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# CELKOVÁ FAKTOROVÁ PRODUKTIVITA A JEJ DETERMINANTY V EURÓPSKEJ ÚNII

# TOTAL FACTOR PRODUCTIVITY AND ITS DETERMINANTS IN THE EUROPEAN UNION

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Problematika európskej produktivity je ústrednou témou mnohých ekonomických a politických debát vzhľadom na fakt, že relatívne nízka miera produktivity predstavuje seriózny problém pre európske ekonomiky. Cieľom práce je odhadnúť tempo rastu celkovej faktorovej produktivity v jednotlivých členských štátoch Európskej únie a identifikovať jej najvýznamnejšie determinanty. V práci aplikujeme metódu rastového účtovníctva a Bayesiánskeho priemerovania modelov. Analýza je prevedená na ročných dátach pre 19 členských štátov a pokrýva obdobie 1996-2014. Výsledky naznačujú, že najrobustnejším faktorom s pozitívnym efektom je otvorenosť a že výrazný vplyv má aj aktívna politika na trhu práce.[23]

Kľúčové slová: Celková faktorová produktivita, Determinanty celkovej faktorovej produktivity, Európska Únia, Bayesiánske priemerovanie modelov, Rastové účtovníctvo

The issue of the European productivity is a central theme of many economic and policy debates as a relatively low level of productivity constitutes a serious problem for the European economies. The aim of this paper is to calculate the total factor productivity growth for the European member states and find out its most significant determinants. As analytical tools we apply the growth accounting method and the Bayesian Model Averaging. The

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Ing. Petra Čekmeová je absolventkou Fakulty medzinárodných vzťahov Ekonomickej univerzity v Bratislave. Momentálne pôsobí ako doktorandka na Ekonomicko-správní fakulte Masarykovej univerzity. Zaoberá sa makroekonomickou konkurencieschopnosťou a celkovou faktorovou produktivitou členských štátov Európskej únie.

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analysis is executed on yearly observations for 19 member states of the European union covering the period from 1996 to 2014. The results suggest that the most robust factor with positive effect is the openness and that the considerably high impact can be attributed to active labour market policies.
Key words: Total Factor Productivity, Determinants of Total Factor Productivity, European Union, Bayesian Model Averaging, Growth Accounting
JEL: C11, E60, E47

## 1 INTRODUCTION

The issue of the European productivity and its improvement is a central theme of many economic and policy debates. It is not surprising given the fact that the relatively low level of productivity constitutes a serious problem for the European economies. More precisely, many economists and policy makers are concerned about the development of the European total factor productivity due to its significant contribution to the economic growth and decisive impact on the national competitiveness. Therefore, a continuously declining trend of total factor productivity in the European Union is alarming. However, to be able to improve the European productivity it is necessary to known the factors which are responsible for this unfavourable development.

The total factor productivity is often considered as the most comprehensive method to measure the national productivity. Compared to other measures, it takes into account a contribution of different production factors to the economic growth. The problem with this measure lies in the availability of relevant data (mainly in the case of smaller economies or longer time periods). Thus, own estimations of the total factor productivity can be really useful.

The aim of this paper is to calculate the total factor productivity growth for the European member states and find out its most significant determinants. In order to calculate the growth rates of total factor productivity we apply a method based on growth accounting. The estimated values will be used as dependent variables in the analysis of the productivity determinants. As the economic theory provides a large set of possible factors, which could explain the variation in the European total factor productivity, an inference based on one (possibly incorrect) regression model is precarious. To overcome the problem of model uncertainty we apply a method called Bayesian model averaging. By application of this method, the contribution of explanatory variables will be assessed based on a weighted average over all possible models. The analysis is executed on yearly observations for 19 member states of the European Union (Bulgaria, Croatia, Cyprus, Estonia, Latvia, Lithuania, Malta, Romania and Slovenia were excluded from the analysis regarding the availability of data) covering the period from 1996 to 2014.

The paper is organized as follows. After a short introduction, the second section introduces the issue of total factor productivity and its determinants in order to provide a brief theoretical explanation for the choice of variables in the empirical part. The third section includes descriptions of the method used for the calculation of the total factor productivity growth and of the Bayesian model averaging method. The data applied in this study are also presented in this section. The fourth section presents the empirical results, namely the development of total factor productivity in the member states of the European Union and the results of the Bayesian model averaging. The last section contains concluding remarks summarizing the main findings of our analysis.

## 2 THEORY OF TOTAL FACTOR PRODUCTIVITY AND ITS DETERMINANTS

Total factor productivity (TFP)[4] reflects the ability of production factors to jointly generate output (Compnet Task Force 2015). On the contrary to partial measures of productivity, it considers the contributions of labour, physical, human and other intangible capital to the output growth (The Conference Board 2015b). With respect to its computation, TFP growth is derived as residual catching up that part of output growth which cannot be attributed to extensive factors.

Economists and policy makers are interested in the development of TFP as it is considered to be the most important factor of GDP growth and cross-country differences in income. The crucial role of TFP in explaining economic growth was already approved in the works of Abramowitz (1956), Solow (1957) and later by Romer (1990), Krugman (1994) or Hall and Jones (1999). Moreover, total factor productivity can be used as proxy for national competitiveness (for instance: CompNet Task Force 2015).

In the context of endogenous growth theories the primary role in fostering productivity belongs to technological progress and human capital. The innovation based theories, developed by Romer (1990), Grossman and Helpman (1991), Aghion and Howitt (1992), relies on the stimulating effects of R&D activities through their impact on innovations. Both domestic and foreign R&D activities matter. The transmission of technologies trough trade and FDI was emphasized by Coe and Helpman (1995) or Nadiri and Kim (1996). As Aiyar and Feyrer (2002) pointed out various factors such as openness, geography, legal framework, human capital, can influence the efficacy with which new technologies are adopted.

The human capital based theories of Romer (1986) and Lucas (1998) emphasize the positive effect of skilled labour force on the productivity growth. The same conclusion is made by empirical works of Barro and Lee (2001) or Benhabib and Speigel (1991). Skilled workers are more capable to efficiently use existing technologies and create new ones (Gehringer et al. 2014). Moreover, human capital

[4] As synonym for Total factor productivity is also used a term Multi-factor productivity (MFP).

facilitates the adoption of innovations from abroad. Authors such as Berman et al. (1998) or Redding (1996) pointed out the complementary relation between technological progress and human capital.

The institutional theories brought a significant contribution to the analysis of productivity drivers concluding that an institutional framework is decisive for the country's long-term development (for example: Acemoglu et al. 2001). Based on this fact, researchers incorporated various institutional factors in their analysis such as bureaucratic inefficiency, corruption, crime and market regulations, civil liberties and political rights (Hall and Jones 1999). With shift in perception of growth determinants, the contribution of labour market institutions to productivity improvements we also taken into account (for example: Lacinio and Vallanti 2013).

The impact of international collaboration has been already mentioned. Beside its positive effect on technological spillover, FDI could boost productivity through their impact on the degree of domestic competition (Griffith et al. 2003). Similarly, foreign trade creates pressures on the competitive position of domestic firms (Greenway and Kneller 2007).

Among the other factors with noticeable impact on the productivity development we can include ICT (Gordon 2000), infrastructure, relative size of services in the economy and development of financial markets (Luintel et al. 2010), share of private savings, size of government, initial level of economic development and share of urban population (Danquah et al. 2013). Moreover, Baudry and Green (2002) showed that population growth facilitates innovations due to population pressures.

## 3 Methods and data

In the literature we can identify various methods how to calculate (estimate) the TFP. In this paper, we introduce a methodology based on growth accounting which was elaborated by Diewert (1976) and applied in numerous empirical studies. It is an alternative to the econometric approach which is frequently used in recent studies. Naturally, both approaches have certain shortcomings. In our case we rely on the former one due to the lack of sufficient data (too short time series could lead to unreliable results in the case of the econometric methods) (Ganev 2005, p. 6).

According to this method, the growth rate of gross domestic product (GDP) is approximated by the first difference of logarithm of GDP and it is decomposed via the following equation

$$\Delta lnY_t = \frac{1}{2}[a_t + a_{t-1}]\Delta lnK_t + \frac{1}{2}[b_t + b_{t-1}]\Delta lnL_t + \Delta lnA_t \quad (1)$$

where $Y_t$ denotes a GDP, $K_t$ stands for a capital stock, $L_t$ is a number of employed persons, $A_t$ is a measure of the total factor productivity and $a_t$, $b_t$ represents the shares of labour and capital incomes in total income.

As the total factor productivity growth rate catches up that part of output growth which cannot be attributed to the growth rate of production factors (labour and capital), the total factor productivity growth rate is calculated as follows:

$$\Delta lnA_t = \Delta lnY_t - \frac{1}{2}[a_t + a_{t-1}]\Delta lnK_t - \frac{1}{2}[b_t + b_{t-1}]\Delta lnL_t$$

*(2)*

Before the application of the equation (2) in an empirical analysis, we need to calculate the level of capital stock in the given economy due to the unavailability of data in the national accounts. In this paper we execute the calculation of $K_t$ by the permanent inventory method. Its basic equation can be described as

$$K_t = I_t + (1 - \delta)K_{t-1}$$

*(3)*

where $I_t$denotes a gross investment and $\delta$ is a rate of depreciation. According to Ganev (2005) we assume that the rate of depreciation is $\delta = 0{,}05$.

The application of permanent inventory method for capital stock calculation allows us to calculate the capital stock recursively back in the time. Then, the equation (3) can be rewritten in the following way:

$$K_t = \sum_{i=0}^{n-1}(1 - \delta)^i I_{t-1} + (1 - \delta)^n K_{t-n} \qquad (4)$$

where $n$denotes a fixed moment in time for which we express the initial level of capital stock and $i$ represents the length of time between the actual and initial year.
The initial level of capital stock is given by:

$$K_0 = I_0/\delta \qquad (5)$$

If we assume full depreciation of the capital, the equation (4) becomes:

$$K_t = \sum_{i=0}^{n-1}(1 - i\delta) I_{t-1} + (1 - n\delta)K_{t-n} \qquad (6)$$

In this paper we use the latter formulation for the capital stock (i.e. linear depreciation method according to the equation (5)).

The rate of labour income in the total income is derived as a ratio of the compensation of employees (for which data are available) to the GDP. As the rate of labour income and the rate of capital income give together one, the latter is computed as follows:

$$b_t = 1 - a_t \quad (7)$$

As it was presented in the section 2, neither the economic theory nor the empirical literature allows us to unequivocally identify a set of explanatory variable for productivity determinants. As we have numerous options how to specify an empirical model for explaining the TFP growth in the European Union we face the problem with model uncertainty.

Formally, the generic representation of an empirical model for the TFP growth is the following:

$$y = \beta X + \epsilon \quad (8)$$

where *y* represent a dependent variable (TFP growth), *X* is a matrix of explanatory variables (TFP determinants), $\theta$ is a matrix of estimated parameters and $\epsilon$ are residuals. If we have *K* potential explanatory variables, we will have $2^K$ possible combinations of regressors. It means, there are $2^K$ different models under consideration, each with certain probability of being the correct model (Benito et al. 2011).

The method applied in this paper provides a way to overcome the problem with model uncertainty via the method called Bayesian model averaging (BMA). This method allows us to estimate all the possible models (as combinations of different regressors) from the given set of productivity determinants and assess the importance of each explanatory variable (CompNet Task Force 2015).

With certain simplification, this method consists of four steps. First, assumptions about prior distribution on the model space and parameter space are made. Second, the posterior distribution of each regressor coefficient for every model including that regressor is estimated. Third, a weighted average posterior distribution is calculated from all posterior distributions with weights given by posterior model probabilities. Fourth, the variables are ranked regarding their posterior inclusion probability that could be considered as a robustness measure in BMA approach (Danquah et al. 2013).

More formally (according to Benito et al., 2011), let us we consider $2^K$ possible models indexed as $M_j$ for $j = 1, \dots, 2^K$. The posterior for the parameter given $M_j$ is defined by a posterior, a prior and likelihood for each model in the following form

$$g(\beta^j \,|y, M_j) = \frac{f(y|\beta^j, M_j)\, g(\beta^j\,|M_j)}{f(y|M_j)}. \quad (9)$$

The posterior density of the parameters for all the models is calculated as followings

$$g(\beta|y) = \sum_j^{2^K} P(M_j|y)\, g(\beta|y, M_j) \qquad (10)$$

where $P(M_j|y)$ is a posterior model probability given by

$$P(M_j|y) = \frac{f(y|M_j)\, P(M_j)}{f(y)} \qquad (11)$$

where $P(M_j)$ is a prior model probability.

The posterior inclusion probability (PIP) for the variable *k* is defined as a sum of posterior model probabilities of all models that include that variable:

$$PIP = P(\beta_k \neq 0|y) = \sum_{\beta_k \neq 0} P(M_j|y). \qquad (12)$$

In this paper we apply a static panel regression based on the methodology introduced by Moral-Benito (2011) which is an application of the BACE approach described in Sala-i-Martin (2004) and its panel data version with fixed effects. We use a software package implemented by Blazejowski and Kiatkowski (2015) in GRETL.

Regarding a calibration of the model, we apply the Uniform Model Prior assuming that all models are identically probable a priori. It also means that the prior inclusion probability for the given regressor is set to *0,5* and that the prior expected model size is set to *0,5*K*. With respect to the prior distribution on the parameter space, we apply the Uniform Information. The application of those priors should outperform any other possible combinations (Eicher et al. 2011).[5]

To calculate the total factor productivity growth rate, according to the proposed growth accounting method, the annual data on gross domestic product, gross fixed capital formation, number of employed persons and compensations of employees for the period from 1995 to 2014 were applied. In the second step, the estimated values of the TFP growth were used as dependent variable to conduct the BMA analysis with aim to find out the main determinants of the European TFP growth.

Despite the fact that the BMA can be used for a large set of possible explanatory variables, some criteria for data collection need to be taken in account (CompNet Task Force 2015, p. 66). First of all, the economic theory served as basis for the choice of our explanatory variables. Second, the character of variables and their relevancy for policy makers were taken in account. We focused on long-term indicators rather than those related to business cycle, as the unfavourable trend of the productivity growth constitutes a long-term problem in the European Union. Moreover,

[5] The same assumptions on priors are used in Raftey (1995), Sala-i-Martin et al. (2004), Moral-Benito (2011) or Danquah et al. (2013).

the variables that could not be influenced by policy measures were not be included. Third, as we used a balanced static panel data model, the availability of data for the whole period and all countries was a crucial factor in the selection process. Finally, we considered the statistical properties of selected variables and highly correlated variables were excluded from the dataset. Moreover, with respect to higher robustness of results in model averaging approach in the case of smaller number of regressors (Benito et al. 2011, p. 14) we did not use the variables that represent proxies for the same theory.

In total, 20 explanatory variables were included in the analysis. To approve our assumption about the crucial role of long-term factors, we included the GDP gap in the analysis to control the effect of real GDP fluctuations on the productivity growth. The whole set of variables with short description and information about their sources is reported in the Table 1.

Tab. 1: Description of variables and their sources

| ***Variable*** | ***Source*** | ***Description*** |
|---|---|---|
| ALMP | OECD.Stat | Public expenditures on active labour market policies (% of GDP) |
| Civil liberties | Freedome House | Index of civil liberties (0-7) |
| COE | Eurostat | Compensation of employees |
| Consumption | OECD.Stat | Household consumption expenditure (% of GDP) |
| EPL | OECD.Stat | Strictness of employment protection, index (0-7) |
| FDI | UNCTADstat | Inward flows of foreign direct investments (% of GDP) |
| GCI | Eurostat | Gross fixed capital formation |
| GDP | Eurostat | Gross domestic product |
| GDPgap | Own estimations | Difference between potential and real GDP |
| Infrastracture | OECD.Stat | Transport infrastructure investments (% of GDP) |
| Internet users | WDI | Internet users (per 100 people) |
| L | Eurostat | Number of employed persons |
| l_GDP p.c. | TED | Logarithm of GDP p.c. (PPP, in USD) |
| Life expectancy | WDI | Life expectancy at birth, total (years) |
| Minimum wages | OECD.Stat | Minimum wages relative to median wages |
| Openess | WDI | Export and import as % of GDP |
| Patents | OECD.Stat | Total patent applications |
| Political rights | Freedome House | Index of political rights (1-7) |
| Population density | WDI | People per sq. km of land area |
| Population growth | TED | Population growth (% change) |
| Share of services | WDI | Services (% of GDP) |
| Tertiary education | Eurostat | Population with tertiary education (% of total) |
| TFP | TED | Total factor productivity growth (% change) |
| Trade unions | OECD.Stat | Trade union density |
| U benefits | OECD.Stat | Public expenditures on unemployment (% of GDP) |

Note: TED – Total Economy Database, WDI – World Development Indicators

Source: Own construction.

The interference was executed on 19 member states of the European Union for the period from 1996 to 2014.

## 4 EMPIRICAL RESULTS – TOTAL FACTOR PRODUCTIVITY AND ITS DETERMINANTS

The long-term development of the total factor productivity in the European Union (EU) is unfavorable. Although there was a slightly rising trend of TFP before the global financial crisis, the EU is still less productive than the USA. According to our calculations based on data from Pen World Table the productivity level in the EU, measured by TFP, was just 78% of the US level in 1990 and only 76% in 2010. The average productivity gap of the EU with USA during these 20 years reached 22 percentage points. Looking at the country level data, only three countries (Ireland, Luxembourg, United Kingdom) enjoyed an average TFP level higher than the US level during the period from 1990 to 2010.

Tab. 2: Index of TFP (2005=1) in the member states of the European Union

| *Country* | *1990* | *2000* | *2010* | *Country* | *1990* | *2000* | *2010* |
|---|---|---|---|---|---|---|---|
| Austria | 0,914 | 0,996 | 0,984 | Italy | 1,035 | 1,055 | 0,935 |
| Belgium | 0,967 | 1,009 | 0,959 | Latvia | 0,967 | 0,803 | 0,925 |
| Bulgaria | 1,152 | 0,898 | 0,945 | Lithuania | 1,060 | 0,797 | 0,976 |
| Croatia | 1,071 | 0,857 | 0,964 | Luxembourg | 0,916 | 1,013 | 0,882 |
| Cyprus | 0,809 | 0,968 | 0,979 | Malta | 0,920 | 1,079 | 0,994 |
| Czech republic | 1,089 | 0,913 | 1,058 | Netherlands | 0,918 | 0,986 | 0,997 |
| Denmark | 0,842 | 0,978 | 0,945 | Poland | 0,648 | 0,893 | 1,065 |
| Estonia | 0,866 | 0,851 | 0,931 | Portugal | 1,004 | 1,053 | 0,970 |
| Finland | 0,816 | 0,954 | 0,962 | Romania | 0,767 | 0,734 | 1,014 |
| France | 1,016 | 0,993 | 0,958 | Slovakia | 0,915 | 0,853 | 1,136 |
| Germany | 1,095 | 1,073 | 1,015 | Slovenia | 0,907 | 0,920 | 0,983 |
| Greece | 0,919 | 0,981 | 0,901 | Spain | 1,178 | 1,043 | 0,967 |
| Hungary | 0,874 | 0,868 | 0,963 | Sweden | 0,811 | 0,941 | 0,992 |
| Ireland | 0,829 | 1,098 | 0,915 | United Kingdom | 0,842 | 0,950 | 0,967 |

Source: Own calculations based on The Conference Board Total Economy Database™ (2015a).

However, it is necessary to point out that we can observe certain differences in productivity levels (TFP) among the member states. The indexes of TFP in 1990, 2000 and 2010 for the individual member states are reported in the Table 2. Not surprisingly, the old member states are generally more productive than those with membership acquired after 1995. From the reported data, we can observe another important trend - stagnation of TFP in the majority of countries. Only few countries (for example: Romania or Poland) enjoyed a significant increase in the level of their TFP between 1990 and 2010.

Tab. 3: Average TFP growth rates in the member states of the European Union

| ***Country*** | ***1996 2000*** | ***2001 2005*** | ***2006 2010*** | ***2011 2014*** | ***Country*** | ***1996 2000*** | ***2001 2005*** | ***2006 2010*** | ***2011 2014*** |
|---|---|---|---|---|---|---|---|---|---|
| Austria | 5,26 | -2,00 | -3,21 | 4,01 | Italy | 3,53 | -1,06 | -2,79 | 2,21 |
| Belgium | 3,91 | 2,14 | 2,53 | 2,73 | Latvia | - | 4,73 | 5,08 | 2,92 |
| Bulgaria* | - | 3,93 | 2,92 | -1,86 | Lithuania | - | 5,67 | 5,58 | 2,94 |
| Croatia* | - | 3,45 | 1,29 | -1,09 | Luxembourg | -3,06 | -3,22 | 4,54 | 3,09 |
| Cyprus | - | 3,54 | -3,60 | 1,81 | Malta | - | -3,51 | -2,49 | 1,58 |
| Czech republic | 3,95 | 4,37 | 3,80 | 0,90 | Netherlands | 5,93 | -2,74 | -4,02 | 3,62 |
| Denmark | 4,96 | -2,22 | -3,72 | 3,82 | Poland | 5,53 | 3,61 | -3,03 | 2,48 |
| Estonia | - | 5,76 | 5,94 | 1,36 | Portugal | 4,99 | 2,88 | 2,32 | 4,06 |
| Finland | 5,43 | 1,39 | -3,57 | 1,89 | Romania | 5,47 | 8,47 | -6,96 | 1,52 |
| France | 5,05 | -3,81 | 3,05 | 3,03 | Slovakia | 5,46 | 5,34 | -5,66 | 1,25 |
| Germany | 3,77 | 4,11 | -4,29 | 5,35 | Slovenia | - | 3,73 | -3,17 | 4,12 |
| Greece* | 3,73 | -3,22 | 2,25 | 3,13 | Spain | 4,16 | -1,53 | 2,35 | 2,71 |
| Hungary* | 4,95 | 3,42 | -2,75 | -2,30 | Sweden | 4,94 | 2,23 | 4,27 | 2,05 |
| Ireland | 6,43 | 2,19 | 4,09 | 2,79 | United Kingdom | 4,41 | 3,16 | 2,41 | 4,27 |

Note: *average for 2010-2014 instead of 2011-2014, - data are not available

Source: Own calculation based on the estimations of TFP growth rates.

Regarding the dynamics of the TFP, it shows greater variability among the countries and periods. In the Table 3, we present the averages of estimated growth rates of TFP for the individual member states of the European Union. The estimation of yearly growth rates (from 1996 to 2014) was provided according to the methodology described in the Section 3.

To sum up the main observations from the presented data, three important fact can be mentioned. First, the best results (in terms of the highest productivity growth) were recorded in the second part of 1990s almost in all countries which corresponded with the continuously increasing trend of the TFP level during that period. Second, negative growth rates of TFP, or at least a slowdown in productivity growth, were already observed in the majority of EU member states before the global crisis. Thus, we suppose that the crisis was not the main factor of the falling productivity in the European Union. It more likely constituted a catalyst which revealed the long-term structural problems of the European countries. Third, only few member states reached higher growth rates of TFP in the first part of 2010s than in the 1990s. The latter is alarming in the context of the future development of the European productivity. However, if we want to improve the situation in the European Union, it is inevitable to know the factors which are responsible for this disturbing trend.

The empirical results of Bayesian model averaging for potential determinants of TFP growth in the European Union are presented in the Table 4.

Tab. 4: Determinants of total factor productivity growth – BMA approach

| | ***With fixed effects*** | | | ***Without fixed effects*** | | |
|---|---|---|---|---|---|---|
| ***Variable*** | ***PIP*** | ***Cond.Mean*** | ***Cond.Std.*** | ***PIP*** | ***Cond.Mean*** | ***Cond Std.*** |
| Fixed effects | 0,062 | 0,013 | 0,043 | - | - | - |
| **Internet users** | 0,989 | -0,034 | 0,008 | **0,991** | -0,035 | 0,008 |
| **Population growth** | 0,568 | -1,081 | 0,412 | **0,599** | -1,083 | 0,412 |
| **Openess** | 0,479 | 0,010 | 0,004 | **0,519** | 0,010 | 0,004 |
| ALMP | 0,378 | 1,041 | 0,482 | 0,407 | 1,044 | 0,483 |
| Infrastructure | 0,279 | -1,049 | 0,522 | 0,286 | -1,041 | 0,523 |
| Consumption | 0,251 | -0,061 | 0,038 | 0,253 | -0,060 | 0,039 |
| GDPgap | 0,219 | 0,000 | 0,000 | 0,246 | 0,000 | 0,000 |
| Share of services | 0,177 | -0,056 | 0,034 | 0,192 | -0,056 | 0,034 |
| Life expectancy | 0,185 | -0,174 | 0,116 | 0,179 | -0,166 | 0,118 |
| Patents | 0,106 | 0,000 | 0,000 | 0,116 | 0,000 | 0,000 |
| FDI | 0,110 | 0,020 | 0,017 | 0,108 | 0,020 | 0,017 |
| l_GDP p.c. | 0,088 | -0,505 | 1,117 | 0,096 | -0,514 | 1,114 |
| U benefits | 0,077 | -0,219 | 0,273 | 0,086 | -0,227 | 0,268 |
| Trade unions | 0,065 | 0,006 | 0,011 | 0,072 | 0,006 | 0,012 |
| Minimum wages | 0,061 | -0,428 | 0,956 | 0,066 | -0,398 | 0,961 |
| Tertiary education | 0,059 | -0,002 | 0,043 | 0,063 | -0,002 | 0,043 |
| Population density | 0,055 | 0,000 | 0,002 | 0,060 | 0,000 | 0,002 |
| EPL reg. contracts | 0,052 | 0,040 | 0,295 | 0,058 | 0,036 | 0,295 |
| Civil liberties | 0,050 | 0,059 | 0,427 | 0,058 | 0,067 | 0,427 |
| Political rights | 0,050 | 0,059 | 0,427 | 0,057 | 0,573 | 1,626 |

Source: Own estimations.

The Table 4 reports the posterior inclusion probability (PIP) and the posterior moments conditional on inclusion of a given regressor in the empirical model, i.e. conditional means (Cond.Mean) and conditional standard deviations (Cond Std.), for both versions of panel data models. The variables are considered to be relevant (robust) for explaining TFP growth if their PIP is higher than the prior inclusion probability set to 0,5. Moreover, the variable has a conditional mean significantly different from zero, if the ration of its Cond.Mean to Cond. Std. exceeds two in absolute value. It approximately corresponds to 95 % Bayesian coverage region that did not include zero (Danquah et al. 2013).

The two models under consideration are static panel data model with fixed effect and pooled OLS without fixed effects. Looking at the PIP of the fixed effects in the first model, it seems that the country specific unobserved heterogeneity does not constitute a robust factor of the TFP growth in the European member states. Based on this fact we rely on the results of the second model. One we considered the second model, three variables appeared to be robust, namely (a) number of internet users (proxy for information and communication technologies), (b) population growth and (c) openness. All of these variables have posterior means significantly different from zero.

The results suggest that the most important factors with positive impact on the TFP growth in the European Union is the share of total export and import on GDP (openness). Regarding the relatively high level of openness in many European countries, this result is not surprising. Moreover, this conclusion is in compliance with the economic theory. Foreign trade allows us to introduce foreign technologies and increases the degree of domestic competition having in turn positive impact on the national productivity.

On the contrary, the additional two robust determinants have negative effect on the European TFP growth. Theoretically, a high rate of population growth should have favourable impact on the productivity. In the case of the European Union, the negative impact of this variable could be interpreted as a negative effect of the actual demographic trend in the European countries (declining population growth) on the growth rate of TFP. The result in case of the last robust variable is surprising as we supposed that ICT should have positively influence on the country's productivity. It could be caused by the fact that the users of internet are also those who are students, unemployed or workers in low-productivity sectors. It seems that other proxy for ICT need to be used for proper inference.

With exception of public expenditures on active labour market policies the other variables have the probability of posterior inclusion considerably low. In recent years many European countries have implemented various labour market reforms with aim to increase the flexibility of markets and improve the employment (mainly after the crisis). The sign of conditional mean indicates positive impact of these reforms on the European productivity. We did not find an evidence of an important role of GDP fluctuations measured by GDP gap. The large portion in the European total factor productivity growth is explained by variables with long-term character. The PIP lower than 0,5 confirms our assumptions that the crisis was only a catalyst which revealed the deep-rooted structural problems of the European countries.

## 5 CONCLUSIONS

The total factor productivity is often considered as the most comprehensive method to measure the national productivity. The higher is the total factor productivity of the country the higher is its economic performance and its competitiveness. Therefore, the relatively low level of the European total factor productivity constitutes a serious problem for the European economies.

The aim of this paper was to calculate the total factor productivity growth for the European member states and find out its most significant determinants. Providing the calculations, we created a dataset of the growth rates of total factor productivity for each member states of the European Union for the period from 1996 to 2014. Regarding the presented data, three main conclusions can be mentioned. First, the best results were recorded in the second part of 1990s almost in all countries. Second, negative growth rates of total factor productivity were already observed in the majority of EU member states before the global crisis. Third, only few member states reached higher growth rates of TFP in the first part of 2010s than in the 1990s which is alarming in the context of the future development of the European productivity.

On the contrary to other empirical works dealing with the issue of the European productivity, we were able to consider a large set of possible productivity determinants thanks to the Bayesian Model Averaging method. The empirical results suggest that the most robust factor with positive effect on the European total factor productivity in the analysed period is openness. On the contrary, the other robust factors, namely population growth and number of internet users (proxy for information and communication technologies) have negative impact. Moreover, a considerably high positive impact can be attributed to active labour market policies.

We did not find an evidence of an important role of GDP fluctuations measured by the GDP gap. On the contrary, the empirical results show that the largest portion in the variation of the European total factor productivity growth is explained by variables with long-term character rather than by economic fluctuations. Thus, we conclude that the crisis was only a catalyst which revealed the deep-rooted structural problems of the European countries. If the European authorities wanted to improve the level of productivity in the member states, well defined structural measures should be taken.

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