TOTAL FACTOR PRODUCTIVITY DETERMINANTS IN DEVELOPED EUROPEAN COUNTRIES

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Abstract: *In this paper we assess the determinants of total factor productivity (TFP) growth in a group of developed European countries, during the period 2000-2013. In this regard, starting from the existing literature, we considered as determinants of TFP, knowledge and technology, infrastructure development, education quality, health level, the intensity of capital use and the manifestation of the financial crisis. Our findings show that in the case of the analysed countries, accumulation and transmission of technology and knowledge, but also the infrastructure development have the most significant positive impacts on TFP growth. On the other hand, the manifestation of the financial crises and the low intensity of capital use have strong negative effects on TFP growth, while education quality and health play a small role in influencing productivity.*
Keywords: *total factor productivity, knowledge, technology, education, infrastructure, intensity of capital use, crisis*

INTRODUCTION

On the background of the aims of each country to obtain sustainable development, economic growth and the welfare of its people, one of the most important issues to be addressed is represented by enhancing productivity, and particularly the total factor productivity, leading thus to the necessity of analysing the ways to do it. However, such a task is not an easy one, while productivity is a complex concept, and the process for achieving it depends on identifying and understanding its determinants and their both separate, but also combined, influences on it.

Moreover, while productivity is usually constantly influenced by some determinants, in time it may occur situations in which it may be influenced by new and important factors, including dangerous phenomena as economic and financial crisis.

Starting from the above considerations, we consider in this paper that the experience gained by developed countries in Europe, regarding their level of productivity, in the period starting from 2000 till 2013, can offer us the basis of an analysis on the impacts of some specific determinants on productivity.

LITERATURE REVIEW

There is a general understanding that productivity, as dimension of efficiency, can simply be expressed as an output-input ratio, comparing the results achieved by using certain inputs. Starting from this idea, it can be considered that the final total output can be viewed as a sum of the outputs determined by each of the inputs, taken separately and, in the end, productivity can be assessed by assessing the productivity of each single input. Thus, in literature, we often find productivity assessed as single-factor productivity, one of the most common measures of this kind being labour productivity, measuring how many units of output are obtained per unit of labour input.

However, it is obvious that the level of the total outputs will depend also on the way each input is used in conjunction with the other inputs, such as capital or materials, and mainly on the capability to use more intensely each of the inputs. This is why, many times, even using apparently the same basic inputs, some entities reach better results than the others, or vice versa. Because of these facts, researchers have introduced and taken into consideration the concept of total factor productivity (TFP), as a different measure of productivity, which is invariant to the dimension of the specific known inputs.

The concept of total factor productivity was developed starting from the research of the neoclassical economist Solow (1956, 1957), who emphasized that part of the productivity growth cannot be explained by the capital and labour input. This residual part, which could be explained by the different intensity of the use of the capital, was later called total factor productivity or multifactor productivity. Under such circumstances, total factor productivity can explain why higher-TFP producers will get bigger outputs with the same set of observable inputs than lower-TFP ones (Syverson, 2011), and becomes so, in the opinion of many economists a much proper measure for the differences in efficiency.

However, total factor productivity remains difficult to assess, because of its residual nature, which makes it to depend on changes in not observable inputs as the dimension of capital or of labour, and these facts have led to different interpretations regarding its determinants.

Many researchers, starting with Solow (1957) and followed by Romer (1990), Prescott (1998) and others, have attributed the central role in determining the total factor productivity to differences in technology and sustained that knowledge is probably the most important factor which improves productivity, beside the observable inputs. In this regard, trying to measure the dimension of knowledge, most of the time authors proxied it with R&D expenses and patent data or with the information and communication technologies.

Empirical studies (Guellec and van Pottelsberghe de la Potterie, 2001; Ulku 2004, Bronzini & Piselli, 2009), have demonstrated the positive impact of R&D activities on TFP in several OECD countries, while other studies (Chen and Dahlman, 2004; Abdih and Joutz, 2005), used data on patents to prove the importance of knowledge in enhancing TFP. These authors sustain and demonstrate that technological knowledge, produced through R&D activity and diffused in economy has a direct effect on TFP, generating productivity growth. Moreover, Jorgenson & Stiroh (2000) proved also, for U.S., that technology, proxied by the production and the use of information and communication technologies, promotes growth.

At the same time, transfer of technology is usually considered important for enhancing productivity and some studies (Keller and Yeaple, 2003; Griffith et al., 2003) show that foreign direct investments (FDI) improves that transfer and also TFP. On the other hand, other authors found either a negative impact of FDI (Aitken and Harrison, 1999) or no effect of them (Hanson, 2001), leading to the conclusion that FDI may have ambiguous effects on TFP.

Human capital quality is accepted by most of the authors to be another important determinant of TFP. In this regard they consider that the level of schooling and the health of the labour force are essential variables that influence the productivity.

Most of the empirical studies (Romer, 1990, Barrett & O'Connell, 1999; Fleisher et al., 2010), show that the quality level of education and training is determining strongly the level of productivity.

At the same time, we found several papers (Bloom & Sachs, 1998; Cole & Neumayer, 2007) that confirm empirically that poor health impacts negatively on TFP, while illness reduce the workers capacity of production.

Another determinant of total factor productivity appears to be the physical infrastructure, as it can offer leverage for all the economic activities. It is usually proxied in studies, by electricity or energy, respectively by the total length of the disposable roads or railways. Regarding infrastructure one can find many studies (Aschauer, 1989; Bronzini & Piselli, 2009; Fleisher et al., 2010) that sustain empirically that infrastructure contributes to productivity improvement.

Literature also includes other studies that take into consideration factors as trade, institutions, competition, financial development or geography as potential drivers of total factor productivity, but only in some specific cases showed that they induced notable effects on productivity. On the other hand, most of the studies have agreed that the intensity of the use of the capital plays a major role in enhancing productivity, however not assessing it in a specific manner and concentrating on the other variables. Moreover, the impact of some dangerous phenomena, such as crises, on total factor productivity, was seldom approached.

DATA AND METHODOLOGY

Based on the previous considerations, and starting from the point of view that total factor productivity is, at the same time, both a most important measure of the efficiency of an economy, but also a complex indicator, determined by less observable factors, we aim, further, to analyse the way some of the major determinants revealed in literature may influence it.

Our analysis will cover the period 2000-2013, partially marked by a severe financial and economic crisis, and will be focused on a group of 13 developed countries from Europe, also OECD members, including Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Netherlands, Portugal, Spain Sweden and United Kingdom. In this regard, we will use yearly data from OECD database and from World Development Indicators database of World Bank. We will use as dependent variable the annual total factor productivity growth (TFPG), from OECD database, and we will apply econometric techniques, including Pearson correlation and Panel Least Squares method, considering the independent variables presented in Table 1.

Table 1 Determinants of total factor productivity growth

Independent variable/ Determinant	Indicator name	Indicator symbol	Expected influence (+/-)	Source
Low intensity of capital use	Gross fixed capital formation to GDP ratio	FCF_G	-	World Bank database
Education quality	Labour force with tertiary education growth	ΔLF_T	+	World Bank database
Low Health	Variation of Log of Length of hospital stay (days)	ΔLog(HD)	-	World Bank database
ICT Technology	Variation of broadband fixed subscriptions per 100 persons	ΔBS	+	World Bank database
Technology transmision	Variation of FDI inward flows as percentage of GDP	ΔFDII_G	+/-	OECD database
Knowledge	Lagged annual R&D expenses to GDP ratio	R&D(-1)	+	World Bank database
Energy	Variation of Log of annual primary energy supply	ΔLog(E)	+	OECD database
Infrastructure	Variation of Log of Length of roads	ΔLog(R)	+	OECD database
crisis	crisis	crisis	-	dummy

As also the table shows, we have introduced as measure for the intensity of the use of fixed capital, the proportion gross fixed capital formation to GDP, while an decrease of this indicator shows that with the same capital it can be achieved a higher GDP or, reversely, the increase of this indicator shows a decrease in the intensity of the use of fixed capital. We also use indicators to catch the impact of the increase in the quality of education of labour force, considering the percentage of the high qualified workers in total workers and, on the other hand the level of health, estimated to increase as the length of hospital stay decreases.

Knowledge and technology are assessed through the lagged R&D expenses as percentage of GDP, considering there is necessary a certain period to implement the new knowledge and technology. We also assess the impact of ICT technology through the variation of broadband fixed subscriptions and the transmission of technology through the changes in FDI inward flows.

Infrastructure is assessed by the length of the roads and also by the primary energy supply. We notice also that the later indicator might be also considered to catch the intensification of capital use.

As table 1 confirms, we have considered necessary to take into account in estimating the effects on total factor productivity also of the financial crisis manifestation, which determined, in the analysed period, significant changes in economy and society. Thus, we introduced also the dummy variable "crisis", marking the crisis period.

RESULTS AND COMMENTS

In order to identify the existence of the linkages between the total factor productivity growth and the considered determinants we used first Pearson correlations to process the panel of data for the developed European countries which are studied and we obtained the results presented in Table 2.

Table 2 The correlation matrix of the variables

Covariance Analysis: Ordinary								
Sample: 2000 2013								
Included observations: 169 after adjustments								
Balanced simple								
Correlation								
Probability	TFPG	FCF_G	ΔLF_T	ΔBS	ΔLog(E)	ΔFDII_G	ΔLog(HD)	R&D(-1)
TFPG	1.0000							

FCF_G	-0.0561	1.0000						
	0.0000	-----						
ΔLF_T	0.0378	-0.1040	1.0000					
	0.6260	0.1784	-----					
ΔBS	0.2349***	0.0861	0.0090	1.0000				
	0.0021	0.2655	0.9078	-----				
ΔLog(E)	0.3348***	0.1970**	-0.0786**	0.0671	1.0000			
	0.0000	0.0103	0.3100	0.3861	-----			
ΔFDII_G	0.1428*	-0.0154	-0.1298*	0.0814	-0.0185	1.0000		
	0.0640	0.8423	0.0925	0.2930	0.8114	-----		
ΔLog(HD)	-0.0326	-0.0119	0.0543	-01466	-0.0006	-0.0382	1.0000	
	0.6736	0.8781	0.4832	0.0572	0.9937	0.6222	-----	
R&D(-1)	0.1310*	-0.1261	-0.1638**	0.0091	0.0274	-0.0330	-0.0010	1.0000
	0.0895	0.1024	0.0333	0.9069	0.7235	0.6706	0.8977	-----
ΔLog(R)	0.1320*	0.2589***	0.0091	0.0766	0.1991***	-0.1923**	-0.1554**	0.1072
	0.0872	0.0007	0.9063	0.3224	0.0095	0.0122	0.0437	0.1654
crisis	-0.3238***	-0.2031***	0.0865	-0.4146***	-0.2819***	-0.1226	-0.1308*	0.1105
	0.0000	0.0081	0.2635	0.0000	0.0002	0.1122	0.0901	0.1525

***, **,* - denotes significance at 1%, 5%, respectively 10% level

According to Table 2, it appears that there are statistically very significant positive correlations, below the 1% threshold, between total factor productivity growth and the advanced use of technology, proxied by the variation of broadband subscriptions (coef.=0.2349, prob. = 0.0021) and increased supply of energy (coef.=0.3348, prob. = 0.0000).

Other statistically significant positive correlations, below the 10% threshold are found between TFP growth and the increase of foreign direct investments inward flows (coef. = 0.1428, prob. = 0.0640), the infrastructure development, proxied by the length of the national roads (coef. = 0.1320, prob. = 0.0872) and with the accumulation of knowledge, proxied by the lagged percentage of R&D expenses to GDP (coef. = 0.1310, prob. = 0.0895).

At the same time, data in Table 2 show the existence of a positive correlation between total factor productivity growth and the quality level of the education of workers, but this correlation is not significant (coef.=0.0378, prob. = 0.6260), in the analysed period.

On the other hand, data in Table 2, confirm also expected statistically significant negative correlations, below the 1% threshold, between total factor productivity growth and the manifestation of the financial and economic crisis (coef.= -0.3238, prob. = 0.0000), but also with the low intensity of capital use (coef.= -0.0561, prob. = 0.0000).

Moreover, even if not statistically significant, the negative correlation between TFP growth and the low health condition of the people (coef. = -0.0326, prob. =0.6736), is also confirmed.

Based the above considerations and results obtained regarding the correlations between total factor productivity growth and the considered determinants, we take into consideration the possibility of deepening our analysis by searching the fixed effects of the later on it. We chose to analyse the fixed effects on the total factor productivity growth while these action of the determinants on the dependent variable is considered independent on other major variables such as the levels of capital and labour used. In this regard, we use the Panel Least Squares method to build and test the following econometric regression model (1) for revealing the impacts of the considered determinants:

$$y_{jt} = c + \sum_i \beta_i \bullet X_{ijt} + \varepsilon \qquad (1)$$

, in which:

- j stands for the specific country
- t stands for the year
- y represents total factor productivity growth
- Xi represent the impact factors considered
- β_i are the coefficients of the impact factors and
- ε stands for the error term.

We tested the proposed model on the data of the 13 developed European countries for determining the fixed effects of the impact factors on total factor productivity growth, for the period 2000- 2013, leading us to the results presented in Table 3:

Table 3 Results of applying the proposed model

Dependent Variable: TFPG				
Method: Panel Least Squares				
Sample: 2000 2013				
Periods included: 13				
Cross-sections included: 13				
Total panel (balanced) observations: 169				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
FCF_G	-0.133419	0.060188	-2.216705	0.0282
ΔLF_T	0.071231	0.128697	0.553477	0.5808
ΔBS	0.094098	0.045577	2.064607	0.0407
ΔLog(E)	12.07286	2.967283	4.068658	0.0001
ΔFDII_G	0.021670	0.011047	1.961668	0.0517
ΔLog(HD)	1.142691	4.669994	0.244688	0.8070
R&D(-1)	1.188359	0.646600	1.837859	0.0681
ΔLog(R)	0.894372	0.495327	1.805619	0.0730
crisis	-0.819070	0.261804	-3.128568	0.0021
C	0.876551	2.247189	0.390066	0.6971
	Effects Specification			
Cross-section fixed (dummy variables)				
R-squared	0.338393	Mean dependent var		0.331059
Adjusted R-squared	0.243878	S.D. dependent var		1.513752
F-statistic	3.580300	Durbin-Watson stat		2.054304
Prob(F-statistic)	0.000003			

Results from Table 3 are quite similar with the identified correlations, and the greatest majority of them are in line with the previous findings in literature.

In terms of coefficients and significance, we find that growth in primary energy supply (coef. = 12.0728, prob. = 0.0001) and the R&D activities (coef. = 1.1884, prob. = 0.0681) have strong impacts of enhancing the total factor productivity growth, in line with the conclusions of previous studies.

At the same time, we find that the development of infrastructure, namely, in our case, of the length of roads (coef. = 0.8944, prob. = 0.0730), but also the increase of the ICT technology use (coef. = 0.0941, prob. = 0.0407) had positive and statistically significant contributions to the total factor productivity growth in the analysed countries, between 2000 and 2013. Moreover, the transmission of technology, facilitated by the advance in foreign direct investments (coef. = 0.0217, prob. = 0.0517) had a positive effect on TFP growth. Thus, all these results are coming to confirm the expected influences on the dependent variable, as well as the conclusions from the former studies in literature.

However, we found also a positive impact of the quality level of education of the labour force but not a statistically significant one, both in terms of the coefficient and of the probability (coef. = 0.0713, prob. = 0.5808), which, even if shows the positive influence of this determinant on TFP growth, is does not confirm the relevance of this factor, which was sustained in other papers.

We also notice that, unexpectedly, low level of health has a statistically insignificant (prob. = 0.8070) role on TFP growth, but its positive coefficient, when following the fixed effects, contradicts the expectations on its influence on the dependent variable.

On the other hand, we notice the significant negative impact of low intensity capital use, proxied by the proportion of fixed capital formation to GDP (coef. = 0.1334, prob. = 0.0282) on TFP growth, which corroborated with the result regarding the energy supply, confirms the results of the theoretical and empirical previous studies, regarding the essential role of the intensive use of capital in enhancing the productivity.

In the end, data in Table 3 show, as expected, also a very significant negative impact of the manifestation of the financial and economic crisis (coef. = -0.8191, prob. = 0.0021) on the total factor productivity growth. Regarding this result, however, we consider that the presence of the crisis affects indirectly the productivity, while its impact can be sensed more clearly on some of the other determinants such as capital use, infrastructure development, R&D expenses or energy.

CONCLUSIONS

While economic growth and development of any country is not possible without ensuring the conditions for reaching a high productivity, it is obviously necessary to find how productivity can be enhanced. At the same time, economists agree that beside the major observable inputs, such as capital and labour, that drive the productivity, its level is also influenced by some other factors, less observable that determine the total factor productivity (TFP), viewed as a residual productivity or an incentive to pure productivity. This is why, under the conditions of limited capital and labour, the total factor productivity becomes very important in enhancing the efficiency of economic activities, leading to the need for analysing its determinants.

Our study aimed to analyse which are the main drivers of total factor productivity, using econometric methods, such as Pearson correlations and Panel Least Square method, in order to find how TFP growth was influenced in the developed European countries and is conducted on a group of 13 such countries, between 2000 and 2013.

In our analysis we found, first, that TFP growth is significantly positively correlated with technology, both with the implementation of ICT technologies, but also with the percentage of R&D expenses in GDP. Moreover, technology transmission, through foreign direct investment inward flows is positively correlated with TFP growth. The development of the infrastructure, as well as the level of the primary energy supply are also positively correlated with TFP growth, while the low intensity of capital use and also the low level of peoples' health and the manifestation of the financial crisis are negatively correlated to TFP growth. Thus, all these results confirm the theory in this area. However, even we found a positive correlation of the education quality of labour force with TFP growth; data did not prove its significance.

Deepening our analysis by building a testing a regression model in order to evaluate the fixed effects transmitted on TFP growth by the considered determinants we found, for the analysed countries significant positive impacts induced by the use of high level knowledge and technology, FDI inward flows, the development of infrastructure and negative effects of the low intensity of capital use and of the manifestation of financial crisis, which, in our opinion impacts indirectly on TFP.

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