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Openness and growth: empirical research on the case of Serbia *

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Summary: This paper shows the results of research related to the impact of Serbia openness to its economic growth in the period between January 2005 and December 2009. The subject of the research are two potential channels of indirect impact, as follows: (a) impact of the openness to economic growth through capital accumulation, and (b) impact of the openness to economic growth through total factor productivity growth. The results of this empirical research point out to positive effect of capital accumulation and total factor productivity growth to the economic growth. On the other hand, there is no reliable evidence about any impact of the Serbian economy openness to TFP growth and capital accumulation. Hence, bearing in mind the results obtained in this empirical research, we cannot make a satisfactorily reliable conclusion that openness affects economic growth of Serbia via the aforementioned channels.

Key words: capital accumulation, economic growth, openness, total factor productivity.

Rezime: Ovaj rad prikazuje rezultate ispitivanja uticaja otvorenosti privrede Srbije na njen ekonomski rast u vremenskom periodu od januara 2005. do decembra 2009. godine. Predmet istraživanja jesu dva potencijalna kanala indirektnog uticaja i to: (a) uticaj otvorenosti na ekonomski rast preko kapitalne akumulacije i (b) uticaj otvorenosti na ekonomski rast posredstvom rasta totalne faktorske produktivnosti. Rezultati empirijskog istraživanja ukazuju na pozitivan uticaj akumulacije kapitala i rasta totalne faktorske produktivnosti na privredni rast. S druge strane, ne postoje pouzdani dokazi o bilo kakvom uticaju otvorenosti srpske privrede na rast TFP i kapitalnu akumulaciju. Dakle, imajući u vidu rezultate empirijskog istraživanja ne možemo zaključiti sa zadovoljavajućim stepenom sigurnosti da otvorenost utiče na privredni rast Srbije posredstvom pomenutih kanala.

Ključne reči: akumulacija kapitala, ekonomski rast, otvorenost, totalna faktorska produktivnost.

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1. INTRODUCTION

Scientific public is to great extent polarised with regard to the influence of the openness of national economies to economic growth. Although there is a prevailing opinion among researchers that the aforementioned relation is positive, disputes are more than obvious. Great deal of economists deem that more open economies grow more rapidly, while the others advocate that there is no enough evidence for such conclusion [16, pp. 1-5]. On the other hand, economic theory corroborates the claim that foreign trade liberalisation stimulates economic growth, but there are still certain dilemmas whether this effect is temporary or permanent. There are certain opinions that there is even a possibility that foreign trade liberalisation can make national economies' growth slower.

Some key problems that appear in the research of this relation generate the majority of these controversies. For example, large number of empirical researches is based on the cross section data, completely abstracting time dimension of the impact, which does not give any contribution to determination of its continuity. In addition, many studies provided for testing of direct impact of openness to growth, which is not compliant with theory. Neither neoclassical, nor endogenous growth models suggest such impact [14, p. 35]. All growth theories are based on indirect relation. Therefore, openness impacts economic growth either by capital accumulation, or through total factor productivity (TFP) growth (Ibidem). Additionally, there are problems in selection of indicators to quantify the openness. In theory, as well as in empirical researches, there is still no generally accepted measure of openness, so researchers use a number of indicators [1, 2, 6, 7, 10, 17, 18, 19, 22]. Their diversity creates pretty much confusion, and quite commonly leads to completely different findings, which is logical to expect. For example, in some researches, countries categorised as open ones according to one indicator are categorised as closed ones according to another in five out of a total of fifteen cases [14, pp. 35-36]. Bearing in mind the mentioned lacks, it is no surprising at all that results of empirical analyses are quite commonly contradictory.

Our intention is to try to estimate dependence of economic growth of the Republic of Serbia on the openness of its economy, i.e. to try to answer the question whether the openness of Serbian economy influences its long-term economic growth. Empirical research we implemented, taking into consideration indirect nature of the impact, is based on the analysis of time series which refer to period between 2005 and 2009.

This paper is composed of five parts. First part is introduction. In the second part we have tried to briefly expose the core of neoclassical and endogenous growth theory, with specific emphasis on theoretical background of our empirical research. Most important information about data we used in the analysis is shown in the third part. Fourth part contains the results of empirical research, which is followed by most significant conclusions, exposed in the fifth part.

2. THEORETICAL BACKGROUND OF THE RESEARCH

2.1 Theories of economic growth

2.1.1 Neoclassical theory of growth

Theories of economic growth are classified into two big groups: (a) exogenous or neoclassical theories of growth, and (b) endogenous theories of growth. Exogenous (neoclassical) theories of growth, or Solow-Swan model, are usually used term for common contribution of a number of authors to the development of long-term economic growth model based on neoclassical economic theory. Neoclassical model of growth was created in 1956, greatly due to Robert Solow's work, as an extension or elaboration of Harrod-Domar's single-sectoral model from 1946. In the model developed by Solow, new capital is more productive than the old one, because new capital is produced by application of modern technology, and technology develops over the time. For his capital contribution to the development of growth theory, Robert Solow was awarded by Nobel Prize in Economic Sciences in 1987.

Exogenous model of growth includes labour and capital as production inputs and is based on diminishing returns of both inputs, partially looking, but with constant returns to scale if taken into account altogether. In addition, the model includes technological variable, which changes over the time. In an open economy, following neoclassical growth theory, foreign trade liberalisation (openness growth) can lead to the increase of saving rate, which would generate increase in investments almost as in a closed economy. The reason for such similarity may be imperfection of capital market, tendency of investors to invest into their own country, etc. Increase in investments would result in increase of income *per capita* and its rate fo growth, which would present only a temporary effect up to the moment when savings would be enough only to compensate depreciation and population growth. At that moment capital per worker would stop to grow despite further savings and investments, which would halt the increase of income *per capita* if certain technological progress is not realised. Therefore, neoclassical model of growth implies only a short-term impact of savings and investments to economic growth. Hence, the more the economies are far from long-term steady state, the faster the economic growth will be. Convergence towards long-term balance means increase in level of *per capita* income, but at the same time decrease in its growth rate until long-term balance is achieved, when its equals zero, provided that no technological progress is realised. Bearing this in mind, openness, through savings and investments, in accordance with neoclassical model of growth, can only temporarily (short-term) impact the pace (rate) of economic growth. In long-term, rate of economic growth can increase or can be maintained at current level only if technological progress is realised.

In other words, measures of economic policy, such as tax relaxation and subsidies for investments, can determine long-term steady state of income *per*

capita, but not its growth rate. As economy converges towards long-term balance, economic growth rate is under short-term impact of capital accumulation determined by savings and depreciation rates. At the same time, savings rate is *inter alia* under the impact of foreign trade liberalisation.

Long-term rate of economic growth, according o neoclassical models, is determined in exogenous manner, i.e. it is determined outside the model – through technological progress. Hence, according to exogenous models of economic growth economies tend to achieve long-term steady rate determined by technological progress rate and labour force growth rate.

Neoclassical models of growth rely on key postulate – postulate of diminishing returns to capital. Therefore, if we assume technological stagnation and fixed scope of employed labour, the additional involvement of capital will after certain period of time be enough only to cover depreciation and population growth due to diminishing returns. Such state is a long-term steady state when income *per capita* does not grow at all. Abandoning the assumption of zero growth rate of labour force somewhat complicates the analysis, but basic logics of the model remains unchanged – increase in scope of employed labour, due to diminishing returns, implies decreasing growth rate of *per capita* income to the long-term steady state when growth is annulled. Introduction of assumption on the existence of technological progress enables that *per capita* income in long-term steady state increases according o technological progress rate which actually presents productivity growth rate.

Main critics to exogenous growth model refer to: (a) not so convincing empirical support, (b) inability of the model to include entrepreneurship and institutional strength which can be important growth generators, (c) absence of explanation why and in what manner technological progress develops. Critical attitude to neoclassical theory of growth resulted in development of endogenous growth theory, transforming technological progress into endogenous variable.

2.1.2 Endogenous theory of growth

Endogenous or new growth theory is based on the premises that economic policy measures can influence long-term economic growth, due to which there is a dilemma whether it presents a revolution in the development of economic science [12, pp. 39-52]. In some endogenous models of growth, subsidising of research and development activities and education stimulates economic growth through increased incentives for innovations. Endogenous theory of growth includes two very important aspects [5, p. 2]: (a) technological progress is seen as a result of economic activity and (b) knowledge and technology are characterised by growing returns leading the economic growth. This theory assumes that households maximise consumption utility bearing in mind limited income, while companies maximise their profit. The key driving elements for economic growth are new technologies and human capital. Specific importance is given to knowledge [Ibidem], because knowledge and knowledge-based ideas can be used with no limits, they can be shared and accumulated, due to which it is not surprising why in cases of knowledge decreasing returns is not expressed,

but quite the opposite – increased returns driving and maintaining economic growth.

New theory of growth assumes constant marginal product of capital at aggregate level [11, pp. 1-7], or at least that marginal product does not tend to zero when quantity of employed capital increases. This does not mean that big companies are more productive than small ones, because at company level there is still a tendency of decreasing marginal product. In models of endogenous growth, principle of linearity is often assumed [8, pp. 11-14], as well as certain level of monopoly power originating from patent protection. The models are bi-sectoral and include sector of final goods production and research and development sector. Research and development sector generates ideas enabling certain degree of monopoly power, but also realisation of monopoly profit through sale of ideas to production companies. In addition, there are certain modifications of endogenous models connecting the pace of economic growth with real energy prices [21, pp. 85-93].

New growth theory reflects transformation of resource-based economy into the knowledge-based economy. This puts forward economic processes which create and extend new knowledge as important processes for implementation of long-term economic growth. This means that economic growth is stimulated by economic policies which opt for openness, competition and innovations, while policies which limit or slow down the changes, protecting certain sectors or companies, most probably slow it down. Hence, the core of endogenous growth theory is the attitude that sustainable development is everywhere and always a process of continual transformations, even specialisation of individual companies and industries [3, pp. 465-471]. Economic growth that has been developing since the Industrial Revolution until the present day could not be possible if countries have not passed through painful changes. Economies which stop transforming are destined for slower growing economies.

Endogenous growth theory explains long-term increase of economic growth rate through three inter-dependent phenomena. The first one is endogenous technological progress creating the assumption for continual and long-lasting sustainable economic growth. Technological progress occurs as a consequence of innovations, imitations and adjustments inspired by tendency of companies to maximise their profit. Foreign trade liberalisation can encourage technological progress and make economic growth long and sustainable one. This scenario could happen due to higher import of modern capital goods, increased transfer of knowledge and technology, higher foreign direct investments and increased incentives for imitating and innovating which can benefit from liberal trade [14, pp. 28-29]. The second phenomenon is contained in the fact that growth in savings and investments, according to AK model, does not decrease incentives for capital accumulation. Basic assumptions of this thesis are constant returns of capital (physical and human ones) and irrelevance of non-renewable production inputs. If foreign trade liberalisation affects growth of savings and investments (capital accumulation), adequate foreign trade policy can encourage long-term sustainable economic growth. The third phenomenon is seen through positive externalities related to capital accumulation implying constant or increased

returns. Increased returns of capital make long-term economic growth possible, because they eliminate its main obstacle according to neoclassical theory – diminishing returns. Externalities encouraged by foreign trade liberalisation can permanently increase the rate of economic growth. Although externalities prevail in closed economies as well, it is assumed that their effect is stronger in open countries with free foreign trade regimes, especially if these are developing countries. If this is correct, developing countries can gain high profit by trading with technologically most developed economies.

Greatest criticism of endogenous growth theory is related to explanation of the so-called conditional convergence found in empirical literature. In addition, much criticism is focused on the possibility of quantification of knowledge [20, pp. 3-10], as well as on the fact that new growth theory is not more successful than exogenous one in explaining income divergence between developed and developing countries [15, pp. 6-9].

Altogether, according to neoclassical growth theory, openness, i.e. foreign trade policy converging towards liberalisation, can only affect the increase of *per capita* income level, but not to its long-term growth rate. In transitional period towards long-term steady state, according to this theory, *per capita* income increases, but its growth rate, which would be annulled in long-term steady state, decreases due to diminishing returns. Unlike neoclassical theory, endogenous growth theory sees technological progress as endogenous variable, so, accordingly, foreign trade liberalisation has long-term impact to economic growth rate. The longer the transitional period towards long-term steady state, the less significant difference between neoclassical and endogenous growth model is. In case of comparable time intervals, capital accumulation, depreciation rate, labour force growth rate and technological progress rate have very similar impact to economic growth rate.

2.1.3 Theoretical background of empirical research

Observing the mentioned theories of economic growth, it is clear that foreign trade liberalisation (openness) can only have indirect impact to long-term economic growth rate, particularly: (a) through capital accumulation, and (b) through increase of total factor productivity representing the technical progress. Empirical base of the first channel has been tested relying on AK model [14, pp. 37-38]. Production function in this model has the following form:

$$Y_t = AK_t \tag{1.1}$$

where (Y) stands for real value of gross domestic product (GDP), (A) for technological level (factor productivity) which is constant, (K) for generally understood capital flow (physical and human) in real expression, and (t) stands for time. Applying logarithm to left and right side of the equation (1.1) we obtain:

$$LnY_t = LnA + LnK_t, \tag{1.2}$$

wherefrom it is derived that $LnY_{t-1} = LnA + LnK_{t-1}$. Subtracting the latter equation from equation (1.2), we derive the following:

$$LnY_t - LnY_{t-1} = LnA - LnA + LnK_t - LnK_{t-1}, \quad (1.3)$$

which, applying logarithm rule, gives:

$$LnY_t/Y_{t-1} = LnK_t/K_{t-1}. \quad (1.4)$$

If we apply antilogarithm operation to both sides of the equation (1.4) we have:

$$Y_t/Y_{t-1} = K_t/K_{t-1}, \quad (1.5)$$

which points out to equality between GDP growth rate and capital stock growth rate. Net increment of capital stocks in *long-term steady state* can be expressed as:

$$\Delta K = iY - \delta K, \quad (1.6)$$

where (i) stands for investment rate in overall (physical and human) capital, and (δ) stands for depreciation rate. If we replace (Y) in equation (1.6) with equation (1.1), and divide both sides of such obtained equality with (K), we will have:

$$\Delta K/K = iA - \delta. \quad (1.7)$$

Given that we have shown with equation (1.5) that GDP growth rate and capital stock growth rate are equal, based on equation (1.7) we can state that:

$$\Delta Y/Y = iA - \delta. \quad (1.8)$$

If we accept the standpoint that two components of widely understood capital (physical and human capitals) are highly correlated without detailed explanation [Ibidem, p. 38], than growth rate of total capital stock can be replaced by growth rate of its physical component, so that relation (1.7) we can state the following:

$$\Delta k/k = iA - \delta, \quad (1.9)$$

where (k) stands for physical capital stock. Consolidating (1.8) and (1.9), we obtain:

$$\Delta k/k = iA - \delta = \Delta Y/Y, \quad (1.10)$$

which points out to the fact that long-term dynamics of economic growth rate in AK model should be similar to long-term dynamics of investments rate, i.e. to the dynamics of physical capital stock growth rate [Ibidem].

The first channel of the impact of openness to economic growth is tested in two phases. The first one is composed of testing of impact of capital stock growth rate to economic growth rate, while in the second part of research impact of openness variables to capital stock growth is tested. In order to explore the mentioned mechanism of indirect impact, we used two indicators of openness: (a) growth of foreign trade - GDP ratio (intensity of foreign trade) and (b) index of real effective exchange rate [Ibidem, p. 36]. In order to neutralise problems created by short-term fluctuations of variables in the process of identification of long-term impacts, we have used the following three techniques of time series smoothing methods: (a) Hodrick-Prescott filter, (b) Holt-Winters smoothing method, and (c) double smoothing method [Ibidem, p. 39]. In other words, empirical research based on time series analysis includes only a trend components of original time series, neglecting short-term fluctuations which

make it difficult to observe long-term relations. Use of different smoothing techniques is aimed at testing of robustness of the obtained results, i.e. at checking whether change in smoothing technique really changes the results of the research.

Empirical testing of openness impact to economic growth through *total factor productivity* (TFP) (second channel) imposes certain technical problems. Actually, this part of research, as well as the previous one, comprises two parts: (a) testing of TFP growth impact to economic growth, and (b) testing of openness variables impact to TFP growth. In order to do this, we need time series of TFP growth, which we have to derive. If we start from Cobb–Douglas' production function with *constant returns to scale*, the equation will have the following form:

$$Y_{(t)} = A_{(t)} K_{(t)}^{\alpha} L_{(t)}^{1-\alpha}, \tag{1.11}$$

where (Y) stands for total production of overall economy (GDP), (K) stands for employed capital stock, (L) for number of employees, (A) for total factor productivity, (α) constact output elasticities of capital, and (t) stands for time. Differentiating (1.11) as complex function per (t), we obtain the following:

$$\frac{\partial Y}{\partial t} = \frac{\partial Y}{\partial K}\frac{\partial K}{\partial t} + \frac{\partial Y}{\partial L}\frac{\partial L}{\partial t} + \frac{\partial Y}{\partial A}\frac{\partial A}{\partial t}. \tag{1.12}$$

Partial derivations of output per production inputs and TFP have the following form:

$$\frac{\partial Y}{\partial K} = \alpha A_{(t)} K_{(t)}^{\alpha-1} L_{(t)}^{1-\alpha} = \frac{\alpha Y}{K_{(t)}}, \tag{1.13}$$

$$\frac{\partial Y}{\partial L} = (1-\alpha) A_{(t)} K_{(t)}^{\alpha} L_{(t)}^{-\alpha} = \frac{(1-\alpha) Y}{L_{(t)}}, \tag{1.14}$$

$$\frac{\partial Y}{\partial A} = K_{(t)}^{\alpha} L_{(t)}^{1-\alpha} = \frac{Y}{A_{(t)}}. \tag{1.15}$$

Replacing these partial derivations in equation (1.12), we have the following:

$$\frac{\partial Y}{\partial t} = \frac{\alpha Y}{K_{(t)}}\frac{\partial K}{\partial t} + \frac{(1-\alpha) Y}{L_{(t)}}\frac{\partial L}{\partial t} + \frac{Y}{A_{(t)}}\frac{\partial A}{\partial t}. \tag{1.16}$$

If we divide both sides of equation (1.16) with (Y), we have:

$$\frac{\frac{\partial Y}{\partial t}}{Y} = \alpha \frac{\frac{\partial K}{\partial t}}{K_{(t)}} + (1-\alpha)\frac{\frac{\partial L}{\partial t}}{L_{(t)}} + \frac{\frac{\partial A}{\partial t}}{A_{(t)}}. \tag{1.17}$$

Bearing in mind that continual growth rates of GDP (*WY*), capital (*WK*), employment (*WL*) and total factor productivity (*WTFP*) can be respectively shown in the following equations:

$$WY = \frac{\frac{\partial Y}{\partial t}}{Y};\ WK = \frac{\frac{\partial K}{\partial t}}{K_{(t)}};\ WL = \frac{\frac{\partial L}{\partial t}}{L_{(t)}} \text{ i } WTFP = \frac{\frac{\partial A}{\partial t}}{A_{(t)}},$$

equation (1.17) can be expressed as:

$$WY = \alpha WK + (1-\alpha)WL + WTFP. \tag{1.18}$$

From equation (1.18) we can express *WTFP* simply as:

$$WTFP = WY - \alpha WK - (1-\alpha)WL, \tag{1.19}$$

which presents the effect of TFP increase to economic growth, i.e. the part of economic growth which is not a consequence of capital stock and employment increase, but of their productivity. The equation (1.19) is known as *Solow residual* [4, p. 1].

Yet, applying this procedure we have not managed to solve all the problems related to derivation of TFP growth time series. As can be seen from (1.19), calculation of *WTFP* requires that elasticity coefficient (α) is known, which forces us to estimate it applying econometrics. This procedure is re-started with Cobb-Douglas' production function. Dividing (1.11) with (*L*), we obtain:

$$\frac{Y_{(t)}}{L_{(t)}} = \frac{A_{(t)}K_{(t)}^{\alpha}L_{(t)}^{1-\alpha}}{L_{(t)}}, \tag{1.20}$$

which can be expressed as

$$\frac{Y_{(t)}}{L_{(t)}} = A_{(t)}K_{(t)}^{\alpha}L_{(t)}^{-\alpha}, \tag{1.21}$$

i.e. as

$$\frac{Y_{(t)}}{L_{(t)}} = A_{(t)}\left(\frac{K_{(t)}}{L_{(t)}}\right)^{\alpha}. \tag{1.22}$$

Applying logarithm to (1.22), we obtain:

$$Ln\frac{Y_{(t)}}{L_{(t)}} = LnA_{(t)} + \alpha Ln\left(\frac{K_{(t)}}{L_{(t)}}\right). \tag{1.23}$$

Bearing in mind that output per employee (*Y/L*) and capital intensity (*K/L*) can be calculated based on original time series, the following regression equation should be estimated so as to estimate elasticity coefficient (*α*):

$$\hat{Y} = C + \alpha\hat{K}\,, \tag{1.24}$$

where Ŷ, C and $\hat{K}$ respectively represent $Ln\frac{Y_{(t)}}{L_{(t)}}$, $LnA_{(t)}$ i $Ln\left(\frac{K_{(t)}}{L_{(t)}}\right)$. The

estimated value (*α*) from (1.24) we inserted in (1.19), so as to derive time series for TFP growth. Hence, knowing the values for inter-annual GDP growth rate (*WY*), capital stock growth rate (*WK*), employment growth rate (*WL*) and estimated elasticity coefficient (*α*), applying the equation (1.19) we calculated time series for inter-annual TFP growth rates (*WTFP*). In addition, similarly to the first part of the research, we eliminated short-term variations of this series through application of already mentioned smoothing techniques, and such obtained series were used in econometric research.

3. DATA

Time series used in empirical research, method of their construction, labels and sources of original data are shown in the table below.

Table 1 clearly shows that we used three main sources in data collection process. Data about real effective exchange rate was downloaded from the official website of the National Bank of Serbia (*http://www.nbs.rs/export/internet/cirilica/80/index.html*). Number of employees in Serbian economy was obtained from Surveys on Labour Force, downloaded from the website of the Statistical Office of the Republic of Serbia (*http://webrzs.stat.gov.rs/WebSite/Public/PageView.aspx?pKey=26*). All the remaining data used in econometric research was downloaded from the World Bank database (*http://databank.worldbank.org/ddp/home.do#ranking*).

Table 1. - Variables we used in empirical research

VARIABLE	DESCRIPTION AND CONSTRUCTION	LABEL	SOURCE
Index of real effective exchange rate	Index of real effective exchange rate (end December 2004 = 100) for the period January 2005-December 2009 smoothened with Hodrick-Prescott's filter. Index exceeding 100 points out to apreciation.	**HPREDK**	Author's calculation based on data dowloaded from http://www.nbs.rs/export/internet/cirilica/80/index.html
	Index of real effective exchange rate (end December 2004 = 100) for the period January 2005-December 2009 smoothened with Holt-Winter's filter. Index exceeding 100 points out to apreciation.	**REDKSM**	Author's calculation based on data dowloaded fromhttp://www.nbs.rs/export/internet/cirilica/80/index.html
	Index of real effective exchange rate (end December 2004 = 100) for the period January 2005-December 2009 smoothened with double smoothing method. Index exceeding 100 points out to apreciation.	**REDKD**	Author's calculation based on data dowloaded from http://www.nbs.rs/export/internet/cirilica/80/index.html
Inter-annual growth of foreign trade to GDP ratio	Inter-annual growth of foreign trade (export + import of goods and services) to GDP ratio for the period January 2005-December 2009, obtained through time disaggregation of annual growth rates, applying ECOTRIM program package.	**HPWTRGBDP**	Author's calculation based on data dowloaded from http://databank.worldbank.org/ddp/home.do#ranking
	Inter-annual growth of foreign trade (export + import of goods and services) to GDP ratio for the period January 2005-December 2009, obtained through time disaggregation of annual growth rates, applying ECOTRIM program package.	**WTRGBDPSM**	Author's calculation based on data dowloaded from http://databank.worldbank.org/ddp/home.do#ranking
	Inter-annual growth of foreign trade (export + import of goods and services) to GDP ratio for the period January 2005-December 2009, obtained through time disaggregation of annual growth rates, applying ECOTRIM program package.	**WTRGBDPD**	Author's calculation based on data dowloaded from http://databank.worldbank.org/ddp/home.do#ranking
Inter-annual GDP growth	Inter-annual GDP growth rates for the period January 2005-December 2009, obtained through time disaggregation of annual growth rates, applying ECOTRIM program package. Such obtained times series was smoothened with Hodrick-Prescott's filter.	**HPWBDP**	Author's calculation based on data dowloaded fromhttp://databank.worldbank.org/ddp/home.do#ranking
	Inter-annual GDP growth rates for the period January 2005-December 2009, obtained through time disaggregation of annual growth rates, applying ECOTRIM program package. Such obtained times series was smoothened with Holt-Winters's filter.	**WBDPSM**	Author's calculation based on data dowloaded from http://databank.worldbank.org/ddp/home.do#ranking
	Inter-annual GDP growth rates for the period January 2005-December 2009, obtained through time disaggregation of annual growth rates, applying ECOTRIM program package. Such obtained times series was smoothened with double smoothing method.	**WBDPD**	Author's calculation based on data dowloaded fromhttp://databank.worldbank.org/ddp/home.do#ranking
Inter-annual growth of physical capital stocks	Inter-annual growth of gross domestic investments for the period between January 2005 and December 2009, obtained through time disaggregation of annual rates, applying ECOTRIP program package. Such obtained time series was smoothened with Hodric-Prescott's filter.	**HPWK**	Author's calculation based on data dowloaded fromhttp://databank.worldbank.org/ddp/home.do#ranking
	Inter-annual growth of gross domestic investments for the period between January 2005 and December 2009, obtained through time disaggregation of annual rates, applying ECOTRIP program package. Such obtained time series was smoothened with Holt-Winter's filter.	**WKSM**	Author's calculation based on data dowloaded from http://databank.worldbank.org/ddp/home.do#ranking
	Inter-annual growth of gross domestic investments for the period between January 2005 and December 2009, obtained through time disaggregation of annual rates, applying ECOTRIP program package. Such obtained time series was smoothened with double smoothing method.	**WKD**	Author's calculation based on data dowloaded from http://databank.worldbank.org/ddp/home.do#ranking
Inter-annual growth of fixed physical capital stocks	Inter-annual growth rate of gross domestic fixed investments for the period between January 2005 and December 2009, obtained with time disaggregation of annual rates, applying ECOTRIM program package. Such obtained time series was smoothened with Hodrick-Prescott's filter.	**HPWFK**	Author's calculation based on data dowloaded from http://databank.worldbank.org/ddp/home.do#ranking
	Inter-annual growth rate of gross domestic fixed investments for the period between January 2005 and December 2009, obtained with time disaggregation of annual rates, applying ECOTRIM program package. Such obtained time series was smoothened with Holt-Winter's filter.	**WFKSM**	Author's calculation based on data dowloaded from http://databank.worldbank.org/ddp/home.do#ranking
	Inter-annual growth rate of gross domestic fixed investments for the period between January 2005 and December 2009, obtained with time disaggregation of annual rates, applying ECOTRIM program package.Such obtained time series was smoothened with double smoothing method.	**WFKD**	Author's calculation based on data dowloaded fromhttp://databank.worldbank.org/ddp/home.do#ranking
Natual logarithm of production per employee	Natural logarithm of GDP per number of employees ratio for the period between January 2005 and December 2009. Time series for GDP and number of employees were obtained through disaggregation of time series at annual level, applying ECOTRIM program package.	**LNYL**	Author's calculation based on data dowloaded from http://databank.worldbank.org/ddp/home.do#ranking and http://webrzs.stat.gov.rs/WebSite/Public/PageView.aspx?pKey=26
Natural logarithm of capital intensity	Natural logarithm of gross domestic fixed investments per number of employees ratio for the period between January 2005 and December 2009. Time series for gross domestic fixed investments and number of employees were obtained through disaggregation of time series at annual level, applying ECOTRIM program package.	**LNFKL**	Author's calculation based on data dowloaded fromhttp://databank.worldbank.org/ddp/home.do#ranking and http://webrzs.stat.gov.rs/WebSite/Public/PageView.aspx?pKey=26
Growth of total factor productivity	Time series obtained in the procedure described in the text - application of inter-annual GDP growth rates, gross domestic fixed investments growth rates and employment growth rates (January 2005 - December 2009). The series was smoothened with Hodrick-Prescott's filter.	**HPWTFPFK**	Author's calculation
	Time series obtained in the procedure described in the text - application of inter-annual GDP growth rates, gross domestic fixed investments growth rates and employment growth rates (January 2005 - December 2009). The series was smoothened with Holt-Winter's filter.	**WTFPFKSM**	Author's calculation
	Time series obtained in the procedure described in the text - application of inter-annual GDP growth rates, gross domestic fixed investments growth rates and employment growth rates (January 2005 - December 2009). The series was smoothened with double smoothing method.	**WTFPFKD**	Author's calculation

Note: Disaggregation of time series was performed with program package ECOTRIM, applying *Boot*, *Feibes*, *Lisman* methods, minimising the sum of squared first differences of disaggregated time series. Econometric analysis was carried out by applying program package EViews 3.1.

4. THE RESULTS OF THE EMPIRICAL RESEARCH

The first step in our analysis was the estimation of elasticity coefficient (α) in order to derive time series for inter-annual TFP growth rates. Taking into account that unit root tests pointed out to non-stationarity of time series LNYL and LNFKL, estimation of relation (1.24) must be based on cointegration analysis. Dynamics of output per employee and capital intensity are almost even (Fig. 1), implying the possibility of their cointegration.

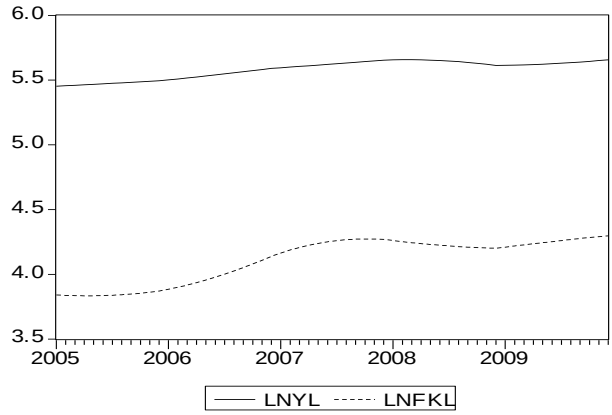

Figure 16. ***Natural logarithm of GDP per employee and capital intensity***

Applying Johansen's procedure, we have obtained the results which point out to presence of one cointegration equation at 5% significance level (Table 2).

Table 2. ***Johansen's cointegration test: estimation of elasticity coefficient (α)***

VALUES OF *LR* TEST STATISTICS	CRITICAL VALUES AT 5% SIGNIFICANCE LEVEL	CRITICAL VALUES AT 1% SIGNIFICANCE LEVEL	HYPOTHESIZED NUMBER OF COINTEGRATION EQUATIONS
21.4646	19.960	24.600	None
6.348925	9.240	12,97	At most 1
Normalized Cointegrating Coefficients: 1 Cointegrating Equation at 5% significance level			
LNYL	LNFKL	C	-
1.000000	-0.412951	-3.885678	-
	(0,01683)	(0,07058)	-

Note: Testing was carried out based on the starting test VAR model, second order, at the level of first differences without intercept in VAR equations and with intercept in cointegration equation.

Hence, equation (1.24) has the following form:

$$LNYL = 3{,}89 + 0{,}41 LNFKL\ . \qquad (1.25)$$

Upon the estimation of elasticity coefficient (α), applying equation (1.19), we can construct time series of inter-annual TFP growth rates, and test non-stationarity of all variables used in empirical analysis. The results of this research phase are shown in Table 3 in very short form.

Table 20. ***Overview of non-stationarity testing results***

VARIABLES	LABEL	ORDER OF INTEGRATION
Index of real effective exchange rate	**HPREDK**	Two certain unit roots (maybe more)
	REDKSM	One unit root
	REDKD	One unit root
Inter-annual growth of foreign trade to GDP ratio	**HPWTRGBDP**	Two certain unit roots (probably more)
	WTRGBDPSM	Two certain unit roots
	WTRGBDPD	Two certain unit roots (probably more)
Inter-annual GDP growth	**HPWBDP**	Three certain unit roots
	WBDPSM	Two unit roots
	WBDPD	Two unit roots
Inter-annual growth of physical capital stocks	**HPWK**	Two certain unit roots (probably more)
	WKSM	Two unit roots
	WKD	Two certain unit roots (maybe more)
Inter-annual growth of fixed physical capital stocks	**HPWFK**	Two certain unit roots (probably more)
	WFKSM	Most probably two unit roots
	WFKD	Two certain unit roots (probably more)
Natual logarithm of production per employee	**LNYL**	Two unit roots
Natural logarithm of capital intensity	**LNFKL**	Two unit roots
Growth of total factor productivity	**HPWTFPFK**	Three unit roots (probably more)
	WTFPFKSM	Two unit roots
	WTFPFKD	One unit root

Note: Detailed test results are available on request.

All time series are non-stationary with one or more unit roots, which makes cointegration of time series an adequate framework for further analysis.

Research results (Table 4) greatly show theoretically expected cause and effect relations, but with certain lacks when talking about their robustness. Actually, impact of capital accumulation to economic growth rate is reasonably positive, where multiplicators, in case of use of total physical capital as independent variable, varies between 0.348 and 0.687 depending on smoothing techniques applied to time series. Reliability of this finding is relative due to the fact that we did not manage to discover cointegration relation when we used growth rate of

fixed physical capital as independent variable, where time series were smoothened with double smoothing method (column 8). In the remaining two cases (columns 2 and 5), expected positive effect of capital accumulation was confirmed. As for the impact to TFP, it is reasonably positive, and values of multiplicators, depending on smoothing technique, significantly vary (0.226 – 3.737).

Table 21. ***Results of testing of capital accumulation and TFP growth impact to GDP growth***

INDEPENDENT VARIABLES	HODRICK PRESCOTT			HOLT WINTERS			DOUBLE SMOOTHING METHOD		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
C	-1.278	-0.589	3.957	1.926	-3.314	1.491	1.744	-	2.209
	-	-	-	(1.63648)	(2.29769)	(4.04738)	(2.01233)	-	(4.70211)
WK	0.687	-	-	0.348	-	-	0.374	-	-
	(0.28794)	-	-	(0.13114)	-	-	(0.16693)	-	-
WFK	-	0.431	-	-	0.652	-	-	-	-
	-	(0.01611)	-	-	(0.16196)	-	-	-	-
WTFPFK	-	-	0.226	-	-	3.066	-	-	3.737
	-	-	(0.18701)	-	-	(2.65621)	-	-	(4.53804)
Critical values at 5% significance level (Ho: no cointegration equation)	15.41	15.41	15.41	19.96	19.96	19.96	19.96	19.96	19.96
Values of LR test statistics (Ho: no cointegration equation)	71.81	51.43	44.10	30.02	52.26	26.51	23.55	*13.58*	24.10
Critical values at 5% significance level (Ho: at most one cointegration equation)	3.76	3.76	3.76	9.24	9.24	9.24	9.24	9.24	9.24
Values of LR test statistics (Ho: at most one cointegration equation)	*0.36*	*0.99*	*2.02*	*6.44*	*8.91*	*1.35*	*6.70*	1.62	*1.03*

Note: Dependent variable is time series of inter-annual GDP growth rates (WBDP) smoothened with appropriate technique. Detailed test results are available on request. Standard errors are given in brackets.

The second part of research dealing with impact of openness to capital accumulation and TFP growth resulted in far more problematic results (Table 5). For example, if we use index of real effective exchange rate as openness indicator, its impact significantly changes depending on smoothing technique and way of capital accumulation quantification. Impact of exchange rate to growth rate of total physical capital is negative (columns 1, 7), except in case of use of double smoothing method when Johansen's test proved that time series are not cointegrated at all (column 13). When attention is paid to the fixed part of physical capital, sign of impact changes depending on smoothing technique (columns 3 and 9), where in case of use of double smoothing method we did not manage to estimate any cointegration vector (column 15).

Table 22. ***Results of testing of openness impact to capital accumulation and TFP growth***

INDEPENDENT VARIABLES	HODRICK PRESCOTT						HOLT WINTERS						DOUBLE SMOOTHING METHOD					
	DEPENDENT VARIABLES																	
	WK		WFK		WTFPFK		WK		WFK		WTFPFK		WK		WFK		WTFPFK	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
C	-	7.590	0.828	10.813	-27.804	0.694	204.141	0.740	58.661	-	17.875	0.859	-	-11.322	-	-	-	-
	-	-	-	(0.13374)	-	-	(73.4974)	(0.98637)	(18.8307)	-	(6.09204)	(0.63646)	-	-	-	-	-	-
@TREND	-	-	-	-	-	-	-	-	-	-	-	-	-	0.161610			-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	(0.06553)			-	-
REDK	-0.204	-	0.091	-	0.246	-	-1.703	-	-0.411	-	-0.148	-	-	-	-	-	-	-
	(0.00752)	-	(0.02097)	-	(0.56634)	-	(0.62712)	-	(0.16214)	-	(0.05244)	-	-	-	-	-	-	-
WTRGBDP	-	0.919	-	0.977	-	0.197	-	1.806	-	7.449	-	0.025	-	1.634	-	6.960	-	-
	-	(0.11302)	-	(0.02645)	-	(0.03346)	-	(0.08495)	-	(5.40183)	-	(0.11903)	-	(0.10449)	-	(5.78617)	-	-
Critical values at 5% significance level (Ho: no cointegration equation)	12.53	15.41	15.41	19.96	15.41	15.41	19.96	19.96	19.96	12.53	19.96	19.96	19.96	25.32	19.96	12.53	19.96	19.96
Values of LR test statistics (Ho: no cointegration equation)	157.85	29.72	254.83	334.36	25.79	52.38	32.54	52.89	43.74	22.58	31.26	28.22	*19.43*	52.69	*11.21*	13.77	6.11	6.87
Critical values at 5% significance level (Ho: at most one cointegration equation)	3.84	3.76	3.76	9.24	3.76	3.76	9.24	9.24	9.24	3.84	9.24	9.24	9.24	12.25	9.24	3.84	9.24	9.24
Values of LR test statistics (Ho: at most one cointegration equation)	*0.18*	*1.55*	*0.06*	*2.79*	*0.36*	*0.58*	*4.82*	*0.23*	*5.24*	*2.41*	*4.12*	*7.48*	4.12	*11.97*	4.35	*1.78*	0.74	2.18

Note: Detailed test results are available on request. Standard errors are given in brackets.

Impact of exchange rate to TFP growth is even more disputable. Actually, movement from Hodrick-Prescott's to Holt-Winters' method changes sign of cointegration coefficient (columns 5 and 11), while application of double smoothing method results in absence of cointegration (column 17).

Inclusion of other indicator of openness into econometric research gives slightly more consistent findings. Impact of foreign trade to GDP ratio growth to the growth of total physical capital (columns 2, 8 and 14) is positive and varies depending on smoothing method between 0.919 and 1.806. If instead of total physical capital we use only a fixed part of it (columns 4, 10 and 16), the effect is also positive, but variations of cointegration coefficient, depending on smoothing method, are quite high (0.977 – 7.449).

The estimated impact of foreign trade intensity to TFP growth is also unreliable. If we follow Hodrick-Prescott and Holt-Winters' methods, the impact is positive (columns 6 and 12), while application of double smoothing method eliminates cointegration (column 18).

5. CONCLUSION

Research of the impact of Serbian economy openness to its economic growth was conducted through the analysis of relevant time series for the period between January 2005 and December 2009. In the analysis we have tested two potential channels of indirect impact: (a) impact of openness to economic growth via capital accumulation, and (b) impact of openness to economic growth through total factor productivity growth. The research is composed of two parts. The first part deals with the impact of TFP and capital accumulation growth to economic growth, while the second one is dedicated to research of the impact of economy openness to capital accumulation and TFP growth.

The first part generated theoretically reasonable and expected findings. Actually, according to them, capital accumulation and growth of total factor productivity positively affect economic growth. Robustness of these results is slightly disturbed with the fact that we did not manage to estimate long-run equilibrium relation between economic growth rate and growth of fixed physical capital when series were smoothened by double smoothing method.

The results obtained in the second part of the research cannot in any way be characterised as reliable ones. Impact of openness variables to TFP growth and capital accumulation is inconsistent and changes as the openness variable changes, but also with the change in way of capital accumulation quantification and with time series smoothing technique. Inconsistency of cointegration coefficients is particularly expressed if index of real effective exchange rate is used as openness indicator. On the other hand, the impact of foreign trade to GDP ratio growth to capital accumulation is positive and significantly varies depending on the applied smoothing method, especially when it is about fixed

physical capital. Bearing in mind unstable nature of the obtained findings, we can conclude that we do not have reliable evidence about the impact of Serbian economy openness to its capital accumulation and TFP growth.

Hence, empirical research of Serbian economy for the period between January 2005 and December 2009 did not manage to find long-run impact of openness to economic growth, because there is no reliable evidence about long-run impact of openness to capital accumulation and TFP growth.

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