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Dynamic Panel Analysis of Influence of Quality of Human Capital on Total Factor Productivity in Old European Union Countries

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**Dynamic Panel Analysis of Influence of Quality of Human
Capital on Total Factor Productivity in Old European Union
Countries**

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Dynamic Panel Analysis of Influence of Quality of Human Capital on Total Factor Productivity in Old European Union Countries

Adam P. Balcerzak¹, Michał Bernard Pietrzak²

Abstract. Improving productivity is the main determinant of long term development. In the EU in Europe 2020 strategy special attention was given to the role of quality of human capital (QHC) as an important determinant of productivity growth. In this context the aim of the article is to assess the impact of the QHC on total factor productivity (TFP) in “old” EU countries. The research is conducted at macroeconomic level. EU economies must build their competitiveness in reality of knowledge-based economy. Thus, the QHC was analysed from the point of view of global knowledge economy. This factor was treated as a multidimensional phenomenon. As a result, it was measured with application of TOPSIS method, which allowed to obtained time series for dynamic panel analysis of determinants of TFP. In order to evaluate TFP parameters of the Cobb-Douglas production function for developed EU countries were estimated. Then, the relationship between the QHC and the level of TFP was assessed with application of dynamic panel model. The research was based on Eurostat data for the years 2000-2010. It confirmed a significant influence of the QHC on the level of TFP in the analysed economies.

Keywords: panel model, TOPSIS, TFP, quality of human capital, EU countries.

JEL Classification: O47, C23, C38

AMS Classification: 90C15

1 Introduction

Improving and keeping high productivity growth is the main determinant of long term sustainable development [Pietrzak et al. 2014; Jantón-Drozdowska & Majewska, 2015; Kuder, 2015; Balcerzak & Pietrzak 2016a; Pietrzak & Balcerzak, 2016a]. However, it also significant from the short term perspective, as it influences the situation on labour markets [Blacerzak (Ed.) 2009; Balcerzak & Żurek, 2011; Muller-Frączek & Pietrzak, 2011; Wilk et al. 2013; Hadaś-Dyduch, 2015], role of the country in international supply chain [Pietrzak & Łapińska, 2015] or macroeconomic fiscal stability [Balcerzak et al., 2016; Balcerzak & Rogalska, 2016, Mackiewicz-Łyziak, 2015]. It is especially important in the case of highly developed countries that cannot utilise simple growth factors. The research on factors improving productivity is not only the core of endogenous growth theory, but it is also policy priority for all developed economies. In the case of EU countries it could be seen in Europe 2020 strategy, where special attention was given to the role of quality of human capital (QHC) as one of the most important determinant of productivity growth at macroeconomic level [Balcerzak, 2015]. In this context the main aim of the article is to assess the impact of the QHC on total factor productivity (TFP) in “old” developed EU countries in the years 2000-2010. The period of the analysis was mostly restricted by the availability of Eurostat data for the whole panel of countries. In the article a macroeconomic perspective was taken. In the research the following tools were applied: TOPSIS method for assessing the QHC and obtaining time serious for econometric research, to evaluate TFP parameters of the Cobb-Douglas production function were estimated. The current analysis is a continuation of previous research of the authors [Pietrzak & Balcerzak, 2016b; 2016c].

2 Total Factor Productivity in Developed EU Countries

In regard to the objective of the article an analysis TFP for 14 developed EU countries that were the members of the EU before 2004 was conducted. Luxemburg was excluded from the research due to the specifics of its economy. The analyzed countries can be considered as relatively homogenous in regard to macroeconomic and institutional factors influencing productivity [Balcerzak, 2009a; 2009b; Balcerzak & Pietrzak, 2014a; 2014b; 2016b], which justifies the application of the Cobb-Douglas production function for assessing productivity for that set of economies [Aimar & Dalgaard, 2005; Severgnini & Burda, 2010; Gehringer et al., 2014]. In the research the following variables were applied: total employment (annual averages in persons - E), real gross value added

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(million euro, reference year 2000 - *GVA*) and gross fixed capital formation (million euro, reference year 2000 - *GFCF*). Eurostat data was used here.

The first step of the analysis was the assessment of the productivity level for the countries in the years 2000-2010 based on the Cobb-Douglas production function. The Cobb-Douglas production function after taking the logarithm of both sides of equation was given with equation 1:

$$\ln GVA_{it} = \eta_i + \alpha \ln GFCF_{it} + (1 - \alpha) \ln E_{it} + gt + \varepsilon_{it} \quad (1)$$

where: GVA_{it} – vector of real gross value added in the country i and the period t , $GFCF_{it}$ – vector of gross fixed capital formation in the country i and the period, E_{it} – vector of employment in the country i and the period, η_i – vector of values of individual effects, in the period t , t – time trend, α – elasticity of labor productivity to the capital, g – rate of technological progress in the sense of Hicks, ε_{it} – a vector of disturbances.

Equation 2 describing the panel model FE (fixed effects) for the level of labor productivity relative to the capital to labor ratio is obtained after subtracting the expression $\ln(E)$ from both sides of equation (1),

$$\ln GVA / E_{it} = \eta_i + \alpha \ln GFCF / E_{it} + gt + \varepsilon_{it}, \quad (2)$$

where: GVA/E – vector of value GVA/E – labor productivity, $GFCF/E$ – vector of the capital to labor ratio, and the remaining variables are the same as in the case of equation 1.

Estimation of parameters of panel model FE (2) for labor productivity allows to determine the value of total factor productivity TFP_{it} for the analyzed countries. In order to assess TFP_{it} the estimated value of parameter α is used, given with equation (3).

$$TFP_{it} = \frac{GVA / E_{it}}{(GFCF / E_{it})^\alpha}. \quad (3)$$

Table 1 presents the results of estimation of parameters of panel model FE with individual effects for labour productivity (equation 2). Individual effects for 14 countries and parameters α i g were statistically significant. The obtained value of estimates of the parameter α indicates that flexibility of labor productivity to capital to labor ratio equals 0,081. The value of estimate of the parameter g at the level 0,008 indicates that the analyzed economies are characterized with 0,8% rate of technological progress in the sense of Hicks. It means that when one assumes that capital investments and the employment are kept constant, the analyzed countries can be characterized with rate of production growth at the level of 0,8%.

Parameter	Estimate	Standard error	t-student statistics
α	0,081	0,04	2,133
g	0,008	0,001	5,540
Coefficient of determination		0,992	

Table 1 The results of estimation of parameters of panel model FE for labor productivity

The estimated value of parameter α allows to estimate TFP_{it} for the analyzed countries in the years 2000-2010. It was conducted with application of equation 3. Table 2 presents TFP for the year 2000 and 2010 and the percentage change of its value in the years 2000-2010. Additionally table 2 presents the classification of the countries into three relatively homogenous subsets, which was done with application natural breaks method [14].

2000			2010			2000-2010		
Country	TFP	Class	Country	TFP	Class	Country	% change	Class
Sweden	35,985	3	Ireland	42,527	3	Ireland	22,56%	3
France	35,537	3	Sweden	40,439	3	Greece	17,17%	3
Denmark	34,720	3	United Kingdom	38,299	3	Portugal	16,30%	3
Ireland	34,699	3	Denmark	37,033	2	Sweden	12,38%	2
United Kingdom	34,613	3	France	36,410	2	Finland	11,79%	2
Belgium	34,549	3	Belgium	36,386	2	Netherlands	10,73%	2
Italy	32,884	2	Finland	35,682	2	United Kingdom	10,65%	2
Germany	32,366	2	Austria	35,042	2	Austria	10,02%	2
Finland	31,919	2	Germany	34,917	2	Germany	7,88%	2
Austria	31,851	2	Netherlands	34,077	2	Denmark	6,66%	2
Netherlands	30,775	2	Italy	32,432	2	Belgium	5,32%	1
Spain	24,212	1	Spain	25,011	1	Spain	3,30%	1
Greece	20,728	1	Greece	24,288	1	France	2,46%	1
Portugal	15,693	1	Portugal	18,251	1	Italy	-1,37%	1

Table 2 Total factor productivity in the developed UE member countries

The classification of the countries confirmed the differentiation of the old member states in terms of TFP. In the year 2000 in the first class with the highest level of TFP one can find Sweden, France, Denmark, Ireland, Great Britain and Belgium. In the second class there are Italy, Germany, Finland, Austria and Netherlands. In the subset characterized with the lowest level of TFP there are Spain, Greece and Portugal.

In the year 2010 there are significant changes in terms of grouping of the countries. In the first class one can find Ireland, Sweden and Great Britain. In the year 2010 the second class is the biggest and groups Denmark, France, Belgium, Finland, Austria, Germany, Netherlands. During the ten years covered by the research the situation of Spain, Greece and Portugal was not changed and they could be found in the first class.

In the years 2000-2010 with the exception of Italy all the countries recorded an increase of TFP. In the class with the highest TFP dynamics, the TFP growth ranged from 16,30% to 22,56%. In the second class it was 6,66% to 12,38% and in the case of the first class from -1,37% to 5,32%.

3 Human Capital as a determinant of Total Factor Productivity

It was stressed in Europe 2020 strategy that EU economies must build their competitiveness in reality of knowledge-based economy. As a result, the QHC was analysed from the point of view of global knowledge economy [Sachpazidu-Wójcicka 2014; Madrak-Grochowska, 2015; Norek & Arenhardt, 2015; Stankiewicz & Moczyłska, 2015; Wildowicz-Giegiel & Wyszowski, 2015, Wronowska, 2015]. This factor was treated as a multidimensional phenomenon [Balcerzak, 2011; Balcerzak, 2016, Balcerzak & Pietrzak, 2016c]. As a result, it was measured with application of TOPSIS method with assumption of constant ideal solution for all the period, which allowed to obtained time series for dynamic panel econometric analysis of determinants of TFP. The detailed description of TOPSIS method applied by the authors is available in Balcerzak and Pietrzak [Balcerzak & Pietrzak, 2016a; 2016d, 2014a, 2014b]. The synthetic measures for the QHC were estimated basing on the six diagnostic variables that were grouped to three economic aspects, which are presented in table 3.

Aspect 1 (A₁) - macroeconomic and labour market effectiveness
– Effectiveness of labour force (percentage of EU28 total based on PPS per employed person)
– Employment rate (in the group of people in the age 20 to 65)
Aspect 2 (A₂) - quality of education
– Lifelong learning - participation rate in education and training (last 4 weeks) (% of population 25 to 64)
– Science and technology graduates (tertiary graduates in science and technology per 1 000 inhabitants aged 20-29 years)

Aspect 3 (A₃) - national innovation system		
– Exports of high technology products as a share of total exports		
– Total intramural R&D expenditure (GERD) - percentage of GDP		

Table 3 Diagnostic variables used for obtaining synthetic measure of the QHC with application of TOPSIS

The results of application of TOPSIS method for evaluation of the level of the QHC is presented in table 4. By analogy to the procedure applied for TFP in table 2, based on the values of the synthetic measure TMD for the QHC the countries were grouped to one of three subsets.

2000			2010			2000-2010		
Country	TMD	Class	Country	TMD	Class	Country	% change	Class
Finland	0,681	3	Finland	0,686	3	Germany	21,84%	3
Sweden	0,670	3	Sweden	0,641	3	Austria	18,65%	3
United Kingdom	0,658	3	Denmark	0,641	3	France	18,29%	3
Ireland	0,616	3	France	0,572	2	Spain	13,23%	3
Denmark	0,570	3	Austria	0,556	2	Denmark	12,55%	3
Netherlands	0,517	2	United Kingdom	0,554	2	Portugal	0,87%	2
France	0,484	2	Ireland	0,551	2	Finland	0,72%	2
Belgium	0,471	2	Germany	0,508	2	Sweden	-4,32%	2
Austria	0,469	2	Netherlands	0,492	2	Belgium	-4,47%	2
Germany	0,417	2	Belgium	0,450	2	Netherlands	-4,81%	2
Italy	0,345	1	Spain	0,300	1	Greece	-9,70%	1
Spain	0,265	1	Italy	0,294	1	Ireland	-10,59%	1
Portugal	0,260	1	Portugal	0,262	1	Italy	-14,90%	1
Greece	0,181	1	Greece	0,163	1	United Kingdom	-15,82%	1

Table 4 Quality of human capital in the developed EU countries

The analysis of results presented in table 4 shows similarities between the QHC presented in table 4 and TFP given in table 2. In the year 2000 in the class characterized with the highest level of TFP one can find: Finland, Sweden, Denmark, Ireland and Great Britain. The domination of Scandinavian countries can be seen here. In the second group there are Netherlands, France, Belgium, Austria, Germany. In the first class with the lowest level of the QHC one can find southern European economies: Italy, Spain, Greece and Portugal.

In the year 2010 Finland, Sweden and Denmark were the leaders. The second class grouped France, Belgium, Finland, Austria, Germany, Netherlands, Ireland and Great Britain. As previously, the situation of the southern countries Italy, Spain, Greece and Portugal was not improved and they were grouped in the first class characterized with the lowest level of the value of TMD for the QHC.

The obtained results justify the further econometric research of the relationship between the QHC and TFP. In the last stage the values of the TMD measure for the QHC were used to verify the influence of the QHC on the TMD. For this purpose a specification of the dynamic panel model given with equation 4 was done.

$$\ln TFP_{it} = \eta_i + \beta \ln TFP_{it-1} + \alpha TMD_{it} + gt + \varepsilon_{it}, \quad (4)$$

where the dependent variable was defined as the logarithm of TFP, independent variable was the measure of TMD for the QHC, α , β were the structural parameters of the model, η_{it} was a vector of individual effects of panel model, and ε_{it} was a vector of disturbances.

Parameter	Estimate	Standard error	t-student statistics
β	0,760	0,118	6,437
α	0,307419	0,15213	2,0208
g	0,00159018	0,000893669	1,7794
Statistical Tests		Statistics of the test	p-value
Sargan Test		12,279	0,99
AR(1)		-2,583	0,009
AR(2)		-1,457	0,145

Table 5 The results of estimation of parameters of dynamic panel model for determinants of TFP

The results of the estimation of the parameters of dynamic panel model are presented in table 5. The positive and statistically significant estimation of parameter α confirms influence of the QHC on TFP. The conducted research confirms the importance of the QHC as a significant factor that supports improvements of TFP, as a result, long term growth in the case of developed EU countries. It means that the policies concentrating on the improvement of the QHC should be the subject of special attention of all European governments.

4 Conclusions

The article concentrates on the determinants of productivity growth in the developed EU economies. In regard to the aim of the paper an analysis of TFP and assessment of the QHC for old EU member states in the years 2000-2010 were conducted. In order to evaluate TFP the parameters of the Cobb-Douglas production function for the analysed countries were estimated. To measure the QHC a taxonomic measure of development based on a set of selected variables characterizing three economic aspects was proposed. The aspects related to: a) macroeconomic and labor market effectiveness, b) quality of education, c) effectiveness of national innovation system. Then the relationship between the QHC and the level of TFP was assessed with application of dynamic panel model. The research confirmed a significant positive influence of the QHC on the level of TFP in the analysed economies. It means that the QHC makes an important determinant of productivity growth in the old EU members states. Thus, it should be the subject of special attention for the governments and EU authorities as a whole.

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