

Stevo Pucar¹
Zoran Borovic²

Measuring Total Factor Productivity: Accounting for cross country differences in income per capita

Мјерење укупне факторске продуктивности: обрачун међудржавних разлика у БДП-у по раднику

Summary

Why are some countries so much richer than others? Why do some countries produce so much more output per worker than others? Influential works by Klenow & Rodriguez-Clare (1997), Hall and Jones (1999), and Parente & Prescott (2000), among others, have argued that most of the cross country differences in output per worker is explained by differences in total factor productivity. Total factor productivity measurement enables researchers to determine the contribution of supply-side production factors to economic growth. Development Accounting is a first-pass attempt at organizing the answer around two proximate determinants: factors of production and efficiency. It answers the question "how much of the cross-country income variance can be attributed to differences in (physical and human) capital, and how much to differences in the efficiency with which capital is used"?

In this article, we will outline framework for growth accounting to account for cross-country difference in income of Republic of Srpska, Republic of Croatia and Republic of Serbia. The current consensus is that differences in income per worker across countries do not arise primarily from differences in quantities in capital or

¹ Faculty of Economics, University of Banja Luka, stevo.pucar@efbl.org

² Faculty of Economics, University of Banja Luka, zoran.borovic@efbl.org

labour, but rather from differences in efficiency with which are these factors used. We find that total factor productivity is very important for the growth of output per worker, but only in cases of Serbia and Croatia. In case of Srpska the most important factor for the growth of output per worker is growth of capital.

Key words: Total factor productivity, capital, labour, efficiency, income per capita.

Апстракт

Зашто су неке земље толико бољашње од других? Зашто неке земље остварују многе веће обиме производње по раднику од других? Утицајни радови Klenow и Rodriguez-Clare (1997), Hall и Jones (1999), и Parente и Prescott (2000), између осталих, иврдили су да је највећи број међународних разлика у обиму производње по раднику резултат разлика у Укупној Факторској Продуктивности. Мјерење Укупне Факторске Продуктивности омогућава истраживачима да утврде допринос фактора на страни понуде привредном расту. Развој "рачуноводства раста" представља први покушај анализирања двије сродне дефиниције раста: фактори производње и ефикасности. Ова анализа даје одговор на питање "колико су међународне разлике у оствареном БДП-у резултат међународних разлика у (физичком и људском) квалитету, а колико су резултат разлика у ефикасности којом се квалитет користи?"

У овом раду ћемо приказати оквир за "рачуноводство раста" који ће се примјенити за обрачунавање међународних разлика у БДП-у по раднику за Републику Српску, Републику Хрватску и Републику Србију. Тренутни консензус међу ауторима је да разлике у БДП-у по раднику између земаља не настају ирривентно због разлика у количинама квалитета или рада, него због разлика у ефикасности са којом се ови фактори користе. Анализом смо дошли до закључка да је Укупна Факторска Продуктивност веома важна за раст производње по раднику, али само у случајевима Србије и Хрватске. У случају Српске најважнији фактор за раст производње по раднику је раст итехничко-технолошке опремљености рада квалитетом.

Кључне ријечи: укупна факторска продуктивност, капитал, рад, ефикасност, доходак по раднику

Introduction

Average incomes in the world's richest countries are more than ten times as high as in the world's poorest countries. It is apparent to anyone who travels the

world that these large differences in income lead to large differences in the quality of life. In 1988, output per worker in the United States was more than 35 times higher than output per worker in Niger. In just over ten days, the average worker in the United States produced as much as an average worker in Niger produced in an entire year. Explaining such vast differences in economic performance is one of the fundamental challenges of economics. Analysis based on an aggregate production function provides some insight into these differences, an approach taken by Mankiw, Romer and Weil (1992) and Dougherty and Jorgenson (1996), among others. Differences among countries can be attributed to differences in human capital, physical capital, and productivity. Theories of country growth are motivated by the tremendous variation in country growth rates. Many papers in literature try to explain why, at any point in time, some countries are significantly richer than others.

The breakdown suggested by the aggregate production function is just the first step in understanding differences in output per worker. Findings in the production function framework raise deeper questions such as: Why do some countries invest more than others in physical and human capital? And why are some countries so much more productive than others? These are the questions that this paper tackles. When aggregated through the production function, the answers to these questions add up to explain the differences in output per worker across countries. Our hypothesis is that cross country differences in income per worker are result of differences in TFP. Survey is based on three countries Republic of Srpska (RS), Republic Croatia (CR) and Republic Serbia (SR).

The approach that has been used here in the measurement of total factor productivity (TFP) is the so-called growth accounting, which, although being simple with respect to the computation technique, leads to sufficiently illuminating results. In growth accounting the concept TFP does not have a stand-alone meaning, until the influence of capital and labor is taken into consideration (and also other factors, for which statistics is available). Generally, the calculation of TFP in addition to the contributions of labor and capital indicates an inability to identify or quantify the remaining objectively existing factors, which determine economic growth. This inability most frequently stems from the lack of suitable statistical data or from the lack of preliminary studies of the values of the omitted factors. When we isolate the influences of the production factors, for which we have available statistical data, there remains the contribution of all other factors, which are generalized in literature with the term TFP. When the computation of the increase of the total factor productivity is carried out using data on capital and labor, the analysis is incomplete by definition, since in modern theory and empirics of economic growth more than two factors of growth have been identified. In the current paper, for example, the factor 'human capital' is missing,

while it is expected to have a significant contribution. As far as technological development and human knowledge, skills, health status, etc. are interrelated, this ‘inaccuracy by definition’ should not pose a significant problem. Although, generally speaking, the more detailed is a set of results, the more valuable it is. Besides growth accounting, in economic literature there is another approach for the identification of factors and their contributions - namely the application of econometric estimation. In the present case this approach has not been chosen, since it is characterized with certain shortcomings, the most important among them underlying the fact that the factors of production might be found to be endogenous (which is the most common case) to the estimated model. There are appropriate techniques to solve the latter problem, but the restriction in the present case stems mostly from the fact that the available annual data on income formation by economic sectors are insufficiently long, which would not lead to stable parameters from regression analysis. s of country growth are motivated by the tremendous variation

1. Theoretical background

Most of the theoretical work on economic growth has been aimed at understanding why growth in per capita income has been a persistent feature of the world economy in the past two centuries. Different strands of the literature use different forces to sustain growth, but all introduce some type of capital whose accumulation overcomes the diminishing returns to physical capital accumulation. One strand uses human capital accumulation to sustain growth (e.g. Lucas, 1988; Jones and Manuelli, 1990; Rebelo, 1991; Stokey, 1991). Another strand perpetuates growth through the accumulation of knowledge, either through learning by doing (Romer, 1986; Stokey, 1988; Young, 1991) or through R&D (Romer, 1990; Grossman and Helpman, 1991; Aghion and Howitt, 1992). Since these models often have different positive and normative predictions, it is important to distinguish between them empirically. In Rebelo (1991) the decentralized equilibrium is Pareto-optimal, so no-intervention is the best policy. Other models feature positive externalities to human capital or ideas, leading to too little growth in the absence of government subsidies. The activity deserving subsidy differs across the models, with some pointing to human capital investment and others to R&D. Moreover, as Romer (1993) emphasizes, the positive and normative implications of openness (e.g. to trade, foreign direct investment, and the flow of ideas) differ drastically across models. Some models imply that greater openness can slow down growth (e.g. Young, 1991; Stokey, 1991), while others imply that openness can speed up growth (Romer, 1991.).

The neoclassical growth model has been the workhorse of most existing attempts to quantify the sources of cross-country levels of output per worker. Prominent examples of these attempts have found completely opposite conclusions: on the one hand Mankiw, Romer and Weil (1992) henceforth found that 78% of the world income variance could be explained by differences in human capital and saving rates across countries. On the other hand, Klenow and Rodriguez-Clare (1997) hereafter, and Hall and Jones (1999) henceforth found that productivity differences are the dominant source of the large world dispersion of output per worker, accounting for around 60% of the variance. The reason why conclusions differ in these studies can be traced back to the measurement of human capital: while Mankiw, Romer and Weil use only secondary schooling, Klenow and Rodriguez-Clare (1997) use in addition primary and tertiary schooling, as well as experience and schooling quality. However, all studies cited above share the common feature of using a framework namely the Solow model augmented with human capital in which the growth rate of productivity is exogenous.

Easterly, Kremer, Pritchett and Summers (1993) document the relatively low correlation of growth rates across decades, which suggests that differences in growth rates across countries may be mostly transitory. Jones (1995) questions the empirical relevance of endogenous growth and presents a model in which different government policies are associated with differences in levels, not growth rates. Finally, a number of recent models of idea flows across countries such as Parente and Prescott (1994), Barro and Sala-i-Martin (1995) and Eaton and Kortum (1995) imply that all countries will grow at a common rate in the long run: technology transfer keeps countries from drifting indefinitely far from each other. Some of the cross-country growth literature recognizes this point. In particular, the growth regressions in Mankiw et al. (1992) and Barro and Sala-i-Martin (1992) are explicitly motivated by a neoclassical growth model in which long-run growth rates are the same across countries or regions. These studies emphasize that differences in growth rates are transitory: countries grow more rapidly the further they are below their steady state. Nevertheless, the focus of such growth regressions is to explain the transitory differences in growth rates across countries.

3. Research objective and hypothesis

The objective of this research is, on the one hand, scientific - to analyze the influence of TFP on economic growth in Republic of Srpska (RS), Republic of Croatia (CR) and Republic of Serbia (SR) and to explain the results in the light of economic growth theory, and, on the other hand, pragmatic - to establish the benefits for policy making that may result from the research.

The economic growth theory and empirical testing show that TFP plays a critical role in economic fluctuations, economic growth and cross-country per capita income differences. Solow (1956) demonstrated that cross-country differences in technology may generate important cross-country differences in income per capita. Many other empirical papers have confirmed the importance of TFP in economic growth. Among many others, Easterly and Levine (2001) find that TFP, measured as Solow residual, “accounts for most of the income and growth differences across nations.”

4. Model and methodology

Growth accounting provides a breakdown of observed economic growth into components associated with changes in factor inputs and a residual that reflects technological progress and other elements. The basics of growth accounting were presented in Solow (1956 and 1957.). The Solow growth model presents a theoretical framework for understanding the sources of economic growth, and the consequences for long-run growth of changes in the economic environment and in economic policy. Solow model belongs to the neoclassical model of economic growth. The basic assumptions of the neoclassical growth model is a competitive market and constant returns to scale. The foundation of neoclassical growth model is a neoclassical production function (Babić, M., 2004):

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

Where Y is the volume of production, K is volume capital, L is labor (number of workers) at time and A is technical progress. Change in production volume can be determined by changing the labour or capital, or changing their productivity, or change in technical progress. Sources of changes in the volume of production (or total differential) can be written as (Babić, M., 2004):

$$dY = \frac{\partial Y}{\partial K} dK + \frac{\partial Y}{\partial L} dL + \frac{\partial Y}{\partial A} dA \quad (2)$$

With some algebraic rearrangement expression (2) becomes (Romer, D., 2006):

$$\frac{dY}{Y} = \frac{\partial Y}{\partial K} \frac{K}{Y} \frac{dK}{K} + \frac{\partial Y}{\partial L} \frac{L}{Y} \frac{dL}{L} + \frac{\partial Y}{\partial A} \frac{A}{Y} \frac{dA}{A} \quad (3)$$

Other words (Romer, D., 2006):

$$\frac{dY}{Y} = \varepsilon_{Y,K} \frac{dK}{K} + \varepsilon_{Y,L} \frac{dL}{L} + \varepsilon_{Y,A} \frac{dA}{A} \quad (4)$$

In this way we have a growth rate of output displayed as the weighted average growth rate of capital, labor and technical progress, where the weights are the

elasticity of production by capital, labor and technical progress. Suppose that the real wages and real interest rates equal marginal productivity of labor and capital, ie. $\frac{\partial Y}{\partial L} = \frac{W}{P}$ and $\frac{\partial Y}{\partial K} = \frac{r}{P}$, then we can write expression (3) as (Romer, D., 2006):

$$\frac{dY}{Y} = \frac{rK}{PY} \frac{dK}{K} + \frac{WL}{PY} \frac{dL}{L} + \frac{\partial Y}{\partial A} \frac{dA}{Y} \quad (5)$$

In the case of Cobb-Douglas function we have

$$Y = AK^\alpha L^{1-\alpha} \quad (6)$$

First, take logs from expression (6):

$$\log Y_t = \log(A_t K_t^\alpha L_t^{1-\alpha})$$

$$\log Y_t = \log A_t + \alpha \log K_t + (1-\alpha) \log L_t \quad (7)$$

$$\log Y_t = \log A_t + \alpha \log K_t + (1-\alpha) \log L_t$$

Repeat this for time t+1 and take differences:

$$\log Y_{t+1} = \log A_{t+1} + \alpha \log K_{t+1} + (1-\alpha) \log L_{t+1}$$

$$\log Y_{t+1} - \log Y_t = [\log A_{t+1} - \log A_t] + \alpha [\log K_{t+1} - \log K_t] + (1-\alpha) [\log L_{t+1} - \log L_t] \quad (8)$$

$$\Delta \log Y_t = \Delta \log A_t + \alpha \Delta \log K_t + (1-\alpha) \Delta \log L_t$$

Notice that we could have skipped from everything in log to everything in $\Delta \log$ by writing Δ in front of each term. This is a useful property of the difference operator Δ (it's a linear operator). Finally, we use the approximation $\Delta \log(x) \approx \% \Delta(x)$ (Mankiw, G. 2002):

$$\frac{dY}{Y} = \frac{dA}{A} + \alpha \frac{dK}{K} + (1-\alpha) \frac{dL}{L} \quad (9)$$

Since $0 < \alpha < 1$, then $1 - \alpha < 1$, which means that increase in technical progress by one percent will have a greater impact on the growth of output than increase in labour or capital by one percent. In Cobb-Douglas production function α represents the share of capital in the actual level of production or in the realized GDP. The share capital in realized GDP (α) is defined as (Mankiw, G. 2002):

$$\alpha = \frac{\partial Y}{\partial K} \frac{K}{Y} \quad (10)$$

Share of labour is defined as:

$$(1-\alpha) = \frac{\partial Y}{\partial L} \frac{L}{Y} \quad (11)$$

The labor share is a key indicator for the distribution of income in a country. It shows how much of national income is distributed to labor and how much to capital. The capital share includes all non-labor income including interest income and economic profit which can be added together and be defined as accounting profit (Mankiw, 2007).

One way to calculate share of labour is (Batini, et al, 2000):

$$(1 - \alpha) = \frac{\sum \frac{W}{P}}{GDP} \quad (12)$$

The expression above fraction is the total amount of paid real gross wages. W is total amount of paid gross wages and P is price index with base in 2001. Based on the determined participation of labour it is easily to identify share of capital.

The easiest way to calculate the share of labor income is to take the ratio of the compensation of employees from the national accounts and the GDP (GVA). However, if we do this, there is a chance that income, which is by virtue labor income, is attributed to capital income. Since such a detailed representation of the sources of income is not available, we will use only the consideration that a share of the total of the net mixed income, for which data is available, may be characterized as labor income. More specifically, this is the value of the net mixed income, which is comprised of the income from unincorporated enterprises and which is received by the owners and the members of their families. Since this income is usually not reported as wages, salaries and related expenditure, but basically performs such a function, we add it to the compensation of employees. It follows that share of labour is (Ganev, K., 2005):

$$(1 - \alpha) = \frac{COE + NMI}{GVA} \quad (13)$$

Where COE is Compensation of Employees and NMI is Net Mixed Income. Compensation of employees consists of gross wages and salaries, including employees' taxes and social contribution (Wages, employment and unemployment, 2012). Net mixed income is formed after extracting consumption of fixed capital from gross mixed income (Wages, employment and unemployment, 2012).

US Bureau of Labor Statistics uses expression (14) to calculate share of labour (Gomme, P., Rupert, P., 2004):

$$(1 - \alpha) = \frac{LC}{GVA} \quad (14)$$

Where LC is Labour Compensation. LC is similar to COE. For simplicity and availability of data for calculating the share of labour we will use expression (14).

In practical analysis it is very often a problem of capital assessment. Data on capital are not published and this requires that it should be calculated addition-

ally. The most common method for its calculation is the so-called 'perpetual inventory method' PIM, which can be described briefly with the equation (Burda, C. M. et al., 2008):

$$K_t = I_t + (1 - \delta)K_{t-1} \quad (15)$$

Where K_t is the volume of capital at time t , I_t is the volume of investments made at time t and δ is the depreciation rate. The PIM method simply integrates the Goldsmith equation (Goldsmith, 1955). Only problem is to determine the amount of the initial or start-up capital. The initial volume of capital is calculated using the following form (Ganev, 2005):

$$K_0 = \frac{I_0}{\delta} \quad (16)$$

I_0 and K_0 have the same meaning as in the previous form, but this time related to the initial period. Here we assume that $\delta = 0.05$, which means that the full depreciation of a given capital unit takes place within 20 years. The choice of this value is not arbitrary but is based on estimates found in various pieces of research. Examples of such studies are Hernandez and Mauleon (2003) for the economy of Spain, Cororaton (2002) for the Philippines, Felipe (1997) for a group of countries in East Asia, etc. Transformation of the expression (13) gives final equation for capital stock (Ganev, 2005):

$$K_t = \sum_{i=0}^{n-1} (1 - \delta)^i I_{t-i} + (1 - \delta)^n K_{t-n} \quad (17)$$

Where n is the fixed moment in time, from which we take the initial capital stock. The current capital stock is the weighted sum of an initial capital value, K_0 , and intervening investment expenditures, with weights corresponding to their undepreciated components. From the perspective of measurement theory, four general problems arise from using capital stock data estimated by statistical agencies. First, the construction of capital stocks presumes an accurate measurement of the initial condition. The shorter the series under consideration, the more likely such measurement error regarding the capital stock will affect the construction of the Solow residual. Second, it is difficult to distinguish truly utilized capital at any point in time from that which is idle. Solow (1957) also anticipated this issue, arguing that the appropriate measurement should be of "capital in use, not capital in place". Third, for some sectors and some types of capital, it is difficult if not impossible to apply an appropriate depreciation rate; this is especially true of the retail sector. Fourth, many intangible inputs such as cumulated research and development expenditures and advertising goodwill are not included in measured capital. The Goldsmith equation implies that mismeasurement of the initial capital condition casts a long shadow on the current estimate of the capital stock as well as the construction of the Solow residual. This is especially true with respect

to long-lived assets such as buildings and infrastructure. The problem can only be solved by pushing the initial condition sufficiently back into the past; yet with the exception of a few countries, it impossible to find sufficiently long time series for investment. RS is a country in transition and there is a limitation of the data that were analyzed. The US Bureau of Economic Analysis (BEA) assumes that investment in the initial period I_0 , represents the steady state in which expenditures grow at rate g and are depreciated at rate δ , so a natural estimate of K_0 is given by (Burda, C. M. et al., 2008):

$$K_0 = I_0 \left(\frac{1+g}{\delta+g} \right) \quad (18)$$

We will use expression (18) to calculate initial volume of capital. Reason for this is that expression (18), among other forms to calculate initial capital provides best results when time series are insufficiently long.

In modern theories of growth most of the attention paid to the contribution of technical progress to economic growth. It is assumed that technical progress is not exogenous variable, but that depends on education, research and development. Therefore, the recent theory called endogenous growth theory. The contribution of technical progress is calculated indirectly based on expression (9) (Babić, 2004):

$$\frac{dA}{A} = \frac{dY}{Y} - \left[\alpha \frac{dK}{K} + (1-\alpha) \frac{dL}{L} \right] \quad (19)$$

Solow residual is the change in output that cannot be explained by changes in inputs. Transformation of the expression (9) gives a growth rate of output per employee (Romer, 2006):

$$\frac{dY}{Y} - \frac{dL}{L} = \frac{dA}{A} + \alpha \left[\frac{dK}{K} - \frac{dL}{L} \right] \quad (20)$$

The expression (9) decomposes labor productivity growth into two components. The first component $\alpha \left[\frac{dK}{K} - \frac{dL}{L} \right]$ tells us what is the contribution of capital deepening (capital intensity) to the growth in labor productivity. The second component $\frac{dA}{A}$ tells us what is the contribution of TFP to the productivity growth.

Klenow et al. (1997) use equation (21) to perform a variance decomposition exercise in order to measure the contributions of capital deepening and TFP to income dispersion. Specifically, variance of output per worker is given by (Klenow, P. J., Rodriguez-Clare, A., 1997):

$$\text{var}(\ln y) = \text{var}(\ln A) + \text{var}(\ln X) + 2 \text{cov}(\ln A; \ln X) \quad (21)$$

Where X is capital deepening and y is Y/L. Klenow suggests that the productivity level TFP is actually endogenous. Klenow propose to assign half of the covariance term to the contribution of X and the other half to TFP, so that the contributions of factors F(X) and productivity F(A) are given by: (Klenow, P. J., Rodriguez-Clare, A., 1997):

$$F(X) = \frac{\text{var}(\ln X) + \text{cov}(\ln A, \ln X)}{\text{var}(\ln y)} \tag{22}$$

$$F(A) = \frac{\text{var}(\ln A) + \text{cov}(\ln A, \ln X)}{\text{var}(\ln y)}$$

Using expressions (19), (20) and (22) we will analyse cross country differences in TFP, labour productivity and reasons for variations in labour productivity.

3. Data and results

All data were collected from Republic of Srpska Institute of Statistics, Statistical office of Republic of Serbia and from Croatian Bureau of Statistics. Real growth rates obtained by the authors differ from those published by official statistics in all three countries. The official real GVA is expressed in previous year prices. Hypothetically, if we want to determine the real growth rate for the economy which produces only one product and real GVA is calculated at prices of one base year, we will use the following form:

$$\frac{Q_t \cdot P_b}{Q_{t-1} \cdot P_b} \tag{23}$$

Where Q_t is output in year t, Q_{t-1} output in previous year and P_b are base year. Based on expressions (23) by canceling out the same values we obtain the actual growth rate of production volume. If we would like to determine the real growth rate for our hypothetical example, between 2012 and 2011 applying methodology of the official statistics in RS, CR and SR then we would use following form:

$$\frac{Q_{012} \cdot P_{11}}{Q_{011} \cdot P_{10}} \tag{24}$$

Where Q_{012} is output in year 2012, Q_{011} output in previous year (year 2011.), P_{11} is price level in 2011, and P_{10} is price level in 2010. Based on expression (24) it is clear that the real growth rate incorporates the rate of price growth in 2011 compared to the 2010. This calculation does not reflect the real state of things and shows real growth higher than it actually is. It is necessary to exclude the effect of price growth. This is achieved by simply multiplying the expression (24) with the reciprocal of the price index in 2011.

$$\frac{Q_{012} \cdot P_{11} \cdot P_{10}}{Q_{11} \cdot P_{10} \cdot P_{11}} \tag{25}$$

By canceling out the same values we obtain the actual growth rate. The real growth rate can be calculated in a similar way. Real GVA published by official statistic we simply multiply with reciprocal value of the price index with base in 2001. Then, we calculate the growth rate with these values:

$$\left[\frac{(Q_{11} \cdot P_{10}) \cdot \frac{P_{01}}{P_{10}}}{(Q_{10} \cdot P_{09}) \cdot \frac{P_{01}}{P_{09}}} \right] \Rightarrow \frac{Q_{11} \cdot P_{01}}{Q_{10} \cdot P_{01}} \tag{26}$$

After adjusting data first we use expression (14) to determinate share of labour. For RS, CR and SR average share of labour is 0.52, 0.57 and 0.53, respectively. For USA and OECD countries share of labour is estimated at 0.7 (Aghion, P., Howit, P., 2007). For Russian Federation share of labour is estimated at 0.62 for total economy and 0.57 for manufacturing (Simon, G. J., 2010). For Romania and Moldova share of labour is estimated at 0.47 and 0.37 respectively for period 2002-2004 (Zaman, G., Goschin, Z., Partachi, I., 2007). For Bulgaria share of labour is set to 0.3 for period 1998-2001 (Zaman, G. et al., 2007). In many analyses it is standard to estimate share of labour to approximately 2/3, or 0.66. The logic would be that it is hard to believe that the production function is fundamentally different from other countries, and the parameter alpha is a parameter of the production function. Similarly, when we look at cross country data, we assume that all countries have the same capital and labor exponents in the production function.³ This assumption is met in many countries mentioned above. But, this assumption is not valid in other countries as former Socialistic countries (Bulgaria, Moldova and Romania). RS is former Socialistic country which is in transition to market economy. Before becoming EU members, Bulgaria and Romania had share of labour at 0.3-0.4. It is same for Moldova.

Second, we use expressions (15) and (18) to calculate initial capital stock and amount of capital for each year. Data on capital, labour and capital per worker are presented in Table 1.

Table 1.
Growth rates of K, L and K/L for RS, CR and SR

Years	RS (growth rates)			CR (growth rates)			SR (growth rates)		
	K	K/L	L	K	K/L	L	K	K/L	L
2005	0,078	0,050	0,027	0,022	0,009	0,012	0,020	0,011	0,009
2006	0,056	0,033	0,023	0,032	-0,005	0,038	0,038	0,060	-0,021

³ This conclusion is result of consultations with professor David Weil.

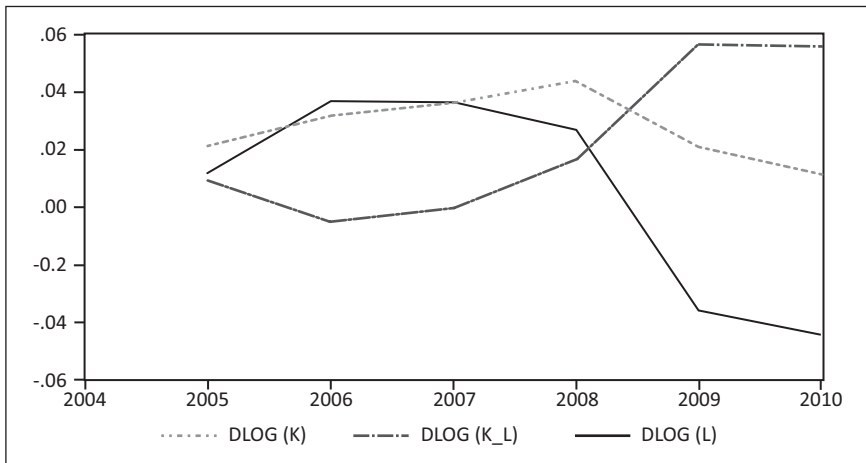
Years	RS (growth rates)			CR (growth rates)			SR (growth rates)		
	K	K/L	L	K	K/L	L	K	K/L	L
2007	0,088	0,046	0,041	0,037	0,000	0,037	0,064	0,076	-0,011
2008	0,105	0,101	0,004	0,045	0,017	0,028	0,072	0,074	-0,001
2009	0,072	0,075	-0,002	0,021	0,058	-0,035	0,042	0,103	-0,055
2010	0,054	0,115	-0,055	0,012	0,057	-0,043	0,039	0,093	-0,049
Average	0,08	0,07	0,01	0,03	0,02	0,01	0,05	0,07	-0,02

Source: authors' calculation

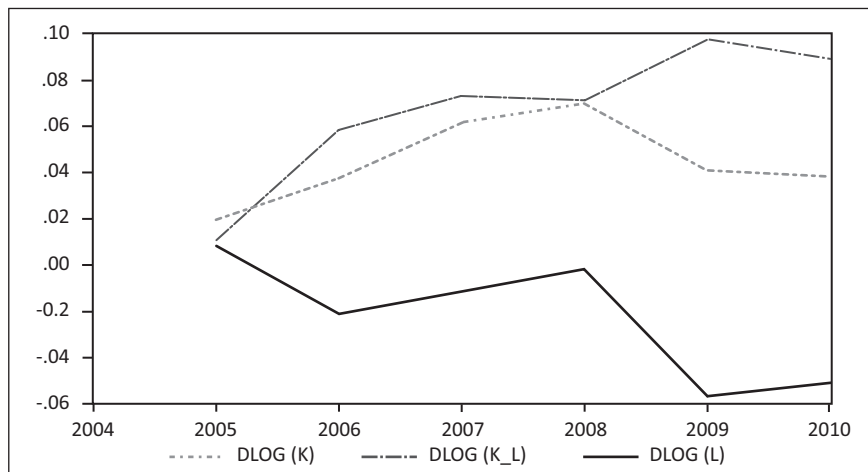
RS has the highest average growth rate of capital of 8%, following SR with 5% average growth rate and CR with 3% growth rate. It is very important to note that we are comparing growth rates of capital and capital per worker, not their absolute values. RS and SR have the highest average growth rate of capital per worker of 7%. CR has very low average growth rate of capital per worker, only 2% on average. All three countries have very small, that is, negative growth rate of labour. For RS and CR it is 1% on average. For SR it is -2%. In absolute, SR has the highest number of workers with 1976018 employees on average, following CR with 1429455 employees on average and RS with 249647 employees on average. Due to very small or negative growth rate of labour, all three countries have significant growth of capital per worker. We come to the same conclusion by analysing same variables graphically.

Graph 1.

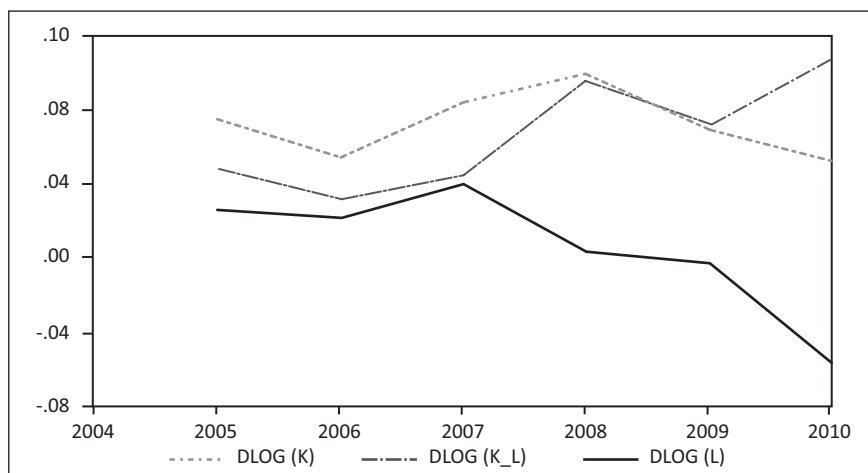
dlogk; dlog k/l, dlogl for CR.



When labour is increasing, capital per worker is decreasing for CR.

Graph 2.*dlogk; dlog k/l, dlogl for SR.*

It is similar for RS. When labour is decreasing, capital per worker is increasing.

Graph 3.*dlog (k); dlog (k/l), dlog (l) for RS.*

For RS all three variables are moving simultaneously for first two years. Then, from 2007 we can see the same pattern as in other two countries - capital per worker is increasing, while labour is decreasing. Growth of capital per worker is even faster from 2009. The reason for this is very high unemployment rate, in 2009 and 2010.

Applying expressions (19) and (20) we obtain growth rate of TFP, income per worker and capital deepening. Results are presented in Table 2 and Table 3.

Table 2.
Growth accounting

Countries	$\Delta Y/Y$	$\Delta A/A$	$\alpha \Delta K/K$	$(1-\alpha) \Delta L/L$
RS	0,05	0,015	0,036	0,003
CR	0,03	0,014	0,012	0,003
SR	0,04	0,026	0,022	-0,011

Source: authors' calculation

These results show that TFP is the most important factor for the growth of output, but only in cases of Serbia and Croatia. In case of Serbia 65% of the average growth of output is directly due to the growth of TFP, in Croatia it is 46.6% and in Srpska it is 30%.

Table 3.
TFP and capital deepening

Countries	$\Delta Y/Y - \Delta L/L$	$\Delta A/A$	X
RS	0,05	0,015	0,033
CR	0,02	0,01	0,010
SR	0,06	0,03	0,03

Source: authors' calculation

In Table 3 X is capital deepening. Values presented in Table 2 and Table 3 are average values for period 2004 - 2010. RS has the highest growth rate of GVA of 5% on average, followed by SR and CR with 4% and 3% on average respectively. All three countries have very small or negative contribution of labour. For CR and SR TFP and capital contribute with 50% each, approximately. For RS TFP contributes with 30% and capital with 70% approximately. The reason for this is high rate of capital growth in RS. Labour contribution is not significant and therefore it is not analysed.

Workers in SR are most productive. SR has highest growth rate of income per worker, 6% on average, then SR and CR with 5% and 2% on average respectively. The reason for this is high growth rate of GVA and negative contribution of labour. Very low values for CR are consequences of low growth rate of capital and absolutely very high number of workers. For RS the main driving force behind the growth of income per worker is capital deepening with contribution of 65%. Contribution of TFP is 35% approximately. As previously said, the reason for this is very high unemployment rate which is increasing. For SR and CR TFP and capital deepening contribute with 50% each.

To perform a variance decomposition exercise in order to measure the contributions of capital deepening and TFP to income dispersion we apply expression (22). The results are presented in Table 4.

Table 4.*Variance decomposition*

Countries	var(lny)	var(lnA)	var(lnX)	cov(lnA, lnX)	F(X)	F(A)
RS	0,002033	0,002	0,000214	0,000	0,158054	0,820906
CR	0,001087	0,001371	0,000136	0,000	-0,03609	1,100459
SR	0,00080	0,00063	0,00021	0,000	0,239303	0,767827

Source: authors' calculation

Analysis shows that variance in TFP for all three countries is the main reason for variance in income per worker. Nevertheless, our previous analysis shows that contribution of TFP is less or equal to contribution of capital deepening. Covariance between lnA and lnX is zero. It means that TFP is actually exogenous.

Conclusion

Our data set covering Republic of Srpska (RS), Republic of Croatia (CR) and Republic of Serbia (SR) over 6 year period provides evidence that a large part of the average growth of output is directly due to the growth of TFP: 65% in case of Serbia, 46% in Croatia and 30% in Srpska. This conclusion, however, reflects substantial variance across these countries – TFP accounts for about 2/3 of the average growth of output per worker in Serbia, 1/2 in Croatia and 1/3 in Srpska. The highest growth rate of Gross Value Added is in Srpska, 5% on average, then in Serbia and Croatia with 4% and 3% on average respectively. All three countries have very small or negative contribution of labor.

According to capital deepening calculation, the main driving force behind the growth of income per worker for Srpska is capital deepening with contribution of 65%. The reason for this is very high unemployment rate which is increasing over analysed period. For Serbia and Croatia the relation of TFP and capital deepening is seen in the fact that both contribute with 50% each.

Variation of the growth of aggregate input per worker and of TFP growth is also important in accounting variation in the growth of output per worker. For all of our data, we can conclude that variation in TFP growth is substantially more important than variation in aggregate input growth. We could simply say that variance in TFP for all three countries is the main reason for variance in income per worker.

All this leads us to the conclusion that TFP is very important factor for the growth of output per worker, but only in cases of Serbia and Croatia. In case of Srpska the most important factor for the growth of output per worker is capital deepening. High contribution of capital deepening to income per worker for all three countries is the consequence of high unemployment rate. Due to this TFP has mathematically smaller contribution than it really has. For real sector of Srpska contribution of TFP is approximately 77% for the same period. During this time, investments in real sector are equal to investments in public administration. Our results in case of Srpska suggest that institutional developments, emphasized by North (1988), Grier and Tullock (1989) and Hall and Jones (1999), and possible disruptions associated with armed conflict are also important determinants of economic growth.

We must emphasise that these conclusions should be taken with caution. The most important limitation of this research was the fact that our data span is not long enough to be used to address interesting, detailed questions. It was the result of conscious choice, which was conditioned by the lack of availability of data. This means that findings and conclusions made on the basis of findings were limited. Possible direction in addressing this problem in future research is to find data on quarterly basis and analyse them. That future research should confirm or disprove our conclusions.

Reference

- Aghion, P. Howit, P. (1992). A Model of Growth Through Creative Destruction. *Econometrica* Vol. 60, No. 2, Mar. pp. 323-351.
- Aghion, P. Howit, P. (2007). Capital, innovation, and growth accounting, *Oxford Review of Economic Policy*. Volume 23, Number 1, 2007, pp.79-93
- Babić, M. (2004). *Makroekonomija-četрнаesto dopunjeno i izmjenjeno izdanje*. Zagreb: Mate D.O.O;
- Barro, R.J., Sala-i-Martin, X., (1995). *Economic Growth*, McGraw Hill.
- Burda, C. M. Severgnini, B. (2008). *Solow Residuals without Capital Stocks*. (SFB 649 discussion paper 2008-040), Berlin: Humboldt-Universität zu Berlin;
- Charles, J. I. (1995) R&D-Based Models of Economic Growth *Journal of Political Economy*, 103, pp 759-784.
- Comin, D. (2006). Total Factor Productivity, In C. R. Braun and Julio Segura (Eds.), *An Eponymous Dictionary of Economics*. Elgar Publishers, Ltd.;
- Comin, D. Hobijn B. Rovito E. (2006). *Five Facts you Need to Know about Technology Diffusion*. NBER Working Paper # 11928.
- Cororaton, C. (2002). *Total Factor Productivity in the Philippines*. Philippine Institute for Development Studies Discussion Paper.

- Dougherty, C. Dale, W. J., International Comparisons of the Sources of Economic Growth,” *American Economic Association Papers and Proceedings*, May 1996, 86, pp 25-29.
- Felipe, J. (1997). *Total Factor Productivity Growth in East Asia: A Critical Survey*. Working paper, Asian Development Bank;
- Ganev, K. (2005). *Measuring total factor productivity: Growth accounting for Bulgaria*. Bulgarian National Bank Discussion Paper, No. 48/2005;
- Goldsmith, R. (1955): *The National Wealth of the United States in the Post-war Period*. Princeton, N.J.: Princeton University Press
- Grossman, G.M., Helpman, E., (1991). *Innovation and Growth in the Global Economy*. CMIT Press: Cambridge, MA.
- Helpman, E. (2004). *The mystery of economic growth*. London: Harvard University press.
- Hernandez, J. A. Mauleon I. (2003). *Estimating the Capital Stock*. Working paper, Universidad de la Laguna; Universidad de Las Palmas de Gran Canaria; Lipsey, R. Carlaw, K. (2001). *What does total factor productivity measure*. Simon Fraser University at Harbour Centre. Study paper version 02;
- Jonathan, E. Kortum, S. S. (1995) Trade in Ideas: Patenting and Productivity in the OECD. NBER Working Paper No. 5049.
- Jones, L.E., Manuelli, R., (1990). A convex model of equilibrium growth: theory and policy implications. *Journal of Political Economy* 98 (5), pp 1008-1038.
- Klenow, Peter J. and Rodriguez-Clare, Andres. The Neoclassical Revival in Growth Economics: Has It Gone Too Far?” in Ben S. Bernanke and Julio J. Rotemberg, eds., *NBER Macroeconomics annual 1997*. Cambridge, MA: MIT Press, 1997a, pp 73-103
- Mankiw, G. N. Romer, D. and Weil, D. N. (1992). A contribution to the empirics of economic growth. *Quarterly Journal of Economics* 107(2):407-437;
- Mankiw, N. G. (2002). *Makroekonomics-fifth edition*. New York: Wort Publishers;
- Rebelo, S., 1991. Long run policy analysis and long run growth. *Journal of Political Economy* 99, pp 500-521.
- Robert, H. E. Charles, J. (1999) Why Do Some Countries Produce So Much More Output Per Worker Than Others. *Quarterly Journal of Economics*, 114(1), pp. 83-116.
- Robert, L. E., Jr. (1988). “On the Mechanics of Economic Development.” *Journal of Monetary Economics* 22(1): pp 3-42.
- Romer P.M., 1990. Endogenous technological change. *Journal of Political Economy* 98 (5) pp 71-102.
- Romer, D. (2006). *Advanced macroeconomics-third edition*. New York: McGraw-Hill/Irwin;
- Romer, P.M., (1986). Increasing returns and long-run growth. *Journal of Political Economy* 94 (5), pp 1002-1037.
- Romer, P.M., (1993). Idea gaps and object gaps in economic development. *Journal of Monetary Economics* 32, pp 543-573.
- Simon, G. J. (2010). Technical progress and its factors in Russia’s economy. *Ekonomski anali*, 55(186), 7-41.
- Solow, R. (1956). A Contribution to the Theory of Economic Growth. *Quarterly Journal of Economics* Vol. 70, No. 1 Feb., pp. 65-94;

- Solow, R. (1957). Technical Change and the Aggregate Production Function. *Review of Economics and Statistics* 39 pp: 312–320;
- Stephen, P. L. Prescott, E. C. (1994). Barriers to Technology Adoption and Development,” *Journal of Political Economy*, 102 (2), pp 298-321.
- Stokey, N.L., (1988). Learning by doing and the introduction of new goods. *Journal of Political Economy* 96 (4), pp 701-717.
- Stokey, N.L., (1991). Human capital, product quality, and growth. *Quarterly Journal of Economics* 106 (2) pp 587-617.
- Wages, employment and unemployment*. (2012), Statistical bulletin, Republic of Srpska Institute of statistics, Retrieved December 13 th 2012 from http://www.rzs.rs.ba/static/uploads/bilteni/rad/BiltenStatistikeRada_4.pdf
- William, E. Kremer, M. Pritchett, L. Summers L. (1993) Good Policy or Good Luck? Country Growth Performance and Temporary Shocks. *Journal of Monetary Economics* 32, 459-483.
- William, E. Levine, R. (2001). What have we learned from a decade of empirical research on growth? It's Not Factor Accumulation: Stylized Facts and Growth Models, *World Bank Econ Rev* (2001) 15(2): 177-219 doi:10.1093/wber/15.2.17
- Young, A., 1991. Learning by doing and the dynamic effects of international trade. *Quarterly Journal of Economics* 106 (2), pp 369-406.
- Zaman, G, Goschin, Z, Partachi, I, (2007). The contribution of labour and capital to Romania's and Moldova's economic growth. *Journal of applied quantitative methods*. Vol. 2, No. 1, pp: 179-185;

