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TFP DETERMINANTS IN EUROPEAN UNION MEMBER STATES IN 2000–2014 IN THE LIGHT OF PANEL STUDY RESULTS

The aim of the article is to examine, whether and to what extent disparities in TFP levels in the group of 27 member states of the European Union in the period 2000–2014 are the result of difference in factors determining them. In the light of the conducted panel data analysis, the countries of the EU-15 group with higher levels of TFP differ from the „new" EU countries in terms of determinants of TFP. In the first group of countries the key role in shaping TFP play human capital resources, in the second group – the degree of involvement in international exchange. Human skills and qualifications are found to be completely irrelevant determinants of TFP levels in the „new" EU members states.

Keywords: Total Factor Productivity, determinants of TFP, panel analysis, European Union Member States.

JEL Classification Codes: C33, F15, O40, O52.

Introduction

In the literature the accumulation of physical and human capital is treated as an important, but not the only, determinant of differences in the level of economic growth of countries and regions. Theoretical studies, and even more so empirical ones, indicate the importance of Total Factor Productivity (TFP). Furthermore, the proponents of the concept of TFP emphasise the necessity of considering the process of real convergence

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in terms of Total Factor Productivity (Hulten, 2000; Caselli and Tenreyro, 2005). They refer to this form of growth as productivity growth, and to the phenomenon of convergence as productivity convergence.

Heretofore, the literature of the subject lacks a fully developed theory of TFP. The need for the formulation of the theoretical basis of multifactor productivity, especially in the context of its determinants has long been suggested (Prescot, 1997). The source of TFP growth in the neoclassical growth theory is not specifically defined. In the endogenous growth theories, multifactor productivity changes are identified as activities in the sphere of research and development as well as human capital accumulation. However, they do not take into account all the factors affecting the level and volatility of productivity. Most economists agree with the idea that determinants of TFP vary depending on the economic, political and social conditions of countries and regions (see, e.g. Durlauf and Quah, 1996; Brock and Durlauf, 2001). In other words, the range of these determinants is similar in countries whose economies operate in a similar manner and on the basis of similar conditions.

Taking into account the political, economic and social conditions mentioned above, European Union countries show a significant differentiation. It particularly concerns the group of the so-called „new" and „old" member states. In addition, as empirical research indicates, EU member states differ in terms of the level and dynamics of TFP. In general, in the period 2000-2014, the average TFP level of the „old" member states (EU-15: Austria, Denmark, Sweden, Finland, Germany, Portugal, Spain, Italy, Greece, Belgium, the Netherlands, Luxembourg, Ireland, United Kingdom, France) was much higher than in the group of the „new" EU members (EU-12: Czech Republic, Estonia, Malta, Cyprus, Lithuania, Latvia, Poland, Hungary, Slovakia, Slovenia, Bulgaria, Romania). However, in the analyzed period the „new" EU countries showed much higher TFP growth rate (about 3.5%). The average annual TFP growth rate for the „former fifteen" was lower and amounted to approx. 2% (Młynarzewska-Borowiec, 2018).

This article is a continuation of research on the diversity of TFP (levels and dynamics) among EU countries. Its purpose is to investigate the causes of existing differences. The hypothesis that TFP differences in the EU were derived from the different factors determining TFP levels in the particular groups of countries, is verified. In the first part of the article, the results of the previous empirical studies on TFP determinants are reviewed. The second part discusses in detail the statistical data and methodology of the panel study. In the third part, using panel models, an analysis of TFP determinants in the European Union in the period 2000–2014 is carried out. Their significance and the impact in relation to the countries with relatively higher and lower levels of TFP (EU-15 and EU-12 group) are assessed.

1. TFP determinants in the light of previous empirical studies

Due to the lack of a theoretical reference, the spectrum of determinants analysed in empirical studies on the causes of differences in the level and growth of TFP between countries conducted intensively since the early 1990s is very wide. Reviewing the empirical studies, Durlauf and Quah (1996) found as many as 90 potential determinants of TFP. However, there is a group of factors most commonly considered in empirical research. They include expenditures on the R&D sector, the degree of openness of the economy, government spending, the structure of the economy and the size and quality of human capital.

With reference to the theory of endogenous growth, there is a close relationship between the creation of knowledge (technology) and multifactor productivity in the economy, in particular the impact of expenditures for research and development (R&D) on innovation, and consequently on the increase in TFP. These expenditures are important from the point of view of highly developed countries as they allow them to create innovation on their own. They are also necessary for countries that are at a lower level of technological and economic development as it allows them to increase the level of the so-called absorption capacity required for the implementation of imported technology (Gomulka, 1990). Empirical studies conducted at the macroeconomic level in most OECD countries generally confirm this thesis and the positive relationship between the size of expenditures for R&D and the level of TFP (e.g. Abdih and Joutz, 2005; Furman and Hayes, 2004). Some of them also consider the issue of the sources of these expenditures. For example, Guellec and Van Pottelsberghe de la Potterie (2001) focused their research on sources of expenditures for R&D broken down into public, private and foreign funds. In the light of the obtained results, they concluded that all the considered sources had a significant impact on TFP in OECD countries, with the largest reported in the case of R&D financed from foreign sources. They also noted an increasing importance of expenditures from private sources. Ulku (2004) stated, in turn, that expenditures for R&D are important only for the countries with the highest level of development, and are also important in the creation of TFP and growth only in a short run. Research on the impact of expenditures for R&D on productivity is also carried out on a large scale at the level of industries and enterprises, and its results confirm the positive correlation between these economic categories (see, e.g. Lichtenberg and Siegel, 1991; Griffith *et al.*, 2000; Wang and Tsai, 2003; Ahn, 2001). Reviewing empirical studies from the above area, one can also find examples of studies where authors explicitly challenge these correlations (Jones and Williams, 1998; Comin, 2002).

The importance of human capital in shaping TFP has profound theoretical justification, mainly in theories of endogenous growth. Nelson and Phelps (1966) argue that human capital stimulates positive changes in TFP by supporting technology transfer. Romer (1991), Aghion and Howitt (1998) emphasise the importance of human capital

in stimulating TFP because of the fact that an increase in skilled workforce accelerates technological innovation in a given country. Obviously, from a theoretical point of view, correlations are not, however, univocally confirmed by empirical studies. Evidence for a significant and positive impact of human capital on productivity was found, inter alia, by Fleisher and Chen (1997), Vandenbussche *et al.* (2006) as well as Fleisher *et al.* (2008). In turn, in his study, Pritchett (2001) found a statistically significant negative impact of human capital on TFP. The discrepancies in the obtained results are mainly explained by the endogenous nature of the creation of human capital (Bils and Klenow, 2000; Krueger and Lindahl, 2001) and an inaccurate manner of measuring human capital, which does not take into account its quality (Hanushek and Kimko, 2000; Bosworth and Collins, 2003).

According to Muendler (2004), an important factor determining changes in TFP is the degree of openness of economies. Increasing the participation of the country in international economic flows facilitates competition in the domestic market, as if „forcing" domestic companies to innovative actions (competitive push), and secondly allows to acquire cheaper resources from abroad, import of capital and technology (foreign input push). Thirdly, in the face of increasing competition from foreign companies, the least efficient companies are eliminated in favour of those having higher efficiency, increasing their market share and, consequently, the overall productivity of the economy (competitive elimination). In the light of the results of past empirical studies, the above theses are not unequivocally confirmed. Studies in which the openness of the economy is measured by the traditional indicator of the share of trade in GDP (exports plus imports) confirm the significant relationship between the degree of openness of the economy and TFP (e.g. Frankel and Romer, 1999; Irwin and Tervio, 2002; Lee *et al.*, 2004; Kumar *et al.*, 2010). A positive and significant relationship between these economic categories is observed in most studies on the impact of exports on TFP, especially with respect to exports from developed countries (Austria, 1998; Miller and Upadhay, 2002; Alkino, 2005). In countries which are at a lower level of development this positive relationship is conditioned by a correspondingly high level of human capital (Upadhay, 2002; Isaksson, 2001). The impact of import on TFP is less clear because some studies provide evidence for the absence or insignificance of this factor (Mahmood and Afza, 2008). Therefore, the impact of the structure of import on TFP is often examined. Kim (2000) observed a positive influence of imports of capital goods and consumer goods, and an insignificant impact of imports of raw materials. Xu and Wang (1999), Mayer (2001), Caselli and Tenreyro (2005) and Cameron *et al.* (2005) show that import of high-tech goods has a significant influence on TFP. Therefore, they perceive import in terms of technology import. Keller and Yeaple (2003) further emphasise the important role of direct foreign investment in the intensity of technology import in the material and intellectual form. In the literature, one can find examples of studies whose results contradict

the thesis about the importance of the openness of economy on multifactor productivity, such as studies by Khan (2006), Gonzalez and Constantin (2009).

From a theoretical point of view, government spending (e.g. expenditures on infrastructure, education, healthcare) can influence both the level and growth rate of TFP (Barro and Sala-i-Martin, 1995). On the other hand, the activities of the government sector are considered less effective than those of the private sector. It can therefore be expected that in the case of an increase in government spending, the efficiency level of the economy, and thus the growth rate of TFP, decreases. So far, empirical studies do not fully confirm or deny the above hypothesis. Thomas and Wang (1993) have shown that appropriate government policies aimed at ensuring macroeconomic stability have a positive impact on TFP, and government spending is positively correlated with productivity growth. In a study of 115 countries for the period from 1960 to 1980 Ram (1986) has shown a positive effect of public spending on the efficiency of the economy, similarly to Garces-Ozanne (2006). In studies that take into account the level of government consumption spending, usually evidence of the negative impact of such spending on TFP is obtained (e.g. Barro, 1991; Landau, 1986; Hansson and Henrekson, 1994). Evidence for a significant and positive relationship is obtained, in turn, in studies that take into account expenditures for infrastructure (Aschauer, 1989; Devarajan *et al.*, 1993) and education (Evans and Karas, 1994; Wyatt, 2005). Khan and Kumar (1997), Loayza *et al.* (2004) on the other hand, prove that the investments of the government sector have the same positive effect on productivity as private sector spending, particularly in less economically developed countries.

Kuznets (1979) argued that it is impossible to achieve high rates of growth of GDP per capita or output per employee without proportional, significant changes in the share of individual sectors in the economy. Therefore, the literature of the subject quite commonly discussed the relationship between structural changes in the economy and the growth of TFP. The above hypothesis was verified, among others, by Chenery *et al.*(1986), who proved that the structural changes of the economy to a large extent explain the growth processes. In turn, Lucas (1993), in studies based on the model of industrial development considered from the point of view of supply, and Verspagen (1993), in studies taking into account a similar model from the point of view of demand, confirmed the importance of structural changes on the growth of multifactor productivity. Fagerberg (2000) proved that the flexible structure of production is an important element of productivity growth. In the light of the results of his tests, countries that specialise in high-tech products reached a higher level of productivity than countries that specialise in goods with a low degree of processing. A significant and positive relationship between structural changes (reallocation of resources in the economy) and the level of productivity was also noted by Akkemik (2005), Berthelmy (2001), Ngai and Pissarides (2007) as well as Chen *et al.* (2011). In turn, Peneder (2003) empirically proved that the structural changes in the economy can have both positive and negative effects on TFP growth,

and the role of structural factors in creating productivity decreases and is ambiguous. Caselli (2005) demonstrated, in turn, that the relationship between the structure of the economy and productivity does not exist.

2. Data and methodology of the study

Taking into account achievements of the previous empirical analyses concerning factors influencing TFP in individual countries or their groups, it appears reasonable to examine determinants of the TFP levels in European Union Member States. The empirical studies mentioned in the first part of the paper apply to the countries of the EU-27 to a limited extent, and the results are not conclusive. Given the significant disproportion in the levels of TFP in the EU-15 and EU-12 countries, studies on the existence and strength of the factors determining TFP were performed separately for the both groups of countries. These are attempts to identify the main causes of TFP differentiation occurring in the period of 2000–2014.

To investigate the „driving forces" of TFP levels in both groups, several alternative econometric panel models were tested. Different sets of variables, the proxies of determinants of TFP proposed in the literature, as well as their time lags were taken into account. The models were built with particular focus on the satisfactory number of variables as well as the statistic quality. Finally, the following *fixed effect* model (1) was applied:

$$ln(TFP_{i,t}) = \alpha_i + \beta_1 \ln(LIB)_{i,t} + \beta_2\, ln(GERD)_{i,t-1} + \beta_3\, ln(GOV)_{i,t-1} + \beta_4\, ln(AGR)_{i,t} + \beta_5\, ln(HUM)_{i,t,} + \varepsilon_{i,t} \quad (1)$$

where:

$\varepsilon_{i,t}$ – random term $\varepsilon_{i,t} \sim IID(0; \sigma_\varepsilon^2)$ for i=1,2….N i t=1,2…T; $^{\forall_{i=1,\ldots,N}} {}^{\forall_{t,s=1\ldots,T}} E\{\mathrm{x}_{\mathrm{it}}, \varepsilon_{is}\} = 0$

x_{it} – independent variables' matrix.

The dependent variable of the model is the natural logarithm of the TFP level of the country *i* in the period *t*. TFP levels of the particular UE countries in the period 2000–2014 were obtained from Author's study for EU countries in the period 2000–2014 (Młynarzewska-Borowiec, 2018).

Independent variables are logarithmised values of the following economic indicators:

a) $LIB_{i,t}$ – showing the degree of openness of the economy, calculated as the value of foreign trade of the country i (EX + IM) in relation to GDP in the period t, based on data obtained from the World Bank WDI Database (2017);
b) $GERD_{i,t-1}$ – showing the level of total expenditures for research and development, calculated as the share of these expenditures in the GDP of the country i in the period t-1, based on data from Eurostat database (2017);

c) $GOV_{i,t-1}$ – showing the degree of involvement of the government sector in the economy, calculated as a share of total government spending in the GDP of the country i in the period t-1, based on data from Eurostat database (2017);
d) $AGR_{i,t}$ – showing the economic structure of the country as a share of agricultural production in the total added value of the economy of the country i in the period t, obtained from the Eurostat database (2017);
e) $HUM_{i,t}$ – reflecting human capital resources, calculated as the share of population with secondary and higher education in the total population aged 15 – 64, obtained from the Eurostat database (2017).

3. Results of empirical studies

To make estimates of the panel models for the EU-15 and EU-12 group the following procedure was conducted. The models were initially estimated using the ordinary least squares method (OLS) as a pooled type models (a panel treated as a set of cross-sectional data). In both cases, diagnostic tests, primarily the results of the Breusch-Pagan test, suggested a rejection of the null hypothesis about the absence of individual effects. For that reason, the models with individual effects were taken into account. A proper method of estimation was selected after conducting the Hausman test and confirmed by the F-test for diversification of the constant in groups. The results in both cases suggested the use of FE (*within*) estimator (*fixed effect model*). Assessing the quality of the models, it should be stated that it was satisfactory. The independent variables explained the TFP variability to a large extent, as evidenced by the values of determination coefficients (LSDV R^2 and within R^2).

In the light of the estimation results of model (1) for the EU-15 group (see Table 1), all explanatory variables, reflecting TFP determinants, are statistically significant (significance at the level of 1% according to the Student's t test for variables). The signs of estimated structural parameters correspond to the expectations formulated on the theoretical basis and generally confirm the results of the previous empirical studies regarding the correlation between the individual determinants and the level of TFP.

The estimates show that human capital resources and liberalisation of the economy had a high positive impact on the level of TFP in the EU-15 group. A one-percent increase in the share of high-skilled workers in population and in the share of trade turnover in GDP, *ceteris paribus*, resulted in an increase in the level of TFP by 0.2 and 0.12 percent, respectively. Expenditures on R&D (made a year earlier) also turned out to affect positively productivity, but to a lesser extent (relatively lower value of the coefficient of the variable approximating R&D expenditures). In the light of the obtained results, government spending negatively affected TFP of the discussed group of countries. A one-percent increase in the share of these expenditures in GDP resulted in

a decrease in the level of TFP by 0.3%. A structure of economy, namely the high share of agriculture in generating GDP, negatively affected productivity in this group of countries. However, the negative correlation in this case turned out to be much weaker than in the case of government spending (elasticity of AGR_{it} variable amounted to -0.07).

Table 1. Estimation results of panel model (1) for the EU-15 countries in the period 2000–2014; dependent variable: *ln* TFP_{it}; FE estimator; number of observations:210

variable	coefficient	std. error	t-retio	p-value	significance
const	6,12899	0,2676900	22,8959	<0,00001	***
LIB_{it}	0,119232	0,0345408	3,4519	0,00069	***
$GERD_{it-1}$	0,0812171	0,0202462	4,0115	0,00009	***
GOV_{it-1}	-0,290402	0,0545066	-5,3278	<0,00001	***
AGR_{it}	-0,0733413	0,0207489	-3,5347	0,00051	***
HUM_{it}	0,185382	0,0577095	3,2123	0,00155	***

Mean dependent var	6,394099		S.d dependent var	0,164158
Residual sum of squares	0,449713		Residual std error	0,048651
LSDV R^2	0,920152		Within R^2	0,631205
LSDV F(19, 190)	115,2380		p value (F)	2,11e-93
Log-likelihood	347,3795		Akaike criterion	-654,7590
Schwarz criterion	-587,8169		Hannan-Quinn	-627,6968
Autocor. rho1	0,652676		Durbin-Watson	0,570262

Model diagnostics:
Test for diversification of the constant in groups
Null hypothesis H_o: groups have a common constant
Test statistics: F(14, 190) = 60,3823
p = P(F(14, 190) > 60,3823) = 4,25535e-062
critical value = 2,1769
test result: rejection of Ho: the use of the fixed effect model is justified

*** means significance at 1%

Source: own calculations using GRETL.

Table 2 presents the estimation results of the structural parameters of model (1) built for the „new" European Union member states in the investigated period 2000–2014. According to the Student's t-test, four of the five independent variables included in model showed a statistical significance (at 1% level).

Table 2. Estimation results of panel model (1) for the EU-12 countries in the period 2000–2014; dependent variable: *ln* TFP_{it}; FE estimator; number of observations:168

variable	coefficient	std. error	t-retio	p-value	significance
const	6,74828	0,511564	13,1915	<0,00001	***
LIB_{it}	0,192982	0,0327455	5,8934	<0,00001	***
$GERD_{it-1}$	0,0923401	0,0294195	3,1387	0,00204	***
GOV_{it-1}	-0,383259	0,0743753	-5,1530	<0,00001	***
AGR_{it}	-0,0957131	0,0257312	-3,7197	0,00028	***
HUM_{it}	0,0493731	0,0761428	0,6484	0,51769	

Mean dependent var	6,256289		S.d dependent var	0,126618
Residual sum of squares	0,510668		Residual std error	0,058154
LSDV R^2	0,809266		Within R^2	0,512201
LSDV F(16, 151)	40,04229		p value (F)	4,34e-46
Log-likelihood	248,4823		Akaike criterion	-462,9646
Schwarz criterion	-409,8572		Hannan-Quinn	-441,4110
Autocor. rho1	0,710226		Durbin-Watson	0,464311

Model diagnostics:
Test for diversification of the constant in groups
Null hypothesis H_0: groups have a common constant
Test statistics: F(11, 151) = 32,6501
p = P(F(11, 151) > 32,6501) = 1,61419e-034
critical value = 2,36728
test result: rejection of Ho: the use of the fixed effect model is justified

*** means significance at 1%

Source: own calculations using GRETL.

The estimates point to a strong positive impact of LIB_{it} variable, approximating the degree of openness of the economy, on TFP level in the EU-12. Its positive change by 1% resulted in TFP growth of about 0.19%. The impact of investment in R&D sector on productivity in the analysed group of countries turned out to be much weaker and comparable to that in the EU-15 (the value of the estimated parameters corresponding to $GERD_{it}$ variable in the both models amounted only to about 0.08–0.09).

In the EU-12 countries, as well as in the EU-15 group, the structure of economy with a high share of agriculture in generating GDP influenced negatively on their productivity level. Moreover, an increase in the share of government spending in GDP by 1% caused, *ceteris paribus*, a drop in their TFP level by about 0.4% on average.

In the light of the estimates obtained for the EU-12, the variable approximating human capital resources in the economy (HUM_{it}) showed a slight positive impact on the explained variable (TFP_{it}) but it turned out to be insignificant from a statistical point of view. Given the fact that human capital was proved to be a key determinant shaping TFP level of the EU-15 countries, the result is a bit surprising.

Conclusion

In the light of the econometric studies conducted in this paper, it can be concluded that the differences between European Union member states in terms of TFP levels, in particular differences between the EU-15 and EU-12 groups, were related to the factors determining them. In the „former fifteen" group the resources of human capital as well as the degree of openness of economies played the most important role in shaping productivity. A positive impact on the level of TFP was also exerted by R&D expenditures, which is not surprising due to the fact that R&D outlays and highly qualified employees are the basis for endogenous creation of technology and increase of innovation level in the countries with a relatively high level of technological development, to which this group is undoubtedly included.

As expected, a high share of agriculture sector in generating GDP negatively influenced the level of productivity in both groups of countries. In the case of government spending, a negative impact on TFP was proved, which is in line with the results of the previous empirical research quoted in the first part of the paper. This negative impact, especially in the EU-12 countries, turned out to be surprisingly strong. Perhaps, an imprecise selection of the variable, reflecting all categories of government spending is the reason. In the future, it is worth introducing a more detailed variable, approximating those categories of government spending that are directly related to technological resources in the economy, e.g. expenditure on education, higher education or infrastructure.

In the EU-12 countries, TFP changes resulted mainly from the increase in their involvement in international exchange (trade). It can be assumed that the level of TFP in these countries was largely due to the successive adaptation of companies to the conditions of „demanding" international market, as well as the import of technology, organizational and management innovations, etc. A high level of expenditures on R&D sector had also a positive impact on productivity in this group of countries. In the light of the obtained results, human skills and qualifications were completely irrelevant. This controversial statement certainly requires in-depth analysis, especially in the face of the prevailing opinion among economists about the key importance of qualified personnel in building the so-called knowledge-based economies. It may be explained by the fact that countries with a relatively lower level of technological development initially focus on eliminating technological shortages and importing innovations from abroad. Expenditures on R&D sector are mostly related to improving absorption and adaptation capacities of the country. Only later, after reaching the higher stage of technological development, which is characteristic for the EU-15 countries, R&D sector is associated with independent creation of technology. In this case, human capital resources become crucial for the successful functioning of R&D sector as well as other high-tech industries in the economy. The results of the empirical study seem to confirm the above view.

In addition, it is worth to consider constructing a more complex indicator reflecting not only the quantity but also the quality of human capital. A more comprehensive study, taking into account the various aspects of human capital (education level of the society, information society development, migration of skilled personnel, lifelong learning, etc.) can shed new light on the issue of the importance of human capital in shaping TFP in the countries that are at the stage of „technological catching up".

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