though the values of the KPSS tests were weaker than the ones for the other types of labour productivity. The first chart presents labour productivity as ratio of gross output and labour compensation; we need to emphasise the important shift of ranks contrasting the previous representations. In this representation, Spain holds the highest levels of productivity for almost the whole analysed period, only for a short period the lead being taken over by Greece. On the chart there appears to be some sort of reverted relationship between the productivity of Spain and the one of Greece, which determined us to test the correlation between the two, expecting a good significance and an average negative value for Pearson coefficient. After performing the test, we obtained indeed a negative value, smaller than expected, but with a rather poor significance of 0.202.

We continued the analysis trying to find an explanation for the huge similarities between the graphical representations of the first four types of labour productivity, respectively between the last two types. We tested if there is any correlation between them and we came up with the results comprised in the table below:

Table 3: Correlations between different Types of Labour Productivity Measurements

		WLGOEMPTOT	WLGOHEMPTOT	WLVAEMPTOT	WLVAHEMPTOT
WLGOEMPTOT	Pearson Correlation	1	.991**	.993**	.987**
	Sig. (2-tailed)		.000	.000	.000
	N	190	190	190	190
WLGOHEMPTOT	Pearson Correlation	.991**	1	.983**	.995**
	Sig. (2-tailed)	.000		.000	.000
	N	190	190	190	190
WLVAEMPTOT	Pearson Correlation	.993**	.983**	1	.990**
	Sig. (2-tailed)	.000	.000		.000
	N	190	190	190	190
WLVAHEMPTOT	Pearson Correlation	.987**	.995**	.990**	1
	Sig. (2-tailed)	.000	.000	.000	
	N	190	190	190	190

**. Correlation is significant at the 0.01 level (2-tailed).

As we can see, all the results are highly significant, the values of the Pearson coefficient being also very high, in fact, almost too high if we consider the fact that value 1 means determination. This brings us to our first conclusion, the fact that for comparing the levels of labour productivity for the selected countries, one can use any type of productivity from those discussed above. We can conclude that all the above indicators of labour productivity measure the same overall phenomenon and that this concept of labour productivity has a quasi-objective existence independent from measurement method. This is an important result that empowers us to deepen the analysis of labour productivity.

As far as labour productivity calculated as ratio of gross output or value added and labour compensation, the results of the correlation testing, are presented in the table below:

Table 4: Correlations between Labour Productivity as Gross Output / Labour Compensation Ratio and Value Added / Labour Compensation Ratio

		WLGOLABTOT	WLVALABTOT
WLGOLABTOT	Pearson Correlation	1	.480**
	P-value (2-tailed)		.000
	N	190	190
WLVALABTOT	Pearson Correlation	.480**	1
	P-value (2-tailed)	.000	
	N	190	190

**. Correlation is significant at the 0.01 level (2-tailed).

As we can see, the results have a very good significance, 0.000, but, contrasting our expectations, Pearson's r has a much smaller value, standing for a positive medium correlation. This leads us to consider that this second group of indicators measure, in fact, a different aspect of productivity, a conceptual clarification of this difference being important to further analysis.

5.2. Capital

For measuring capital productivity we have used the ratio between gross output and capital compensation, respectively value added and capital compensation:

$$WKGOCAP = \frac{GO}{CAP} \qquad WKVACAP = \frac{VA}{CAP}$$

As we did in the case of labour productivity, we have first tested the stationarity of each variable. The KPSS test results are presented in the table below:

Table 5: Stationarity Analysis for Capital Productivity

	Finland	France	Germany	Greece	Spain
WKGOCAPTOT	Level 0 0.113	Level 2 0.179	Level 1 0.136	Level 3 0.190	Level 0 0.155
WKVACAPTOT	Level 0 0.177	Level 1 0.201	Level 0 0.196	Level 3 0.179	Level 0 0.178

While in the case of labour productivity, stationarity and trend-stationarity did not prove to have relevant value, in the case of capital productivity, almost all countries present stationarity tendencies. In the case of Finland, there is a risk higher than 10% to deny a true stationarity hypothesis for WKGOCAPTOT at 0 lag order. For the same variable and lag order Spain presents a risk higher than 2.5%, while Germany presents a risk higher than 5% of denying a true stationarity hypothesis for 1 lag order.

As far as WKVACAPTOT is concerned, Finland and Spain continue to present small values for the autocovariance weighted by Bartlett-Kernel, the list being completed by Germany. As we can see in the table, all three countries belong to the 2.5% interval. France and Greece registered relevant values only for 1 lag order, respectively for 3 lag order.

In order to see if there is indeed a risk of denying the stationarity hypotheses, we wanted to represent graphic the evolution over time of the two capital productivity variables. The charts below include the values for the two variables:

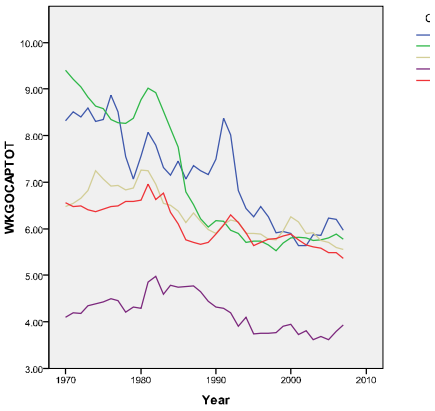


Chart 9. Capital productivity as Gross Value Output / Capital compensation ratio (1970-2007)

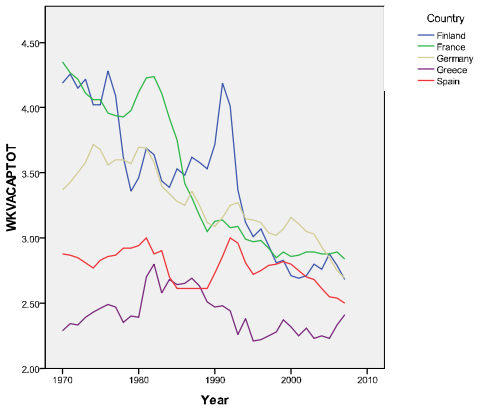


Chart 10. Capital productivity as added / Capital compensation ratio (1970-2007)

It is quite hard to declare any of the two variables as stationary or trend-stationary. But we can see clearly that the lowest levels of capital productivity belong to Greece, regardless of the method chosen for its calculation. Another interesting aspect that needs to be emphasised is the fact that the countries seem to present a decreasing tendency of capital productivity.

The two charts look very similar and that is why we chose to test whether there is any correlation between the two variables. The results of the test confirm the existance of a correlation between the two variables. We can see that the Pearson coefficient has a very high value, 0.949 and also a very good significance, 0.000 which means that between the two variables there is a strong positive correlation.

Table 6: Correlations between capital productivity as Gross Output / Capital Compensation ratio and Value added / Capital compensation ratio

		WKGOCAPTOT	WKVACAPTOT
WKGOCAPTOT	Pearson Correlation	1	.949**
	P-value (2-tailed)		.000
	N	190	190
WKVACAPTOT	Pearson Correlation	.949**	1
	P-value (2-tailed)	.000	
	N	190	190

**. Correlation is significant at the 0.01 level (2-tailed).

As before, we can consider the two methods of measurement as largely referring to the same underlying concept.

Measuring labour and capital productivity over time represents a means of recording economic growth and innovation. However, as we have shown in this section, there are several approaches to productivity measurement and their "calculation and interpretation requires careful consideration, in particular when undertaking international comparisons" (OECD, 2001).

5. Conclusions

The theoretical background of productivity presents us with a complex concept able to describe how efficient an economic process is. However, as we have shown in the section dedicated to the empirical analysis, there are several aspects that need to be considered when analysing how productive an economy is.

We began by considering productivity as a ratio between outputs and the inputs needed to produce them. We have limited our analysis to labour and capital productivity, the productivity of intermediate inputs, energy, materials and services, also, the productivity of technological progress and *know how* remaining open for future research.

As we have shown, the countries chosen for the analysis differ in size, population, GDP and economic growth levels, they face both common problems like labour force aging, susceptibility to the vulnerability of the global system, and, also, specific problems. We have chosen countries with different profiles in order to identify the common aspects and trends in relation to capital and labour productivity. According to Dogan (1990), when comparing nations, there are basically two types of comparisons that could serve as approaches: comparing similar cases or comparing different cases. For the first type of comparison, the goal of the researcher is to find the differences between the similar cases, while for the second type the goal is to identify the similarities between the different cases. For this research we have chosen the second type of comparison and the similarities we have identified are presented below.

The first aspect that needs to be emphasized is the fact that productivity is not stationary or trend-stationary. We have tested the stationarity hypothesis by using the KPSS test which retrieved values high enough for infirming the null hypothesis.

When calculated as ratio of gross output or value added and number of employees or number of hours worked by the employees, productivity presents a neat evolution over time in all analyzed countries, while when calculated as ratio of gross output or value added and labour compensation, productivity presents a chaotic development, with abrupt increases and steep decreases. The obvious lack of trend of labour productivity calculated in relation to labour compensation is an interesting result that needs to be further analyzed.

The two types of labour productivity measurements generate rather diverse results. For the first type of measurement, Germany, France and Finland hold the highest levels of productivity, the hierarchy between them changing over time, while for the second type of measurement, Spain and Greece take over the lead in labour productivity levels. This could be partly explained by the existence of relevant differences between the salary levels from the analyzed countries. While on a global scale, the investigated countries are not very different in standards of living, labour compensation differences lead to essential differences in the development of productivity. Here lies an issue that affects not only productivity itself, but the whole social-economical nexus of development and social equity.

The other problem hidden in the data, is the difference between productivity calculated as gross output ratio and productivity calculated as value added ratio. These two ways of measurement are largely overlapping as long as numbers of employees or hours worked by these are concerned, but differentiate clearly when the computation involves the compensation of labour. Further research and calculations are needed in order to identify how these differences evolve. Nevertheless, an essential hypothesis for further research emerges.

As far as capital productivity is concerned, this proved to be non-stationary as well, with an evolution similar to the one of labour productivity calculated in relation to labour compensation. This can be partly explained by the relationship between the two variables, the database developers having generated capital compensation as value added minus labour compensation. On the other hand, capital productivity seems to be decreasing over time; France registered the most important decrease, the values retrieved by the end of the analyzed period representing half of the values from the beginning of the period. Spain and Greece, again, stand out, their capital productivity levels varying less over time, notwithstanding the fact that they have the lowest levels of capital productivity during the considered period.

We have used an overall of six measurements for the productivity of labour and two measurements for the productivity of capital. A first conclusion, a similarity for these different countries, is the negative relationship that exists between these two concepts. While during the investigated period the overall productivity of labour has increased, the productivity of capital has decreased. The correlation of the relationship is poor when labour productivity is calculated considering the persons engaged or the hours worked. On the other hand, there is a medium correlation between labour productivity calculated as *gross output/labour compensation* ratio and capital productivity, while the correlation between labour productivity and capital productivity calculated considering labour compensation, respectively capital compensation is very high.

Focusing on the two separate concepts we find that not all measurements are coherent in reflecting the concepts. While the two measurements of capital productivity correlate highly and significantly, this is not the case for all measurements of labour productivity. There is a sound linkage between the measurements of labour productivity calculated on gross output and value added both for numbers of employees and numbers of hours worked by them. All four correlate highly.

While the number of employees and the hours they work are naturally highly correlated, the results also prove that the underlying concepts of gross output productivity and value added productivity overlap to a very large extent. When turning to the compensation of labour this coherent picture disappears.

To this end, the paper has revealed the complexity of the productivity concept and the need for a comprehensive approach when performing comparisons between countries. Furthermore, the paper brought to light several hypotheses that can constitute a starting point for future research. Therefore, we consider identifying the meeting point of the different types of productivity measurement, as being the goal of our further analysis.

Acknowledgement

The authors show their deepest gratitude to prof. Robert D. REISZ from West University of Timisoara for his contribution and support in the development of the methodology for productivity measurement and analysis.

This work was supported from the European Social Fund through Sectorial Operational Programme Human Resources Development 2007 – 2013, project number POSDRU/159/1.5/S/142115, project title "Performance and Excellence in Postdoctoral Research in Romanian Economics Science Domain".

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