Total Factor Productivity and the Significance of the Public Sector*

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Sonja ŠLANDER WOSTNER
France KRIŽANIČ
Boštjan BREZOVNIK
Borut VOJINOVIĆ

Sonja ŠLANDER WOSTNER
Assistant Professor, PhD, School of Economics and Business, University of Ljubljana and EIPF, Institute of Economics, Ljubljana, Slovenia
Tel.: 00386-15-892.488
E-mail: sonja.slander@ef.uni-lj.si

France KRIŽANIČ
PhD, Scientific Councilor, EIPF, Institute of Economics, Ljubljana, Slovenia
Tel.: 00386-12-521.688
E-mail: france.krizanic@eipf.si
ORCID: 0000-0002-8609-7856

Boštjan BREZOVNIK
Professor, PhD, Institute for Local Self-Government Maribor, Maribor, Slovenia
Tel.: 00386-31-687.788
E-mail: bostjan.brezovnik@lex-localis.info
ORCID: 0000-0001-8297-9862

Borut VOJINOVIĆ (corresponding author)
Professor, PhD, IPDP, Institute of Business Diagnosis and Forecasting and EIPF, Institute of Economics, Ljubljana, Slovenia
Tel.: 00386-41-655.989
E-mail: borut.vojinovic@eipf.si
ORCID: 0000-0002-6417-6166

Abstract

It is typical in the modern world that most economic growth is explained by an increase in total factor productivity, commonly accompanied by the rise of real capital. After the last financial crisis, Slovenia was specific in the growth of total factor productivity between 2009 and 2019 in that the 44 analyzed industries substituted the decline of net real values of fixed capital, associated with a large contraction in bank loans to non-financial corporations. During this period, Slovenia's total factor productivity strengthened due to increases in innovative potential, human capital (employees with higher education), and the share of foreign trade in Slovenia's GDP.

The public sector played an important role in this, as the increase in innovation potential and human capital was the result of the increase in the real level of Slovenian Export and Development Bank loans to enterprises and from extensive EU Structural and Cohesion Funds placements. The growth of innovation potential was influenced by the rise in the number of full-time researchers, and the increase in human capital was influenced by the economic climate in the EU.

Keywords: Total Factor Productivity, fiscal policies, EU, GDP, capital.

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1. Introduction

In our paper, we address a specific topic in a small, extremely open economy, a member of the EU and the Eurogroup, which managed to restore economic growth during and after the 2008 financial crisis, despite more than halving bank loans to non-financial corporations to a level where these credits do not reach annual gross operating surplus – the sum of depreciation and profits (Bank of Slovenia, 2016, 2021; Statistical Office of the Republic of Slovenia, 2021). Our basic research question is 'can endogenous growth factors (investments in research and development, or more broadly in intellectual products and in human capital) compensate for the effects of the credit supply restriction by influencing total factor productivity (TFP)?' The Slovenian example shows that it can. The paper analyzes what prompted the corresponding increase in TFP and endogenous growth factors during this period in Slovenia.

Slovenia is at a post-industrial stage of development. In 2019 the GDP per capita reached 23,165 euros or 25,934 dollars (Statistical Office of the Republic of Slovenia, 2021). Institutions related to the economic development of Slovenia have evolved using the process of imitation of the continental European development model (Križanič and Vojinović, 2019). It consists of a 'diffusion oriented' technology policy linked to an educational push, in which the development of new technologies takes place in small and medium-sized enterprises (Ergas, 1987). Slovenian companies use their own resources, EU funds, co-financing of customers, services of public research institutes, benefits of tax releases, etc. to finance their development and related research, but they do not share the results of developmental knowledge with each other (Prokop and Stejskal, 2017).

In the great global financial and economic crisis from 2008 to 2013, Slovenia's GDP fell by 9% in real terms (Table 1). The initial decline in GDP was associated with a collapse in export demand (exports of goods and services fell by 17% in 2009), and the continuation of the crisis in 2012 and 2013 was the result of inadequate (restrictive) fiscal policy associated with strong economic pessimism. Slovenian exports of goods and services began to grow in 2010. From 2010 to 2019, the share of exports of goods and services in GDP increased from 64% to 84% (Table 1). Stable export growth also enabled the start of real GDP and employment growth in 2014. Finally, in 2017, a fiscal balance was also established (Križanič and Vojinović, 2019).

The results in Table 1 also show a reduction in the deficit (2009), the establishment of balance (2010 to 2012), and then the strengthening of the current account surplus of the Slovenian balance of payments; between 2017 and 2019 it reached 6% of GDP. The unemployment rate was 4.4% in 2008, rising to 10.1% during the financial crisis until 2013 and then falling again to 4.5% by 2019. Inflation approached 6% in 2008, but declined rapidly during the financial crisis. In 2015 and 2016, there was even deflation in Slovenia.

In July 2010, the Bank of Slovenia increased the required capital adequacy ratio of banks and this, together with the tightening of criteria for assessing the creditworthiness of bank receivables, led to a gradual reduction in the volume of loans from foreign owned or domestic owned banks in Slovenia. Until September 2016, they declined continuously and decreased by 58% (Bank of Slovenia, 2016, 2021).

Table 1: Main characteristics of the Slovenian economy 2008–2019

	GDP in real terms	Share of exports of goods and services in GDP	Current account as a share of GDP	Unemployment rate	Inflation rate
Year	Index 2008 = 100	%	%	%	%
2008	100	66	-5	4.4	5.7
2009	92	57	-1	5.9	0.9
2010	94	64	-1	7.3	1.8
2011	95	70	-1	8.2	1.8
2012	92	73	1	8.9	2.6
2013	91	74	3	10.1	1.8
2014	94	76	5	9.7	0.2
2015	96	77	4	9.0	-0.5
2016	99	78	5	8.0	-0.1
2017	103	83	6	6.6	1.4
2018	108	85	6	5.1	1.7
2019	111	84	6	4.5	1.6

Sources: Statistical Office of the Republic of Slovenia, 2021; Bank of Slovenia, 2021.

Difficult access to capital has particularly affected the digitalization process in Slovenia. The net real value of ICT equipment as a part of stocks and fixed assets fell by 47% from 2008 to 2014 and was still 44% lower in 2019 than in 2008 (Statistical Office of the Republic of Slovenia, 2021). Since 2014, the Slovenian economy has barely compensated the depreciation of ICT assets. In contrast, intangible assets or intellectual property assets (research and development, computer software and databases), as they are newly marked in the statistics, increased by 13% in net real value from 2008 to 2019. This is a consequence of the process of increased development intensity in the Slovenian economy, when an even more pronounced 59% increase in the number of higher educated employees was observed in the same period (Statistical Office of the Republic of Slovenia, 2021). The increase in intellectual property products (intangible assets) and the increase in human capital (employees with higher education) were the results of market conditions that caused the need to achieve higher quality standards followed by higher market shares. Furthermore, this process was also influenced by the Slovenian development policy measures related to the absorption of EU funds and loans from the State Export and Development Bank. The Structural and Cohesion EU Funds grants increased by 176% from 2008 to 2019. They peaked in 2014 when they were four and a half times larger than in 2008 (Republic of Slovenia, GOV.SI, 2020). From 2008 to 2019, the Slovenian Export and Development Bank's (SID) development loans increased by 43% in real terms (SID, Slovenian Export and Development Bank, 2010, 2012, 2014, 2017, 2018, 2019). Part of these loans was financed by the European Investment Bank. With an intensive development policy, the share of R&D in Slovenia's GDP increased from 1.6% in 2008 to 2.6% in 2013 and then decreased to 2% (Statistical Office of the Republic of Slovenia, 2021). Fluctuations in

investments in R&D were related to Slovenia's difficulties in the ongoing implementation of development policy during the transition from the EU financial perspective 2007–2013 to the new EU financial perspective 2014–2020. If Slovenia had relied solely on its own resources to promote the introduction of new technologies, companies, and business practices, it would have found itself in much greater difficulties during the financial crisis of 2008 and later, than the temporary decline in R&D investment after 2013. A study by Santos-Arteaga *et al.* (2020) shows that the deterioration of financial stability in EU member states that are followers of technological progress has a strong negative impact on their innovation capacity.

Slovenia has clearly succeeded in taking advantage of international (EU funds), national and regional entrepreneurship factors (Fortunato *et al.*, 2017). By increasing investments in intellectual property products it achieved a higher level of competitiveness in the global market. In 2014, Slovenia was among the top eight EU member states (Kraftova and Kraft, 2018) with more than 1.5% of business investment in R&D in GDP. During the analyzed period, Slovenia was able to increase its exports of goods and services owing to the EU's market of around 500 million inhabitants in the dominant middle class with differentiated product needs (Jung, Seo and Jung, 2018). The structure of the paper is as follows. First, the introduction with an incorporated description of the Slovenian economy, and after that, the theoretical framework, explanation of methodology, and data used, including the presentation of empirical results. The final part of the paper provides the conclusion, literature, and data sources.

2. Theoretical framework

On one hand, total factor productivity (TFP) shows the part of the output that is not explained by the amount of inputs used in the production process, and on the other hand, TFP also shows how efficiently and intensively the inputs are used in this process. TFP is an important factor of long-term economic growth as well as short-term fluctuations in this growth (Tsounis and Steedman, 2021). TFP or the productivity of capital (including natural resources) and labor together change with economies of scale, improvements in productive factors allocation, and technological progress (Akkaya and Güvercin, 2018; Kim and Loayza, 2019). The latter are the three components of TFP.

The components of TFP vary from country to country according to their economic development. Developing countries are moving from factor-driven economies to investment-driven economies and further to innovation-driven economies (Porter, 2003; Lopez-Carlos, 2009). In this process, the importance of TFP increases.

TFP was first analyzed econometrically by Moses Abramovitz (1956) and Robert Solow (1956) as a constant in the Cobb-Douglas production function. The first calculations already showed that TFP explains about three quarters of US economic growth (Metcalfe, 1991).

Various studies, particularly including Grossman and Helpman (1991), Aghion and Howitt (1992), Coe and Helpman (1995) and also their reassessment with more modern

econometric techniques (Coe, Helpman and Hoffmaister, 2008) have shown that TFP is influenced by domestic R&D and the R&D of trading partners, human capital, business cycle, infrastructure, openness of the national economy (share of exports and imports to GDP), foreign direct investment and direct investment of a given national economy abroad. The impact of R&D on TFP is heterogeneous. It is different for large and small countries, but also dependent on institutions (Acemoglu, Aghion and Zilibotti, 2006). Similarly, Kim, Loayaza and Meza-Cuadra (2016) classified the determinants (drivers) of productivity growth into five groups: (1) innovation (creation of new technologies), (2) education (the ability of the workforce to absorb the knowledge of new technologies), (3) market efficiency (promoting efficient and flexible allocation of resources by sector and enterprise), (4) infrastructure (transport, telecommunications, energy, water, and sewage and sanitation), and (5) institutions (regulation, judiciary, police), political system – protection of property rights and fundamental civil rights to ensure social and economic stability.

Variables that show innovation activity in TFP analyses include investment in R&D, number of patents, number of publications in scientific and technological journals (Nadiri, 1993; Chen, Dahlman, 2004; Guellec and Van Pottelsberghe de la Potterie, 2004), as well as the share of intangible assets in all assets (Bistrova *et al.*, 2017; Matos and Neves, 2020). Variables that show human capital in TFP determinant studies are the number of years of schooling, number of employees with completed secondary and tertiary education, public investment in schools, the number of students per teacher, test results (Kim and Loayza, 2019), as well as the number of tertiary educated employees (Antonelli and Fassio, 2016).

More recent analyses explain TFP in several equations. Antonelli and Fassio (2016) first explain intellectual capital (patents per employee) and the share of knowledge-intensive business services in total employment and use these two variables together with the real level of R&D expenditure and human capital (share of tertiary education students in the total population) to explain TFP. The structure of the model estimated by Vila, Cabrer and Pavia (2015) is similar, except that the TFP-weighted distance between regions is included as an explanatory variable to indicate cross-border impacts on economic development.

Policies affecting TFP were developed in response to the stagflation crisis and the reduction in aggregate supply during the two oil shocks (1973 and 1979). Namely, at that time the most economically developed countries began to promote productivity growth (development policy, industrial policy) and, in the conditions of technological progress associated with the Cold War and the space race, accelerated economic development based on information and communication technologies; we know the process as the information revolution. It is described by the endogenous growth theory (Romer, 1986, Grossman and Helpman, 1991) emphasizing the importance of investments in R&D and the growth of human capital. Policies that can affect these two factors have been analyzed by the evolutionary school of economic thought based on Schumpeter's assumptions about economic development (Nelson and Winter, 1982), the new trade theory (Krugman, 1990), and the new economic geography (Krugman, 1998). Successful development policies promote technological advancement with increasing returns, learning by doing, and a positive

impact on the rest of the economy, i.e., positive externalities (Evenson and Westphal, 1995; Mazzucato, 2013).

3. Methodology and data used

The total factor productivity of industry is estimated from the Cobb-Douglas production function according to the equation developed by OECD (1999). In agriculture, the land is not included in capital and the state and public services do not pay rent on the capital they use, so it does not make sense to estimate TFP for agriculture, public administration, defense, education, health, social welfare services, and culture. If used, the results would be biased as they would show the excessive impact of labor on added value or output. There is no production of tobacco products or petroleum/coke products in Slovenia, so, when explaining TFP factors in Slovenia from 2009 to 2019, we take into account the remaining 44 industries.

In our analysis, the growth rates of TFP in Slovenia from 2009 to 2019 are explained by the growth rates of human capital – employees with higher education (Vila, Cabrer and Pavia, 2015), the growth rates of intangible assets – the real value of intellectual property assets (Bistrova *et al.*, 2017; Matos and Neves, 2020) and the growth rates of Slovenia opening to the world (De Melo and Robinson, 1992), presented by the share of exports and imports in the Slovenian GDP.

The growth rates of intellectual property assets by industry are explained by the growth rates of the number of full-time researchers, the growth rates of the amount of EU structural and cohesion funds launched in Slovenia (real terms), the growth rates of the real value of loans from the Slovenian Export and Development Bank Inc. (SID) to companies (Fazzari, Hubbard and Petersen, 1989), and by the growth rates of the net real value of information and communication assets (ICT) in the given industry (Seo, Lee and Oh, 2009; Spiezia, 2012). A dependent variable shifted by one period explains the distribution of the influence of independent variables in all previous periods – infinite distributed lag model or Koyck lag (Koyck, 1954). There is a constant in the equations and since the analysis is stochastic, we also have an unexplained residual.

The dynamics of human capital are explained by the dynamics of EU receipts from the Structural and Cohesion Funds, the dynamics of the real net value of ICT funds and the dynamics of real GDP in EU. The equation again includes a one-period lagged explanatory variable (infinite distributed lag), constant and unexplained residual.

The equations are estimated on the annual data variables for 2009 to 2019 in the panel of the 44 branches of the Slovenian economy (NACE Rev. 2, two-digit numerical code). Data at the level of industries on the number of employees, the number of employees with higher education, compensation of employees, the net value of fixed assets, the net value of ICT equipment, and the net value of intellectual property products, as well as data on industry real and nominal value added are obtained from the SIStat Database (Statistical Office of the Republic of Slovenia, 2021). The same source of data on GDP, exports, imports, inflation, and the number of full-time employed researchers at the national level is

used. Data on the dynamics of real GDP in the EU-28 are obtained from Eurostat (2021). Data on the amount of EU funds spent by the Structural and Cohesion Funds are obtained from the Portal GOV.SI (Republic of Slovenia, 2020). Data on loans from the Slovenian Development Bank to companies are obtained from the annual reports of this bank (SID, Slovenian Export and Development Bank, 2010, 2012, 2014, 2017, 2018, and 2019).

Industry data on the added value deflator are calculated from data on nominal and real value added by industry. Aggregate data on the share of foreign trade in GDP is calculated from aggregate data on nominal exports and imports of goods and services and aggregate data on nominal GDP.

The series used in the analysis were tested for Unit Root (Dickey and Fuller, 1979). If the single root hypothesis could not be rejected, the series were rejected. Series were also tested for the effect of cointegration (Pedroni, 2000; 2001). Only series where the cointegration hypothesis between the growth rates of the variables was rejected were included in the equations. Heteroscedasticity was eliminated in the equations by taking into account fixed effects, and the potential autocorrelation (interdependence of unexplained residues) was also reduced by the inclusion of an autoregressive component. EViews 10 software was used in the analysis.

In the equations explaining the dynamics of development activity (Intellectual property products) and the dynamics of human capital (Employees with higher education), we found that the impact of explanatory variables is concentrated with a certain time lag, and the continuation of the effect is also spread over a very long period. This distribution of impact is shown by the one-time lagged explanatory variable. From the regression coefficient of the short-term elasticity for one period of the lagged dependent variable, we estimate the long-term elasticity (distribution of influence over a longer period of time) of the independent variables on the dependent variable (Koyck, 1954; Berndt, 1991).

4. Empirical results

The results of our analysis are presented in Tables 2, 3 and 4. We explained 39% of Slovenia's total factor productivity dynamics, 35% of the real intellectual property products dynamics, and more than 63% of the dynamics of employees with higher education. In the equations that explain the dynamics of total factor productivity and the dynamics of human capital, the autocorrelation is reduced by the inclusion of the third order autoregressive component.

The first column in Tables 2, 3, and 4 sets out the determinants that, according to economic theory, affect total factor productivity. The second column shows the variables that represent these determinants. The parentheses on the right of the variables' names in this column indicate the time lag (how many years of change in the independent variable are needed to produce the change in the dependent variable). The third column of the tables presents the coefficients showing the influence of an independent variable on the dependent variable. The t-statistic values are in brackets below the coefficients. For all the independent variables involved, these are much larger than 1. The impact is therefore

statistically significant. The last column of the tables shows the long-term elasticity of the dependent variable to a given explanatory variable.

The results presented in Table 2 show that with a 1% change (growth or decline) in real value of intellectual property products, the Slovenian total factor productivity increases (decreases) by 0.2%. The impact occurs in the current year. The impact of 1% growth or decline in the number of employees with higher education is almost the same, with the difference that it occurs after one year. Slovenian total factor productivity is also affected by the change in the openness of the Slovenian economy to the world, as shown by the share of foreign trade in GDP. An increase in this share by 1% affects the increase in Slovenia's total factor productivity by more than 0.6%. The growth of exports of goods and services increases economies of scale (Nishimizu and Robinson, 1984; De Melo and Robinson, 1992), while the growth of imports of goods and services enables the transfer of new or improved technologies (Khan, 2006). The effect occurs after three years.

The growth or decline in the net real value of intellectual property products in Slovenia is related to development intensity (dynamic of the number of researchers at the aggregate level shows the development efforts of companies and investments of development policy in universities and research institutes), aggregate placement of EU development funds (Structural and Cohesion Fund), aggregate loans from the Slovenian Export and Development Bank Inc. (SID) and the level of digitalization (real net ICT assets). Table 3 shows that a 1% increase or decrease in the number of full-time researchers has a short-term effect of a 0.12% increase or decrease in the real net worth of intellectual property products. The impact occurs with a time lag of one year; it increases to 0.14% in the long run. The change in payments of EU funds from the Structural and Cohesion Funds by 1% (in real terms) leads to a 0.02% change in the net real value of intellectual property products

Table 2: Explanation of the dynamics of total factor productivity in Slovenia 2009–2019

Growth rates	Dependent variable	Total factor productivity
	Independent variable (lag in years)	Coefficient (t-statistics)
	Constant	-0.0129 (-2.0)
Innovation potential	*Intellectual property products* / *Value added deflator*	0.1954 (4.7)
Human capital	Employees with higher education (-1)	0.1779 (2.9)
Openness to the world	Share of foreign trade in GDP (-3)	0.6482 (4.2)
Third order autoregressive component	AR (3)	-0.2041 (-3.3)
R^2	39.3	
	44 industries in the period from 2009 to 2019	

Source: Own calculations.

Table 3: Explanation of the dynamics of the volume of intellectual property products in Slovenia 2009–2019

Growth rates	Dependent variable	*Intellectual property products* / *Value added deflator*	
	Independent variable (lag in years)	Coefficient (t-statistics)	Long-term elast.
	Constant	0.0064 (1.6)	
Develop-mental intensity	Number of full-time researchers (-1)	0.1233 (3.1)	0.14
EU development funds	$\frac{\textit{Structural and Cohesion Fund payments}}{\textit{Slovenian inflation rate}}$ (-3)	0.0243 (2.7)	0.03
Development loans	$\frac{\textit{SID loans to enterprises}}{\textit{Slovenian inflation rate}}$ (-1)	0.2042 (3.7)	0.23
Digitalization	$\frac{\textit{ICT assets}}{\textit{Value added deflator}}$ (-3)	0.0569 (1.8)	0.06
Lagged dependent variable	$\frac{\textit{Intellectual property products}}{\textit{Value added deflator}}$ (-1)	0.1123 (2.0)	
R^2		35.3	
	44 industries in the period from 2009 to 2019		

Source: Own calculations.

in Slovenia. The time lag is three years; in the long run, this effect increases to 0.03%. The increase or decrease in the real volume of loans of the Slovenian Export and Development Bank Inc (SID) to companies after one year affects a 0.2% increase or decrease in the net real value of intellectual property products. In the long run, the effect increases to 0.23%.

Table 3 also shows that the real change in the 1% net real value of ICT equipment reaches 0.06% influence on the volume of intellectual property products in Slovenia. The impact occurs after three years and increases only slightly in the long run; similarly, Venturini (2015) also proved in his analysis that ICT investments affect TFP with a relatively long time lag. In Slovenia, investments in software, as part of intellectual property products, are obviously not significantly related to investments in ICT assets. The reason is the specific functioning of the Slovenian capital market in the second decade of this century. Saving of capital was achieved by the continuation of introducing new technologies, products, and business approaches with significant savings on the purchase of new computer hardware.

Table 4 shows that a 1% change in the aggregate placements of the EU Structural and Cohesion Funds after two years affects a 0.05% change (in the same direction) in the number of employees with higher education. In the long run, this effect only slightly increases. The economic environment of Slovenia has a very strong influence on the employment of highly educated people. A 1% increase in real GDP in the EU-28 led to a 0.78% increase in the employment of people with higher education over a three-year time period. In the long run, this elasticity increases to 0.86%. The effect can be explained by the role played by the total factor productivity and with it the employment of highly educated people in the growth of potential GDP in Slovenia between 2009 and 2019. Most of the potential GDP

Table 4: Explanation of the dynamics of employees with higher education in Slovenia 2009–2019

Growth rates	Dependent variable	Employees with higher education	
	Independent variable (lag in years)	Coefficient (t-statistics)	Long-term elast. coefficient
	Constant	0.0563 (8.8)	
EU development funds	$\frac{\textit{Structural and Cohesion Fund payments}}{\textit{Slovenian inflation rate}}$ (-2)	0.0454 (4.3)	0.0504
Economic growth in Slovenian environment	Real GDP growth in the EU (-3)	0.7766 (3.0)	0.8610
Digitalization	$\frac{\textit{ICT assets}}{\textit{Value added deflator}}$ (-3)	0.0578 (1.9)	0.0641
Lagged dependent variable	Employees with higher education (-1)	0.0980 (1.2)	
Third order autoregressive component	AR (3)	-0.0812 (-1.4)	
R^2		62.7	
	44 industries in the period from 2009 to 2019		

Source: Own calculations.

increased in this way, as the growth of induced investments in fixed assets was limited by the contraction of credit. The increase or decrease in the real net value of ICT equipment led to a 0.06% increase or decrease in the employment of highly educated employees with a three-year time lag in the observed period. Long-term elasticity is only slightly greater than short-term.

From 2008 to 2019, the net real value of fixed assets decreased by 1% in 44 analyzed Slovenian industries, while the number of persons in employment (3%) and total factor productivity (12%) increased (Statistical Office of the Republic of Slovenia, 2021; own calculation). The data thus show that in the Slovenian production function between 2008 and 2019, tangible capital was replaced by labor and especially by the improvement in the total factor productivity. It prevented the collapse of credit from affecting the economic stagnation in Slovenia. However, economic growth slowed down despite significant incentives for development and research. Between 2002 and 2008, Slovenia's GDP increased in real terms by 4.4% per year, and between 2013 and 2019 by an average of 3.3% per year (Statistical Office of the Republic of Slovenia, 2021). Slovenia's success in the observed period is that it maintained and developed its innovation system despite very unfavorable circumstances, which hampered the growth of investment in fixed assets (Demšar and Kontler-Salamon, 2019). The relationship between significant R&D investment in Slovenia and only slow economic growth after the last financial crisis was also noted by Kraftova and Kraft (2018): 'In this context, Slovenia is an interesting case, which has more relative R&D expenditures than the Netherlands and the United Kingdom but does not reach their economic performance, although it is exceeded only by the 'peculiar' Cyprus, which joined the EU after 2003, with the lowest value of R&D at the average GDP-PC level'.

5. Conclusion

Slovenia is an open country, a member of the EU and the Eurogroup. It traditionally belongs to Central Europe and throughout history has adopted a continental European development model in which technologies are dispersedly developed or imitated by small and medium-sized enterprises. Its specific position, being the most productive economy in the former Yugoslavia, enabled Slovenia to develop into a relatively stable net exporter. In the financial crisis from 2008 onwards, it was first severely affected by the decline in export demand, and then the recession was prolonged by pursuing a restrictive fiscal policy in 2012 and partly in 2013. In the last ten years (2009 to 2019), Slovenia's development model was put to a serious test due to errors in the regulation of the financial system. The restrictive policy of the Bank of Slovenia in this area (from 2010 onwards) caused bank loans to the economy to more than halve and to fall to a lower level than the annual national gross operating surplus (sum of depreciation and profit). The economic collapse was prevented by increased spending by the economy and the state on research and development as well as other forms of innovation potential, and in particular by increased human capital engagement. These are the two most important creators of endogenous economic growth in the economic analysis presented as improvement in total factor productivity.

In our analysis, we explained the growth rates of Slovenia's total factor productivity with the growth rates of innovative potential (the net real value of intellectual property products) and the growth rates of human capital (highly educated employees). Other influences, especially the takeover of technologies through imports and the effect of economies of scale along with the export dynamics are shown by the growth rates of the share of foreign trade in Slovenia's GDP. The impact of innovation potential and human capital on total factor productivity is approximately equally strong in Slovenia.

The impact of innovation potential already occurs in the current year, while the change in human capital affects total factor productivity with a time lag of one year. The effect of changes in the share of foreign trade occurs only after three years. However, this impact on Slovenia's total factor productivity is strong and statistically highly significant.

The explanation of the dynamics of innovative potential and human capital shows that between 2009 and 2019 the growth or decline of EU Structural and Cohesion Funds and ICT equipment affected the dynamics of intellectual property products and the dynamics of employment of highly educated employees. The impact was slow (in two or three years) and, measured per unit of investment, small. Of course, the significant volume of EU Structural and Cohesion Funds' investments in the observed period must also be taken into account. The growth or decline in the net real value of intellectual property products was relatively strongly and statistically significantly influenced by the growth or decline in the number of full-time researchers and the growth or decline in the real level of loans of the Slovenian Export and Development Bank Inc. (SID). The influence occurred with a time lag of one year. The dynamics of employment of the highly educated were influenced by the economic situation in the EU (real GDP growth in the EU-28). This impact was slow (after three years) but strong.

Our analysis shows that Slovenia's economic growth between 2009 and 2019 was characterized by the replacement of capital with the growth of total factor productivity. The decline in physical investment was offset by investment in knowledge, R&D and other components of innovation potential. The results of our analysis provide an answer to the fundamental research question of our analysis i.e., 'can endogenous growth factors (investments in research and development, or more broadly in intellectual products) and in human capital through the influence on total factor productivity, compensate for the effects of the credit supply restriction?' The Slovenian example shows that they can.

We also put in the light that the state plays a major role in promoting TFP growth, since, at least in the case of Slovenia, in the period between and after the financial crisis, it provided funds through the EU Structural and Cohesion Funds and the Slovenian Export and Development Bank, which enabled the economy to increase investments in intellectual property products and increase the engagement of human capital. The analysis also revealed that the public sector (research infrastructure as indicated by the total number of researchers) played an important role in the increase of TFP.

The conclusions of our analysis can serve as an information base for other countries on the periphery of the EU. Investments in the promotion of growth and the application of endogenous factors of economic growth (R&D or, more broadly, intellectual property products and knowledge or human capital), which saved Slovenia from economic collapse, can serve other countries to speed up the 'catching up' process. Individual EU members with a developed school system could achieve relatively quick (ten years) and great results here. In terms of GDP per capita, they could approach the EU average. Let us add that in this process, Slovenia benefited from EU funds and loans from the state Development Bank according to strict capital placement criteria, which largely prevented the possible negative effect of rent-seeking and moral hazards.

Further research could, by generalizing to more countries, show the role of substitution between TFP, labor, and capital at different levels of economic development and for different sizes of countries. Such a generalization of the research could also show typical patterns of development policy in relation to different countries, with different levels of economic development and different histories.

Disclosure statement

There is no financial interest or benefit that could arise from the application of this research.

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