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# TOTAL FACTOR PRODUCTIVITY CONVERGENCE CASE OF THE WESTERN BALKAN COUNTRIES

## КОНВЕРГЕНЦИЈА УКУПНЕ ФАКТОРСКЕ ПРОДУКТИВНОСТИ АНАЛИЗА ЗЕМАЉА ЗАПАДНОГ БАЛКАНА

**Summary:** *This study examines Total Factor Productivity (hereinafter TFP) convergence in the Western Balkan countries (Republic of Slovenia-SL, Republic of Croatia-CR, Republic of Serbia-SR, and the Republic of Srpska-RS). Our analysis will cover the time period 2000-2018. Our goal here is threefold. First, we will estimate the TFP for selected countries, and to do so, we will apply the growth accounting. Second, we will use the development accounting to test for the unconditional catching up. And third, we will test the country's ability to learn or absorb new technology from the more advanced leader through the "technology gap" and "technology spillovers". In our survey, we will assume, a priori, that most developed country is Slovenia, followed by Croatia, Serbia, and the Republic of Srpska.*

**Keywords:** *Total Factor Productivity; convergence; technology gap; technology spillovers*

**JEL classification:** *O11, O40, O47.*

**Резиме:** *Ово истраживање има за предмет анализу конвергенције Укупне Факторске Продуктивности (у наставку TFP) на узорку земаља Западног Балкана (република Словенија- SL, Република Хрватска- CR, Република Србија- SR и Република Српска- RS). Наша анализа се односи на период 2000-2018. година. У овом истраживању дефинисали смо три циља. Први циљ је да примјеном "рачуноводства раста" утврдимо вриједности TFP-а за наведене земље. Други циљ је да примјеном "развојног рачуноводства" тестирамо присуство тзв. "безусловног сустизања". И трећи циљ подразумјева да тестирамо способност земаља да уче и апсорбују нове технологије од напреднијих земаља кроз "технолошки геп" и кроз "технолошка прелијевања". У истраживању, априори, полазимо од претпоставке да је Република Словенија најразвијенија држава, који слиједе република Хрватска, Република србија и Република Српска, као најмање развијена држава.*

**Кључне ријечи:** *укупна факторска продуктивност; конвергенција; технолошки геп; технолошка прелијевања*  
**JEL класификација:** *O11, O40, O47.*

## 1. INTRODUCTION

The present paper examines the productivity convergence for the Western Balkan countries over last two decades. The convergence, by its very definition, is considered to be a synonymous with reduction in the degree of economic inequality among countries. The main reason for studying the convergence hypothesis is the possibility for reduction and even the near elimination of poverty in the international community.

Ever since Solow's (1957) anthological paper on economic growth, the technology is considered to be a main driving force of economic growth. Yet, one question is still very intriguing for scientist and policymakers. This question focuses on main drivers of the technological progress and more importantly on countries' ability to adopt technology already developed somewhere else.

A number of papers in the literature have been focused on a standard neoclassical growth framework. In this paper, we will rely on the "Schumpeterian" creative destruction mechanisms. According to the "Schumpeterian" creative destruction mechanisms, the innovations are considered to be the main driving force behind the growth in economies at, or close to, the "technology frontier". The countries innovation rate, at the aggregate level, depends on the resources which are devoted to the innovation effort (i.e. R&D and human capital), and on the stock of existing knowledge (knowledge spillovers). According to the "Schumpeterian" creative destruction mechanisms, the main

driving force behind economic growth are the rate of innovation and the rate at which “state-of-the-art” technologies are adopted. Countries that are close to the technology frontier will mainly grow thanks to the introduction of new technologies, whilst the “follower” grouping of countries will derive the largest share of their TFP growth from the adoption of better, but already existing, technologies which are available “at the frontier” (Havik, et al. 2008, 5).

In the sense of the “Schumpeterian” creative destruction mechanisms, the main factors which determine the relative position of countries in the global innovation race are institutions and policies. This kind of framework has a direct impact on countries' relative ability to innovate at the frontier or to adopt existing, leading-edge, technologies. On one hand, the countries that fall behind the frontier would benefit from the institutions and policies which are designed to favor the cost-efficient adoption of existing technologies. On the other hand, countries that are operating at the frontier would gain from policies that promote excellence in higher education and R&D; financial markets that reward risky projects; and regulations that do not put an excessively heavy burden on either incumbent firms or on potential entrants.

The hypothesis of this paper is whether technology can be considered as a channel of productivity growth for a country that falls behind the frontier. Regarding the TFP, our position is close to the “conventional view”. According to the “conventional view” the TFP measure the rate of technical change. Our goal here is threefold. First, we will estimate the TFP for selected countries, and to do so, we will apply the growth accounting. Second, we will use the development accounting to test for the unconditional catching up. And third, we will test the country’s ability to learn or absorb new technology from the more advanced leader through the “technology gap” and “technology spillovers”. In this paper we will estimate the TFP over two last decades.

Our analysis will focus on the following sample: Republic of Slovenia (SL), Republic of Croatia (CR), Republic of Serbia (SR), and Republic of Srpska (RS). These countries have a very similar political and economical past. They were a part of the former Socialistic Federative Republic of Yugoslavia, which has been characterized by central planning. The Republic of Slovenia and the Republic of Croatia are full members of the European Union (EU). The candidate status for the Republic of Serbia was granted in March 2012. The Republic of Srpska, as a part of Bosnia and Herzegovina, has not yet been granted candidate country status.

This paper is organized in the following manner. Section 2 discusses the existing literature and gives some theoretical background. Section 3 provides information on data, model specification and applied methodology. Section 4 presents empirical results and discussion. Section 5 concludes the paper

## 2. THEORETICAL BACKGROUND

Total Factor Productivity (TFP) is the portion of output not explained by the amount of inputs used in production (Comin 2008). The TFP is considered to be the only factor which does not suffer from diminishing returns as other homogeneous inputs typically do. Within the economic literature the different authors have a different stand regarding a TFP. There are three different views of TFP (Lipsej, et al. 2001, 3):

- One group holds that changes in TFP measure the rate of technical change (Law, Krugman, Young). We refer to this as the “conventional view”;
- The second group holds that TFP measures only the free lunches of technical change, which are mainly associated with externalities and scale effects (Jorgenson, and Griliches). We refer to their position as the “J&G view”;
- The third group is sceptical that TFP measures anything useful (Metcalf and Griliches).

As it is already mentioned in the introduction, our position is close to the “conventional view”.

Nicoletti and Scarpetta (2003) have conducted an analysis on a panel of OECD countries on sectoral TFP growth. Their results show that entry liberalisation and privatisation have a positive impact on TFP and that this impact is stronger the further away are countries from the technology frontier. The simple explanation is that the adoption of existing up-to-date technologies was set back by entry regulation and public ownership. If the country is further away from the frontier, this impact is much stronger because the TFP growth is based on adoption rather than on innovation.

Baier (Baier et al. 2006) conducted a survey based on 145 countries over 57 years and found that TFP growth makes an unimportant contribution to average output growth. In the same survey, the TFP growth for the Western European countries and in Newly Industrialised Countries accounts for 18-25% of overall growth. On the other hand, in the Central and Eastern European, Central and Southern Africa, and the Middle East, the TFP growth is negative.

The decomposition of economic growth in the EU countries before and after the introduction of the Maastricht Treaty in 1992 was carried out by Dimelis and Dimopoulou (2002). The TFP growth is found to have been the main source of growth for the time period 1986-1991. However, due to recessions at some point in 1986-1991 which most of the EU countries experienced, the TFP growth generally decelerated in those years.

For the eight Central Eastern European countries, during the catching-up process, the TFP growth contributed more to GDP growth than capital accumulation (Arratibel et al. 2007). For the Central Eastern European countries for the years 1996-2006 the TFP contributes to 25-49% of overall growth. This level contribution from TFP growth is far higher than is often found in fast growing economies.

The analysis of 27 transition economies in Europe for the time period of 1990-2003 was carried out by Rapacki and Prochniak (2009). They have used the perpetual inventory method to evaluate the capital stock. The anchor capital stock is determined simply by setting the capital-output ratio at either 3 or 5. Their results shows that, among the Eastern European countries, Baltic states had the fastest rates of TFP growth. The Czech Republic and Hungary showed the worst performance.

The study carried out by Dombi (2013) includes the crisis period and its immediate aftermath. Dombi used a growth accounting for ten Central and Eastern European countries for the time period 1996-2012. The time period was split into two subperiods: the catching up years 1996-2007, and the crisis years 2008-2012. The study shows that the main driving engine of economic growth is the capital accumulation. This could be due to the low capital intensity and comparatively low TFP growth at the beginning of the sample. For the catching up years 1996-2007, and the crisis years 2008-2012, the results are very different. The study also shows the different results between two group of countries: Visegrad countries and Slovenia, and a group of lesser-developed countries consisting of Bulgaria, Romania, and the Baltic states.

The similar study was carried out by Levenko (Levenko et al. 2019). They have used the growth accounting, based on the sample of 11 EU countries from Central and Eastern Europe for the years 1996-2016. The average growth for the Central and Eastern Europe was from 2.1% to 4.3%, which is higher than in EU15. For the EU15 Western Europe countries, the economic growth was 1.6% for the best-performing countries, which are the Baltic states, Poland and Slovakia, the contribution of growth of the capital was 1.7-2.4 percentage points, which is higher than the contribution of TFP, which was 1.0-1.8 percentage points. For the EU 15 Western Europe countries the contribution of TFP, labor, and capital are equal, but the contribution of the labor contribution in the Central and Eastern Europe countries is negligibly small with the sole exception of Romania. The main source of growth for the Central and Eastern Europe countries is the TFP whose contribution was quite significant. The contribution of TFP varies between 0.63 and 2.45 percentage points, which corresponds to between 26 and 85 percent of the contribution, with a mean of 1.25 percentage points or 39%.

Aghion, et al (2003) have conducted an analysis on the patenting activity of UK firms at the US patenting office. They find that the product market competition has a stronger positive impact on innovation for the firms which are close to the national technological frontier. The interpretation for this conclusion is that the incentives to innovate for firms that have been far from the frontier are reduced by reducing innovators' rents more strongly.

During the global financial crisis of 2008-2009, the capital stock grew at very low rates, but the capital utilization decreased markedly (Levenko et al. 2019). In the post-crisis period, the economic growth has been very slow for the Central and Eastern European countries. The contribution of capital growth and capital deepening to the economic growth was equal. In this period the TFP growth was gone. The catching-up process and the ability of these countries to sustain growth without the increased use of resources were held back in the absence of the TFP growth (Vuegelers 2011).

The aggregate TFP determinants in a panel of OECD countries were analyzed by Vandebussche et al. (2005) and their results show that that high-skilled human capital has a positive effect on TFP growth, an effect which is stronger the closer a country is to the technology frontier.

Ioannis (2011) tested the hypothesis whether technology is a conduit of productivity growth for a country that falls behind the frontier, based on two EU members which form the periphery and the core of Europe, Germany, and Greece. The results of the analysis show that the speed of technology transfer is very slow, below the other findings in the literature. The high technological gap between Greece and Germany can be explained, to a large degree, by the low speed of technological convergence.

### 3. MODEL SPECIFICATION AND METHODOLOGY

The first goal of the present paper is to estimate the TFP for selected countries. The estimation of the TFP can be carried out by applying econometric or mathematical models. Even though our sample contains countries that have a very similar political and economic past, in the present our sample is very heterogeneous regarding structural and institutional factors affecting productivity. Two countries from our sample are full members of the EU (SL and CR). The candidate status for the Republic of Serbia was granted in March 2012. The Republic of Srpska, as a part of Bosnia and Herzegovina, has not yet been granted candidate country status. The Republic of Srpska is still in a transition process that has not yet been finished. For the two EU members, the sufficiently long and dependable data series are easily obtainable. But, the characteristic for the RS and SR is the lack of sufficiently long and dependable data series. With all this in mind, it would be very difficult to construct a production function with stable, and comparable parameters. So, the estimation of the TFP by applying the econometric models is ruled out. For all these reasons we will apply the growth accounting, based on value-added (here and after GVA) to estimate the TFP.

The growth accounting is based on the neoclassical production function:

$$Y = f(K, L, A) \quad (1)$$

Where Y is the volume of production (in our case the GVA), K is volume capital, L is labor (number of workers) and A is the TFP. In the case of the standard Cobb-Douglas production function we have:

$$Y = AK^\alpha L^\beta \quad (2)$$

The standard Cobb-Douglas production can be rearranged as:

$$\Delta \log Y = \Delta \log A + \alpha \Delta \log K + \beta \Delta \log L \quad (3)$$

From the equation (3), the TFP, as a rate of the technological progress, can be calculated in the form of the residual. Here, we assume the constant return to the scale,  $\alpha + \beta = 1$ . We define parameters  $\alpha$  and  $\beta$  as the factors marginal (social) products:

$$\alpha = \partial Y / \partial K \quad K/Y \quad (4)$$

$$\beta = \partial Y / \partial L \quad L/Y \quad (5)$$

In the present paper we will assume that factors are paid their full marginal products so that  $\alpha$  and  $\beta$  represent the share of capital and labour in the realized GVA. The share of labour  $\beta$ , can be calculated as (Batini, et al, 200):

$$\beta = WN/PY \quad (6)$$

The W stands for labour cost per employee, N is employment, P is the GDP deflator at factor cost, and Y is national income. According to the US Bureau of Labor Statistics, the share of labour  $\beta$ , can be calculated as (BLS 2017):

$$\beta = (EC + PC)/O \quad (7)$$

Where EC represents the employee compensation, PC is for proprietors labour compensation, and O stands for Output. In the case of Bulgaria, Ganev (2005) applied the following equation to calculate the share of labour  $\beta$ :

$$\beta = (COE + NMI)/GDP \quad (8)$$

In the previous equation, the COE represents the compensation of employees, and the NMI stands for the net mixed income. In our paper, we will use the Compensation of employees as a percentage of GDP, published by EUROSTAT and official national statistics offices, as a proxy for labour share. Compensation of employees is defined as the total remuneration, in cash or in kind, payable by an employer to an employee in return for work done by the latter during the accounting period and it consists of wages and salaries, and of employers' social contributions (EC Europa 2020). According to the Republic of Srpska institute of statistics, the compensation of employees consists of gross wages and salaries, including employees' taxes and social contribution (RZS 2019). The two previous definition are basic. In the present paper, we will use the expression (3) to calculate the TFP as a residual.

In order to assess the capital volume, the perpetual inventory method (PIM) was used. The perpetual inventory has been used very often in many studies for assessment of the capital stock, and it can be described with equation:

$$K_t = I_t + (1 - \delta)K_{(t-1)} \quad (9)$$

Where I stands for investments and  $\delta$  stands for the depreciation rate and the subscript t represents the beginning of the time period t, and t-1 is for the previous time period. All other variables have the same meaning as in expression (1). Before we estimate the capital stock, we will assess the anchor capital stock. There are several methods used in many studies for assessment of initial capital volume.

The first method was proposed by Ganey (2005a and 2005b):

$$K_0 = \frac{I_0}{\delta} \quad (10)$$

Where  $K_0$  represents the initial capital stock, and  $I_0$  stands for the investments in the anchor period. The other variables have the same meaning as in previous equations.

Second method was proposed by Easterly and Levine (2001):

$$K_0 = \frac{Y_0 \sum_0^T \frac{(I/Y)}{T}}{\sum_0^T \frac{\Delta Y}{Y} + \delta} \quad (11)$$

Where T stands for time, and The other variables have the same meaning as in previous equations.

The third method was proposed by Kyriacou (1991):

$$K_0 = \frac{I_0}{\sum_0^T \frac{\Delta I}{I} + \delta} \quad (12)$$

All variables have the same meaning as in previous equations.

The expression (9) can be rearranged in order to get a geometric depreciation method:

$$K_t = (1 - \delta)^t K_0 + \sum_{i=0}^{t-1} (1 - \delta)^i I_{t-i} \quad (13)$$

In the expression (13), the  $n$  is the fixed moment in time, from which we take the initial capital stock. The geometric depreciation method implies that even with  $n \rightarrow \infty$  the amortized value of initial capital will never be equal to zero. For the purpose of this analysis, we assume that capital has to have a finite life. If we rearrange the expression (9) we get a linear depreciation method:

$$K_t = (1 - t\delta)K_0 + \sum_{i=0}^{t-1} (1 - t\delta)I_{t-i} \quad (14)$$

In this way, we have ensured a linear reduction of the initial capital, and the value of investments that are made between the initial and the present moment. The linear depreciation method implies that the capital stock will be a fully depreciated for  $1/\delta$  periods. The current capital stock is the

weighted sum of initial capital value,  $K_0$ , and intervening investment expenditures, with weights corresponding to their undepreciated components (Burda et al, 2008).

The depreciation rate plays a key role in order to determine the anchor capital volume, and for estimating the capital stock from period to period. For the purpose of our analysis, we assume that the depreciation rate is constant over the period and across countries, and we set the depreciation rate at 0.05. Our decision is not arbitrary. The depreciation rate is set within the range between 0.04 and 0.10 in many studies and papers in literature (Vanags and Bems 2005; Griliches 1980; Nehru and Dhareshwar 1993; Romer 1988; Kamps 2006; Berlemann and Wesselhöft 2014; Harberger 1988; Nadiri and Prucha 1996). The examples of studies with the depreciation rate at 0.05 are De la Fuente and Doménech (2006), Hernandez and Mauleon (2003) for the economy of Spain, Cororaton (2002) for the Philippines, and Felipe (1997) for a group of countries in East Asia, Borovic, et al (2013) for the real sector of the Republic of Srpska, and Pucar, et al (2013) for the Republic of Croatia, Republic of Serbia, and for Bosnia and Herzegovina.

In our paper, we will use the expression (10) to estimate the initial capital volume, and a linear depreciation method to obtain the current capital stock. We assume the full capital utilization.

The second goal of the present paper is to use the development accounting to test for the unconditional catching up. The development accounting will enable us to identify how much of the crosscountry income variance can be attributed to the differences in factor accumulation and factor productivity.

We define:

$R_i^y$  the ratio of output per worker in country  $i$  to output per worker in the country  $t$ ;

$R_i^p$  the ratio of productivity in country  $i$  to productivity in the country  $t$ ;

$R_i^f$  the ratio of factor accumulation in country  $i$  to factor accumulation in the country  $t$ ;

The relationship between these variables can be described as:

$$R_i^y = R_i^p * R_i^f \quad (15)$$

We can rewrite the expression (15) in logarithmic form:

$$\ln(R_i^y) = \ln(R_i^p) + \ln(R_i^f) \quad (16)$$

To perform a variance decomposition exercise in order to measure the contributions of factor accumulation and productivity to income dispersion, Klenow et al. (1997) suggested the following procedure:

$$\text{var}(\ln(R_i^y)) = \text{var}(\ln(R_i^p)) + \text{var}(\ln(R_i^f)) + 2\text{cov}(\ln(R_i^p), \ln(R_i^f)) \quad (17)$$

According to Klenow et al. (1997), half of the covariance term is assigned to the factor of accumulation, and the other half to the productivity. Thus:

$$F(A) = \frac{(\text{var}(\ln(R_i^p)) + \text{cov}(\ln(R_i^p), \ln(R_i^f)))}{\text{var}(\ln(R_i^y))} \quad (18)$$

$$F(X) = \frac{\text{var}(\ln(R_i^f)) + 2\text{cov}(\ln(R_i^p), \ln(R_i^f))}{\text{var}(\ln(R_i^y))} \quad (19)$$

Where  $F(A)$  represents fraction of income variance due to productivity, and  $F(X)$  is fraction of income variance due to factor accumulation. Under the model hypothesis that A is exogenous, the covariance term in expression (17) should be zero.

To test for the unconditional catching up we will apply the coefficient of variation on selected variables for the time period 2000-2019.

The third goal is to test the country's ability to learn or absorb new technology from the more advanced leader through the ``technology gap`` and ``technology spillovers``. In the present paper, we will apply a reduced form of the basic innovation-imitation model. In this model, we will regress the TFP growth on two key explanatory variables (Havik et al. 2008, 6):

- a measure of the technology gap (i.e. the distance between the TFP of the country analysed and that of the country with the highest level of efficiency); and
- an estimate of the growth rate of TFP at the frontier (i.e. the TFP growth rate of the most efficient country).

The first variable, the technology gap, describes the countries ability to learn or absorb new technology from the more advanced leader. The second variable, the growth rate of TFP at the frontier, describes how much of the TFP growth in a country that falls behind the frontier can be explained by the extent of innovation and knowledge spillovers which are taking place in the technologically most advanced country.

Due to the objective lack of data, and because of a small size of our sample, we were unable to construct a steady state model for all four countries.

#### 4. DATA, RESULTS AND DISCUSSION

We will conduct our analysis on following Western Balkan countries for the time period 2000-2018: Republic of Slovenia (SL), Republic of Croatia (CR), Republic of Serbia (SR), and Republic of Srpska (RS). Variables, their definition and sources are presented in Table (1).

*Table 1 Variables description*

Variable	Description	Source
Y	GVA - Chain linked volumes (2005), million euro; GVA is defined as GDP less intermediate consumption (for the RS in the previous years prices)	EUROSTAT (for the RS-Republic of Srpska institute of statistics)
y	Output per worker; calculated as GVA per employee	Authors calculation
I	Gross fixed capital formation, the chain linked volumes (2005), in millions of euros (for the RS the current prices)	EUROSTAT (for the RS-Republic of Srpska institute of statistics)
K	Capital Stock	Authors calculation
k	Capital/labor ratio	Authors calculation
L	Employment type: Harmonized ILO definition (in millions)	Penn World Table (for the RS-Republic of Srpska institute of statistics)
$\alpha$	Capital share as a percentage of GDP	Authors calculation
$\beta$	Labor share: Compensation of employees as a percentage of GDP	EUROSTAT (for the RS-Republic of Srpska institute of statistics; for the SR-Penn World Table)
TFP	Total Factor Productivity	Authors calculation
F(A)	Fraction of income variance due to productivity	Authors calculation
F(X)	Fraction of income variance due to factor accumulation	Authors calculation

Source: Author calculation

For the SL, CR and SR we have collected data for the whole time period 2000-2018. For the RS, due to the objective lack of data, we could not calculate the capital stock for the whole time period. Thus, the comparison between RS and the rest of the sample would not reflect the true state of things. If we want comparable data, the estimation of initial capital must be in the same year for the whole sample, and all the data must be in the same unit (chain linked volumes (2005), million euro).

This is not a case for the RS. For all of this reasons, we will not compare the RS with the rest of the sample.

The descriptive statistic for the GVA per employee, and for the capital/labor ratio are presented in table (2).

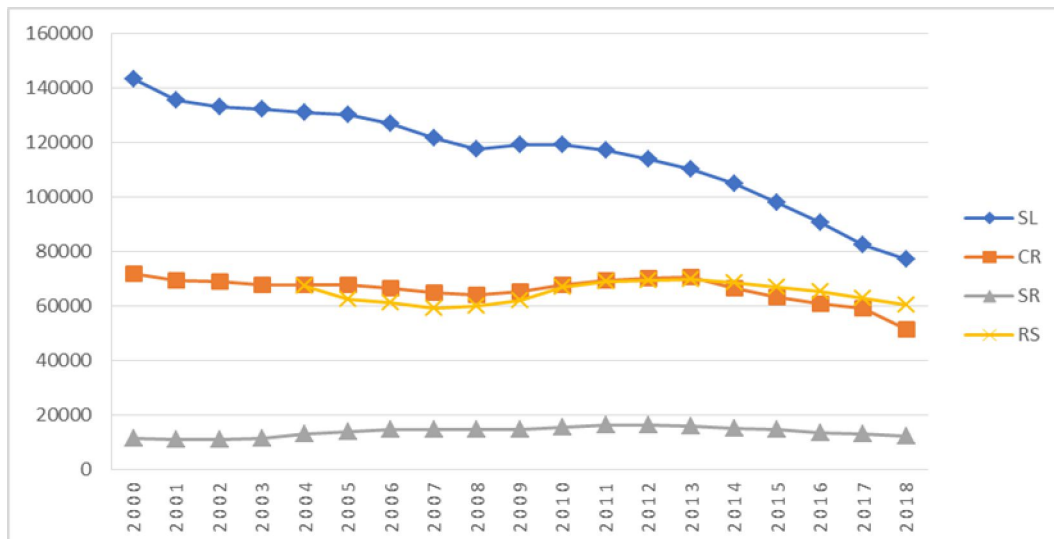
Table 2: Descriptive statistic for the capital/labor ratio and output per worker

Country	Variable	Obs	Mean	Std. Dev.	Min	Max
SL	Y/L	19	28560.09	2735.949	23176.15	33238.15
	K/L	19	116092.9	18402.86	76992.98	143599.3
CR	Y/L	19	19095.89	1502.266	15523.98	21543.58
	K/L	19	65952.28	4787.632	51527.08	71853.02
SR	Y/L	19	6280.145	1224.821	3731.752	7429.286
	K/L	19	13736.44	1777.375	10813.59	16388.37
RS	Y/L	18	25249.01	6470.142	13853.64	33114.21
	K/L	15	64758.85	3796.138	59038.39	69675.64

Source: Author calculation

Slovenia has the highest level of output per worker, and capital/labor ratio.

Graph 1: Capital/labor ratio for selected countries



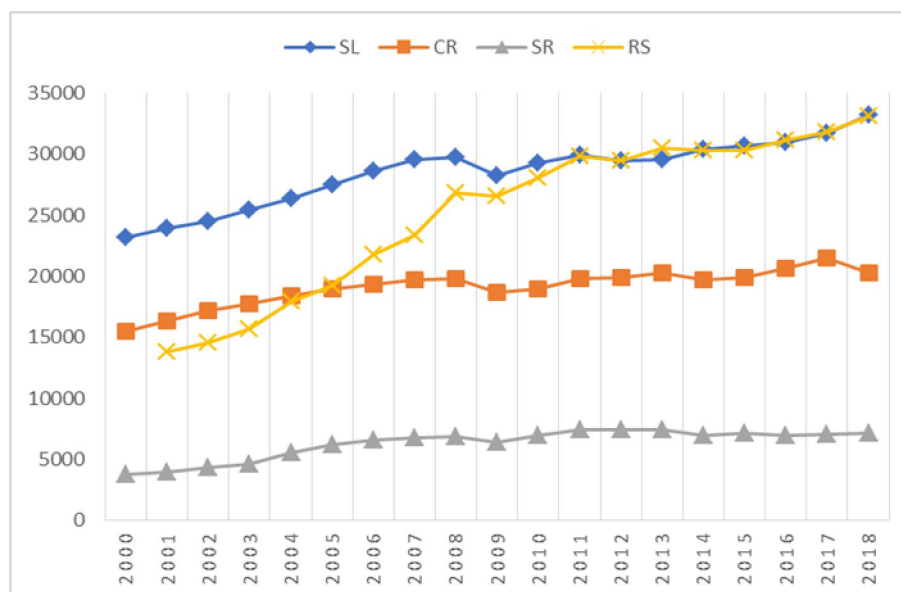
Source: Author calculation

Slovenian and Croatian capital/labor ratio is decreasing, and they tend to converge in the following years. The capital/labor ratio for the Republic of Srpska is almost at the same level as it is for Croatia, and it follows the same pattern. It would be wrong to conclude that the Croatia and the Republic of Srpska has the same level of technology per employee. The capital for the RS is not comparable with the rest of the sample, the data on investments are in current prices, and the employment in the RS is 6.5 times less, on the average, than in CR. In RS the capital/labor ratio is almost constant over the time. The capital/labor ratio for the SR is lowest, and it is almost constant over the time.



The output per worker is presented on the Graph (2).

Graph 2: GVA per employee for selected countries

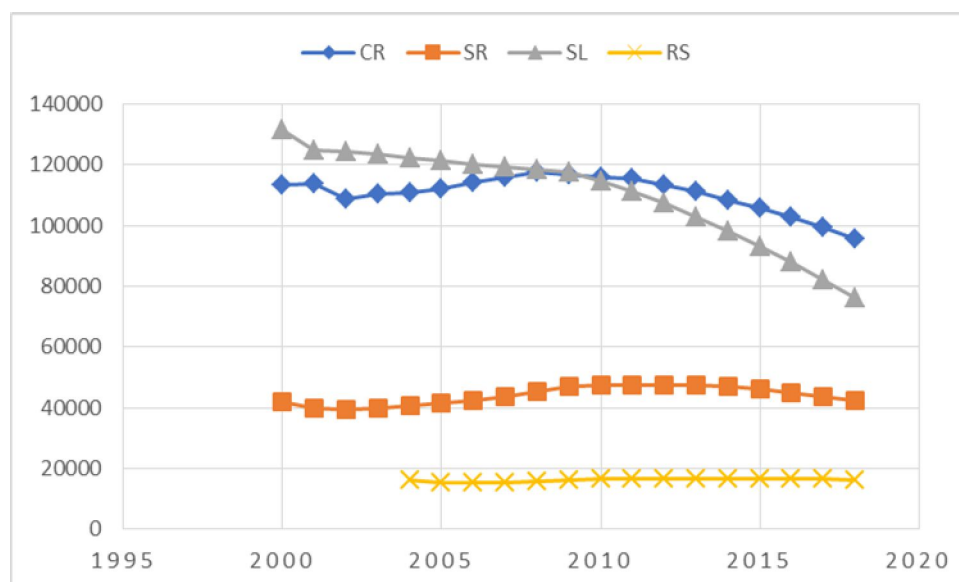


Source: Author calculation

For Slovenia and Croatia, the GVA per employee is increasing, with a tendency to diverge, in contrast to the capital/labor ratio, in the following years. For the RS, the GVA per employee is constantly increasing. For the SR, the GVA per employee is almost monotonically increasing.

The data on the capital stock are presented on the Graph (3).

Graph 3: Capital stock for selected countries

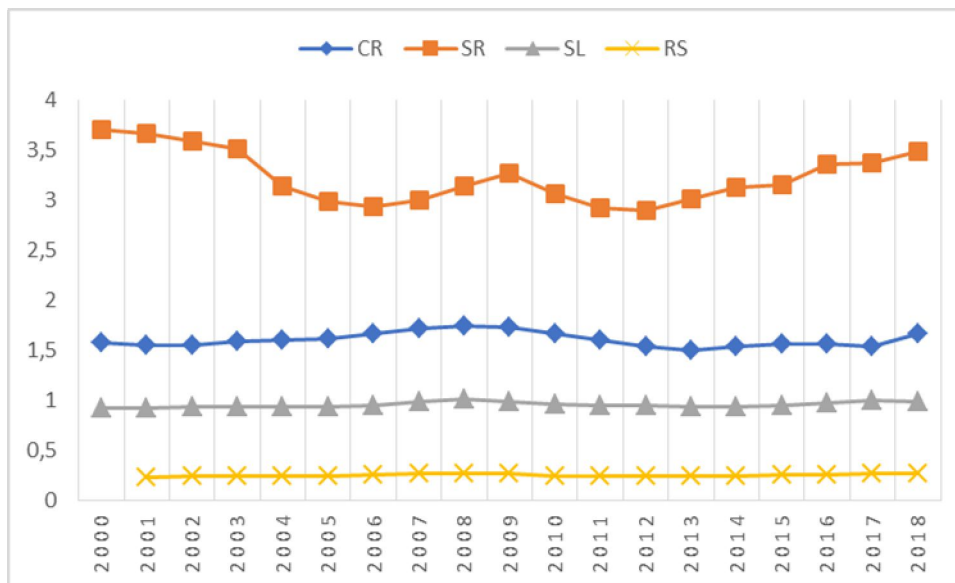


Source: Author calculation

For Slovenia and Croatia, the capital stock is constantly decreasing, in 2010 the capital stock for these two countries is equal, and from 2010 Slovenian capital stock is decreasing at a higher rate than the Croatian capital stock. For the RS and SR, the capital stock is basically constant over time.

The data on the labor force are presented on the Graph (4).

Graph 4. Labor force for selected countries

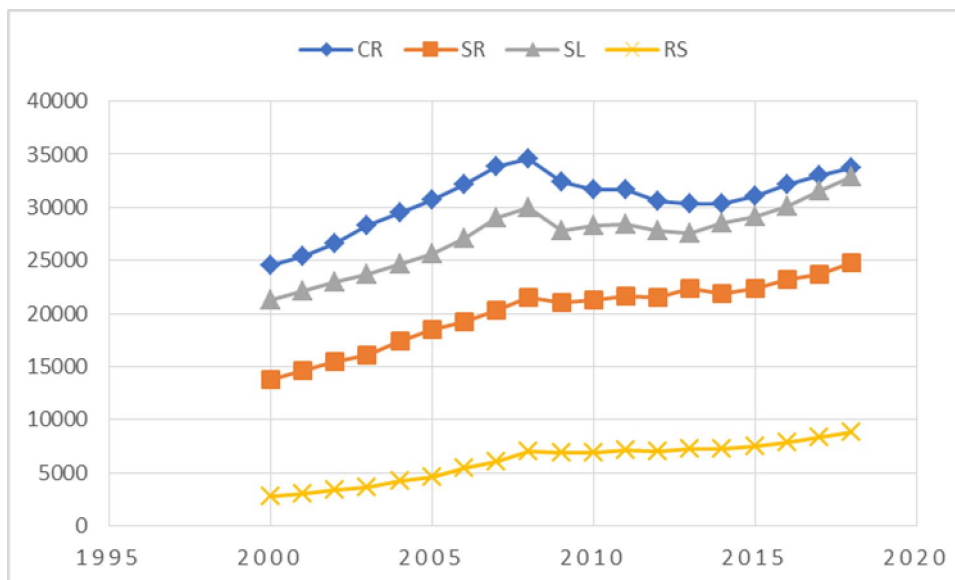


Source: Author calculation

Both Slovenia and Croatia are far behind Serbia regarding the labor force. But, nonetheless, Slovenian labor productivity is constantly increasing. With Slovenian capital/labor ratio and capital stock constantly decreasing, their workers are far more productive than the workers in other countries.

The data on GVA are presented on Graph (5)

Graph 5. GVA for selected countries



Source: Authors calculation

The GVA is constantly increasing for the whole sample during the time period. For Croatia and Slovenia, the GVA follows the same pattern, and they tend to completely converge in 2020. The capital stock and GVA for Slovenia and Croatia are following almost the same pattern with a tendency to completely converge in the following years. The difference in the labor force for these two countries is almost constant over the time period. And, yet, their average productivity tends to diverge.

The first goal of our paper is to calculate the TFP. The data on the TFP are presented in Table (3).

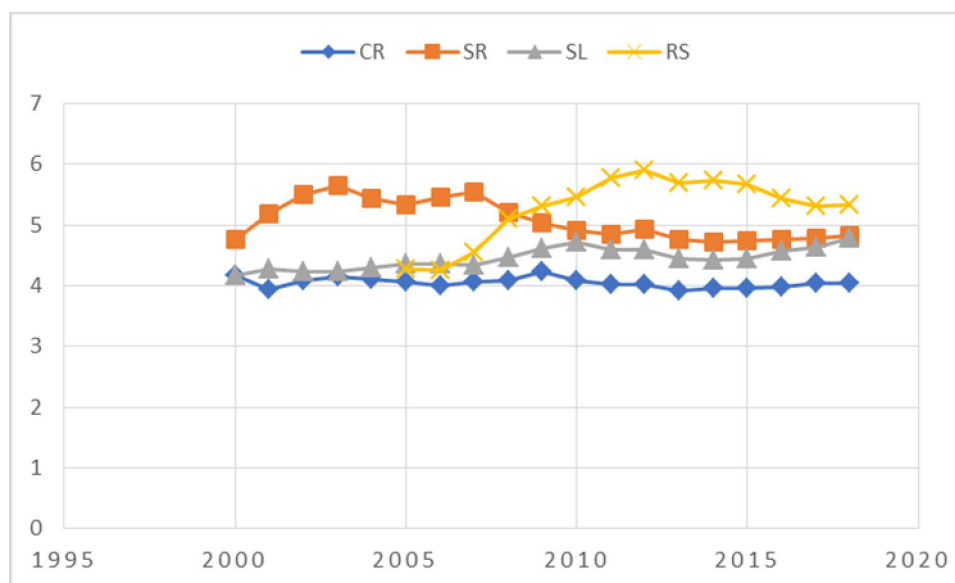
Table 3: TFP for the selected countries (in logs)

Country	Obs	Mean	Std. Dev.	Min	Max
cr	19	4.047921	0.080978	3.921491	4.225316
sr	19	5.070764	0.324513	4.714376	5.645354
sl	19	4.446665	0.175182	4.172862	4.774467
rs	14	5.271562	0.541958	4.258989	5.900795

Source: Author calculation

The data on the TFP are presented on the Graph (5).

Graph (5). TFP for selected countries (in logs)



Source: Author calculation

Until 2010, Slovenian and Croatian TFP are almost at the same level, and they follow the same pattern. From 2010, they tend to diverge. It seems that TFP for these two countries follows the same pattern as their output per worker. The conclusion based on data presented in Table (3), and on Graph (5) is that Serbia is a country with the highest level of productivity. This kind of conclusion would be wrong.

The GVA in Serbia is 65% of the value in Croatia, and 73% of the value in Slovenia, on average. When analyzing the capital stock, the relative difference is even bigger. The capital stock in Serbia is 41% of the value in Croatia, and 39% of the value in Slovenia, on average. The economy in Serbia is mostly labor-intensive. The factor share in realized GVA for Serbia are 38% and 62%, on average, for capital and labor respectively. For Slovenia the factor share is 50%:50%, on average, and for Croatia, the factor share in realized GVA is 52% and 48%, on average, for capital and labor respectively. The labor force in Serbia is twice higher than in Croatia and almost four-time higher than in Slovenia. Serbia is behind Croatia and Slovenia regarding capital/labor, and output per worker. With all this in mind, mathematically, the TFP in Serbia has to be the highest, regarding the relative difference in capital stock, and the labor-intensive nature of Serbia's economy. The problems in the measurements themselves could be a reason for the high level of the TFP in Serbia. The growth accounting is based on many assumptions, which are not fully met, especially in Serbia which has been granted the candidate status in march 2012. For all of these reasons, the TFP in Serbia is mathematically at the highest level.

The second goal of our paper is to apply development accounting to test for the unconditional catching up. The unconditional catching up refers to those countries that have been shown to have experienced some degree of convergence in the variable in question, without correcting for the influence exercised by other pertinent variables (Baumol et al. 1994, 200). Explained convergence

refers to statistical evaluation of the role of pertinent and measurable variables that can reasonably be expected to influence the time path and degree of convergence experienced by some economies (Baumol et al. 1994, 200). The data on development accounting are presented in Table (4).

Table 4: Development accounting

Average 2000-2018				
Country	y	k	$K^{\alpha}L^{\beta}$	TFP
SL	1	1	1	1
CR	0.67	0.57	1.66	0.66
SR	0.22	0.12	0.39	1.94
Coefficient of variation (whole sample)				
2000-2005	0.710723	0.667462	0.854441	0.65717
2006-2011	0.565079	0.653831	0.785109	0.608151
2012-2018	0.376228	0.558938	0.712565	0.611109
Coefficient of variation (SR excluded)				
2000-2005	0.122766	0.234362	0.455163	0.259456
2006-2011	0.298008	0.39106	0.409929	0.286921
2012-2018	0.388258	0.431162	0.294206	0.291144

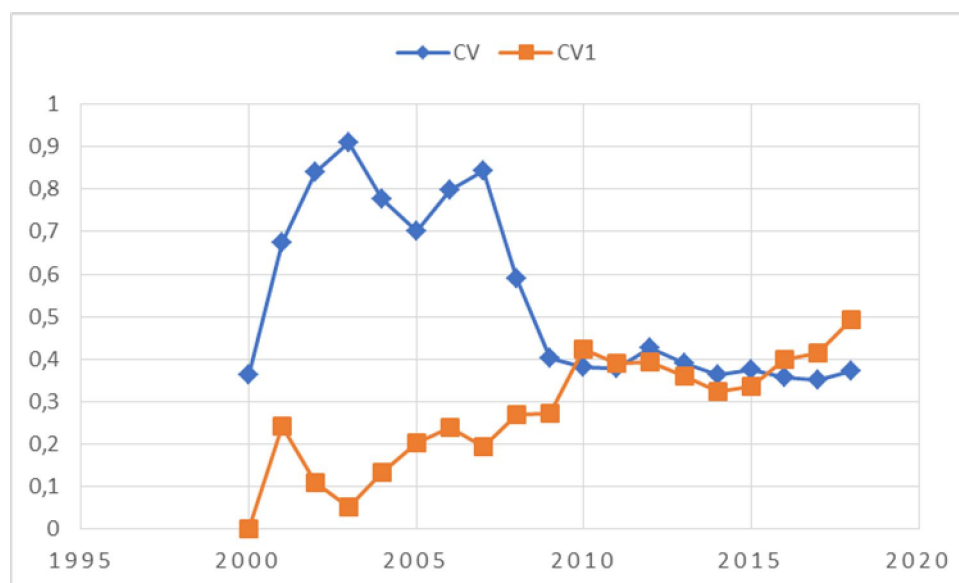
Source: Author calculation

Croatia has a lower level of physical capital per worker and a lower level of output per worker than Slovenia does. In terms of factor accumulation, Croatia is better off. But comparing productivity, we find that Croatia is at only 66% of the Slovenia level and thus is significantly poorer than Slovenia.

Serbia is far behind Slovenia regarding output per worker capital/labor ratio and factor accumulation. But, regarding productivity, Serbia is 94% off Slovenia. Even though Serbia is 94% off Slovenia level of productivity, Serbia is significantly poorer than Slovenia.

When analyzing the coefficient of variation for the TFP, on six years average for a whole sample, we find a decline, which indicates the convergence process. But, when we exclude Serbia, then, we find the increase in the coefficient of variation, which indicates the divergence process. The coefficient of variation, regarding the TFP for the whole sample, and for Slovenia and Croatia are presented on Graph (6).

Graph (6). The coefficient of variation for the TFP



Source: Author calculation

Where CV stands for the coefficient of variation for the whole sample, and CV1 stands for the coefficient of variation for Slovenia and Croatia. Regarding the TFP, for a whole sample, the

coefficient of variation increases until 2007, when it starts to decline. But, when we exclude Serbia, the coefficient of variation is constantly increasing, which indicates the divergence process.

Based on the available data we conclude that the productivity is responsible for 35% of the variation in income per capita and that factor accumulation is responsible for 65%. These results must not be taken lightly. The main limitation is a small sample, which contains only three countries. And, there is an unusual high TFP in Serbia. For all of this, the results of the variance decomposition should not be taken for granted.

The third goal of our paper is test the country's ability to learn or absorb new technology from the more advanced leader through the ``technology gap`` and ``technology spillovers``. Here, we will regress the TFP growth rates on the TFP growth rate of the leader, and on the TFP gap:

$$\Delta \log TFP = \beta_1 \overline{TFP} + \beta_2 T\dot{F}P \quad (20)$$

Where  $\overline{TFP}$  is the TFP gap, defined as the difference between each country's estimated TFP and the leader's TFP, and  $T\dot{F}P$  is the growth rate of TFP at the frontier. The fraction of the gap that is closed each year is measured by the parameter  $\beta_1$ . The sample leader is Slovenia, i.e. all countries in the sample, Croatia and Serbia, learn from the leader. While Slovenia does not always have the highest absolute TFP levels, it is still used as the regional leader because it has managed to maintain consistent output per worker growth for much longer periods than any other country. Here, we will use a panel OLS regressions as estimation method, and robust standard errors with respect to heteroschedasticity and possible correlation within countries. According to Hausman test, the random effect is the best estimator for our data. The results are presented in Table (5)

Table 5: Panel analysis

TFP	Coeff.	Robust Std. Err.	P	95% Conf. Interval	
Technological gap	-.0864513	.1433261	0.014	-.3673652	.1944627
TFP growth at the frontier	-.0445077	.0182049	0.5578	-.0801887	-.0088267
Constant	-.0032617	.0156262	0.3294	-.0338885	.0273651
R sq.	0.20				

Source: Author calculation

A significantly negative relationship between TFP growth and the gap in technology is in line with empiric literature. It appears, that for our sample, the TFP growth is driven only by the technology gap variable, with a nonsignificant impact from the growth at the frontier.

## 5. CONCLUSION

The goal of our survey is threefold: first, we will estimate the TFP for selected countries, and to do so, we will apply the growth accounting, second, we will use the development accounting to test for the unconditional catching up, and third, we will test the country's ability to learn or absorb new technology from the more advanced leader through the ``technology gap`` and ``technology spillovers``. In present paper we have tested hypothesis whether technology can be considered as a channel of productivity growth for a country that falls behind the frontier. The time period of the analysis is set for the two last decades.

We have focused our analysis on the following sample: Republic of Slovenia (SL), Republic of Croatia (CR), Republic of Serbia (SR), and Republic of Srpska (RS). These countries have a very similar political and economical past. They were a part of the former Socialistic Federative Republic of Yugoslavia, which has been characterized by central planning. The Republic of Slovenia and Republic of Croatia are full members of the European Union (EU). The candidate status for the Republic of Serbia was granted in March 2012. The Republic of Srpska, as a part of Bosnia and Herzegovina, has not yet been granted candidate country status. The main limitations were a very small sample, only four countries and the incomparable data for the RS.

Due to the incompatibility of the data, the results for the RS were not compared with the rest of the sample. Regarding the capital/labor ratio, output per worker, GVA, and capital stock, Slovenia

outperforms Croatia and Serbia. But in terms of the labor force, Serbia is far beyond the rest of the sample.

We have calculated the TFP by applying growth accounting. Surprisingly, Serbia has the highest level of the TFP, with Slovenia, and Croatia behind. We have stressed numerous reasons why, in our opinion, the TFP is mathematically at the highest level in Serbia, which does not reflect the true state of productivity in Serbia.

We have applied the development accounting to test for the unconditional catching up. Firstly, we have tested for the unconditional catching up for the full sample. Secondly, we have tested for the unconditional catching for Croatia and Slovenia only. We have left out Serbia due to very high level of the TFP. In first case we have found strong evidence for convergence in TFP. In second case, we have found strong evidence for divergence in TFP.

To test for the country's ability to learn or absorb new technology from the more advanced leader through the "technology gap" and "technology spillovers", we have applied panel OLS regressions as the estimation method, and robust standard errors with respect to heteroscedasticity and possible correlation within countries. According to the Hausman test, the random effect is the best estimator for our data. We find strong evidence the TFP growth is driven only by the technology gap variable, with a nonsignificant impact from the growth at the frontier. Thus, our hypothesis is confirmed.

We can conclude that for Western Balkan countries, the TFP growth has been driven by the adoption of existing up-to-date technologies, and less by innovation activity. These results could indicate that the extent of catching-up across our sample is growing stronger over time.

## REFERENCES

- Aghion, Philippe, Nick Bloom, Richard Blundell, Rachel Griffith, and Peter Howitt. 2005. "Competition and innovation: An inverted-U relationship". *Quarterly Journal of Economics* 120(2): 701-728. <http://dx.doi.org/10.7910/DVN/24223>.
- Arratibel, Olga, Heinz, Frigyes Ferdinand, Martin Reiner, Przybyla Marcin, Serafini, Roberta, Zumer, Tina and Rawdanowicz, Lukasz. 2007. "Determinants of Growth in the Central and Eastern European EU Member States - A Production Function Approach". ECB Occasional Paper 61. Available at SSRN: <https://ssrn.com/abstract=977351>.
- Baier, Scott, Gerald P. Dwyer jr. and Robert Tamura. 2006. "How important are capital and total factor productivity for economic growth?" *Economic Inquiry* 44 (1): 23-49.
- Baumol, William, Nelson, Richard R. and Wolff, Edward. 1994. *Convergence of Productivity: Cross-National Studies and Historical Evidence*. Oxford University Press, <https://EconPapers.repec.org/RePEc:oxp:obooks:9780195083903>.
- Berlemann, Michael and Jan-Erik Wesselhöft. 2014. "Estimating aggregate capital stocks using the perpetual inventory method: New empirical evidence for 103 countries". *Review of Economics* 65(1): 1-34.
- BLS. 2017. *U.S. Bureau of Labor Statistics*. U.S. Bureau of Labor Statistics. February 1. <https://www.bls.gov/opub/mlr/2017/article/estimating-the-us-labor-share.htm>.
- Borović, Zoran, and Darko Milunović. 2013. "Measuring TFP: Growth accounting for the real sector of the economy in the republic of Srpska." *Industrija* 41: 87-108.
- Burda, C. Michael and Battista Severgnini. 2008. *Solow Residuals without Capital Stocks*. Berlin: Humboldt-Universität zu Berlin
- Comin, Diego. 2008. *Total Factor Productivity In The New Palgrave Dictionary of Economics*. Edited by Steven Derlauf and Larry Blume, U.K: Palgrave Macmillan.
- Cororaton, Caesar. 2002. *Total Factor Productivity in the Philippines*. Philippine Institute for Development Studies.
- De Le Fuente, Angel and Rafael Doménech. 2006. "Human capital in growth regressions: How much difference does data quality make." *Journal of the European Economic Association* 4 (1): 1-36.
- Dimelis, Sophia and Maria Dimopoulou. 2002. "Evaluating productivity growth measures in the EU". *Economics of Planning* 35(2): 161-181. doi: 10.1080/14631377.2018.1460713
- Dombi, Ákos. 2013. "Economic growth and development in Central and Eastern Europe after the transformation." *Public Finance Quarterly* 58(4): 452-468.
- Easterly, William and Ross Levine. 2001. "It's Not Factor Accumulation: Stylized Facts and Growth Models", Central Bank of Chile Working Paper 164. doi: 10.2139/ssrn.269108.
- EC Europa. 2020. *Compensation of Employees - Annual Data, Million Units of National Currency (tipslm13)*. Accessed December 25. [https://ec.europa.eu/eurostat/cache/metadata/en/tipslm13\\_esms.htm](https://ec.europa.eu/eurostat/cache/metadata/en/tipslm13_esms.htm).

- Felipe, Jesus. 1997. *Total Factor Productivity Growth in East Asia: A Critical Survey*. Asian Development Bank.
- Ganev, Kaloyan. 2005a. "Can Educational Attainment Explain Total Factor Productivity? Growth Accounting Evidence from Seven Transition Countries for the Period 1991-2000." *Journal of World Economic Review* 2 (1): 1-23. doi: 10.2139/ssrn.2025900.
- Ganev, Kaloyan. 2005b. "Measuring Total Factor Productivity: Growth Accounting for Bulgaria", *Bulgarian National Bank Discussion Paper* 48/2005. doi: 10.2139/ssrn.2025902.
- Griliches, Zvi. 1980. "R&D and the productivity slowdown." *American Economic Review* 70(2): 343-348.
- Harberger, Arnold. 1988. "Perspectives on capital and technology in less-developed countries", *Estudios de Economía* 15(1): 1-24.
- Havik, Karel, Kieran Mc Morrow, Werner Röger and Alessandro Turri. 2008. "The EU-US total factor productivity gap: An industry perspective." *European Economy – Economic Papers* 339. doi 10.2765/95206
- Hernandez, Jose, and Ignacio Mauleon. 2003. "Estimating the Capital Stock", Universidad de la Laguna & Universidad de Las Palmas de Gran Canaria.
- Ioannis, Bournakis. 2012. "Sources of TFP growth in a framework of convergence-evidence from Greece." *International Review of Applied Economics*, 26(1): 47-72. doi: 10.1080/02692171.2011.557056.
- Kamps, Christophe. 2006. "New estimates of government net capital stocks for 22 OECD countries 1960-2001", *IMF Staff Papers* 53(1): 120-150.
- Kyriacou, George. 1991. "Level and Growth Effects of Human Capital: A Cross-Country Study of the Convergence Hypothesis." *Working Papers* 91-26, C.V. Starr Center for Applied Economics, New York University.
- Levenko, Natalia, Kaspar Oja, and Karsten Staehr. 2019. "Total factor productivity growth in Central and Eastern Europe before, during and after the global financial crisis", *Post-Communist Economies*, 31(2): 137-160.
- Lipsev, Richard, Kenneth Carlaw. 2001. "What does Total Factor Productivity measure", *Study Paper Version 02*.
- Nadiri, M. Ishaq, and Ingmar Prucha. 1996. "Estimation of the depreciation rate of physical and R&D capital in the US total manufacturing sector." *Economic Inquiry* 34(1): 43-56.
- Nehru, Vikram, and Ashok Dhareshwar. 1993. "A new database on physical capital stock: sources, methodology and results", *Revista de Análisis Económico* 8(1): 37-59.
- Nicoletti, Giuseppe, Stefano Scarpetta. 2003. "Regulation, Productivity and Growth: OECD Evidence." *Economic Policy* 36: 9-72.
- Pucar, Stevo, and Zoran Borović. 2013. "Measuring Total Factor Productivity: Accounting for cross country differences in income per capita." *Acta Economica* 19: 75-95.
- PWT 9.1. 2019. *University of Groningen*. September 26. <https://www.rug.nl/ggdc/productivity/pwt/?lang=en>.
- Rapacki, Ryszard, and Mariusz Próchniak. 2009. "Economic Growth Accounting in Twenty-Seven Transition Countries, 1990-2003." *Eastern European Economics* 47(2): 69-112. doi: 10.2753/EEE0012-8775470205
- Romer, Paul. M. 1988. "Capital accumulation in the theory of long run growth." *RCER Working Papers*, University of Rochester, Center for Economic Research.
- RZS. 2019. *Nacionalni računi 2019*. Banjaluka: RZS.
- Solow, Robert. 1957. "Technical Change and the Aggregate Production Function." *Review of Economics and Statistics* 39: 312-320.
- Vanags, Alf, and Rudolfs Bems. 2005 "Growth acceleration in the Baltic states: what can growth accounting tell us." *BICEPS Research Reports Accessed July 4*. <http://www.biceps.org/en/publications/research-reports.html>.
- Vuegelers, Reinhilde. 2011. "Assessing the potential for knowledge-based development in the transition countries of Central and Eastern Europe, the Caucasus and Central Asia." *Society and Economy* 33(3): 475-501.