Does Implementation of the Smart Growth Priority Affect Per Capita Income of EU countries?—Empirical Analysis for the Period 2000–2017

Izabela Młynarzewska-Borowiec¹

Received: 13 November 2019 / Accepted: 29 June 2020 / Published online: 8 July 2020

© The Author(s) 2020

Abstract

Smart growth is one of the priorities of the Europe 2020 strategy, implemented by European Union member states since 2010. Developing economy based on knowledge, human capital and innovation, ipso facto, implementing the smart growth objectives, is theoretically justified and should stimulate growth processes in EU economies. The aim of this study is to examine the existence and nature of the relationship between the state of implementation of the smart growth targets in the new and old EU countries and their GDP per capita. The analysis for the period 2000–2017 indicated a varied degree of advancement of EU countries in implementing the smart growth targets. The assessment of the overall level of the smart growth targets' implementation, expressed in the smart growth summary index calculated in this paper, leads to the conclusion that the new EU members, having a relatively lower level of initial implementation of the smart growth objectives, showed a much higher dynamic in this field than the old EU members. The surveys conducted with the use of econometric models confirmed that effective implementation of the smart growth targets resulting in a higher employment rate and improvement of the quality of human capital had a positive impact on GDP per capita in EU countries, especially in the new member states. The results indicate that investment in R&D did not automatically affect the level of GDP per capita of the analysed economies. This impact was spread over time and limited only to the countries where R&D expenditure was higher than 1.5% of GDP.

Keywords Smart growth · European Union · Smart Growth Summary Index (SGSI) · Fixed effect models

✉ Izabela Młynarzewska-Borowiec
i.mlynarzewska@uthrad.pl

¹ Faculty of Economics and Finance, Kazimierz Pulaski University of Technology and Humanities in Radom, Radom, Poland

Introduction

Smart growth defined as developing economy based on knowledge, human capital and innovation is one of the priorities of the Europe 2020 strategy, implemented by European Union member states since 2010. The idea of moving towards the so-called knowledge-based economy within the EU is longer, because its assumptions have already been the subject of interest of a large part of the EU countries under the Lisbon strategy since 2000. The above strategies implemented both at EU and national levels are an attempt to counteract the EU's structural problems reflected by weakening pace of economic growth and competitiveness of the EU countries in relation to the largest trade partners, i.e. the USA, China and India, and resulting mainly from the relatively low level of professional activity, education and European society's propensity to innovate, as well as lower level of investment in research and development and utilisation of new technologies (European Commission 2010). Smart growth priority is assumed to interact also with other Europe 2020 strategy priorities, i.e. sustainable and inclusive growth. Technological progress and innovation have a positive impact on environmental protection, resource saving and the development of sustainable production methods. It creates new jobs, reduces unemployment as well as economic and social exclusion (Begg 2010). Smart growth, requiring high R&D expenses and the use of mechanisms conducive to application of theoretical knowledge in practice is regarded as a growth creating high added value (Dziawgo and Dziawgo 2016; Yi 2013). It is growth connected with the increasing role of education, knowledge and innovation, which is potentially more universal and sustainable (Rusca 2011; Balcerowicz and Rzońca 2015).

Focusing on implementation of the smart growth priority in the EU undoubtedly originated from many theoretical concepts indicating a significant impact of innovations and human capital on increase in GDP per capita level and the role of institutional factors supporting this relationship. The precursor of this approach was Solow (1957), who identified technological progress (total factor productivity changes) as the exogenous source of GDP. In the version of the neoclassical growth model presented by Mankiw et al. (1992), the key role of human capital in stimulating GDP was for the first time emphasised. An important role in its creation (as an endogenous resource) was attributed to properly conducted economic policy. It was also in line with the previous concepts of Schumpeter (innovation theory) or F. Machlup (concept of knowledge industries), emphasizing the importance of implementing innovation by entrepreneurs–innovators and the development of the sectors responsible for development and distribution of knowledge (e.g. education, R&D, information services) for economic growth processes (Schumpeter 1934, 1939; Machlup 1962). The theoretical justification for including the smart growth idea into the priorities of European Union policy can be found especially in endogenous growth theories. According to them, an increase in individual qualifications of employees, learning opportunities and innovative abilities of economies are the main GDP drivers. They are particularly connected with investment in R&D and education and should be supported by a state policy (Barro 1997). P. Romer (1990) proves the theoretical and empirical relationship between GDP and the accumulation of human capital obtained by improving the quality of the education system, learning by doing, external effects between companies (spillover effects) and relevant government activities in the field of supporting technological

changes (investment in R&D), monitoring the process of creating and distributing knowledge and protecting entities responsible for inventions. R. Lucas (1988) defines the sources of GDP per capita growth as the initial state of human capital resources, the quality of which can be improved as a result of “internal effects” (self-development, skills improvement, increasing productivity) and “external effects” (impact of an individual employee on the performance of others). S. Rebelo (1991), in turn, claims that GDP growth is mainly associated with the effective production of final capital goods and the gradual increase in human capital used in their production. He underlines the importance of involving both private entities and public bodies in creating human capital resources and actions aimed at increasing the professional activation of society.

The implementation of the smart growth priority under the Europe 2020 strategy in EU countries, which, as indicated above, is deeply theoretically justified, involves the achievement of several objectives by 2020, i.e. increasing R&D expenditure, improving the quality of human capital by increasing the percentage of people with tertiary education and lowering the rate of early leavers and increasing professional activation of European society. The progress of individual countries in their implementation is monitored by the European Commission through the European Semester, an annual cycle of macro-economic, budgetary and structural policy coordination (Rzeszotarska 2016; European Semester 2019).

This issue is also the subject of interest of many economists. They focus very often on the progress of EU member states in achieving the overall Europe 2020 objectives, including those related to smart growth. In their research, they point at a significant variation in the level of implementation of the strategy across EU countries. The disparities are noticeable between the “old” and “new” EU members, between the highly developed western countries and south European countries (Fura et al. 2017), and among the new member countries (Stec and Grzebyk 2018). The convergence between the EU-15 and EU-13 countries in the implementation of the Europe 2020 strategy goals has also been proven (Szymańska and Zalewska 2018). The reasons for these differences are seen in the countries’ socioeconomic status, previous backlog in reaching the strategy goals in some of the community countries (Kukuła 2017), relatively high level of unemployment and unfavourable demographic structure in many EU member states, as well as in a public finance policy aiming to mitigate the effects of the 2008–2009 economic crisis (Klikocka 2019). In addition, there are voices questioning the success of the strategy and postulating the need to extend its time horizon (Kukuła 2017; Klikocka 2019).

However, there are a few studies where only the degree and prospects of the smart growth implementation in EU countries are examined. Majority of them focus on the attempts to create a tool measuring the level of implementation of the smart growth priority and assess the position of individual EU countries in this respect. Pasimeni (2012, 2013) makes an attempt to measure the performances of the EU member states in the Europe 2020 strategy, including its smart growth dimension, with the use of the Europe 2020 index (based on a set of relevant, accepted, credible, easy to monitor and robust indicators presented by the European Commission). Walheer (2018) decomposes the above index (by distinguishing between three different components: country-, group- and objective-specific indexes) and extracts the new indices allowing better quantification and monitoring of the progress of the European countries towards the achievement of the smart growth objectives, i.e. the Smart Growth Index and country-specific Smart Growth

Index. Żelazny and Pietrucha (2017), assuming that smart growth is based on innovation and institutions, carry out a survey for EU countries in 2004–2014 using the creative economy index whose components are both variables diagnosing innovativeness of the economy as well as variables characterising institutional environment. In the studies on the EU members' degree of smart growth targets implementation, composite indicators based on Hellwig's synthetic measure of development (HSMD) are also used. Skordzka (2016) ranks EU countries in terms of the value of the synthetic measure of the level of smart growth in 2013. This synthetic indicator is based on the selected variables from the Knowledge Economy Index (the World Bank) and the European Innovation Scoreboard (European Commission) methodologies. Hellwig's method of linear ordering is also used by Tusińska (2015) to determine the position of EU countries in the area of the fundamentals of innovativeness in 2012. The synthetic indicator created for this purpose includes a number of variables approximating important smart growth dimensions, i.e. the education system, R&D expenditure, innovative system and patent activity. In more in-depth studies, authors attempt to identify the factors determining the progress of EU members (also CEE countries) in meeting individual targets adopted under the smart growth pillar. The reasons for differences between EU countries are seen in the industry structure, intensity of using knowledge in particular sectors of the economy and research possibilities of individual countries (Mazur-Wierzbicka 2019). Żelazny (2017), in turn, assessing the positive changes in Poland in creating conditions for smart growth, points at the significant importance of human capital and creativity as the basis of innovation as well as institutional factors (freedom and property rights, business regulations, fiscal institutions etc.). In the context of all CEE countries, among the factors determining the effectiveness of implementing the smart growth objectives, authors also mention the level of the brain drain phenomenon, socio-economic conditions for retaining and attracting highly educated and qualified people (Talamaciu and Cismas 2016), innovation and education systems, effective use of ICT technologies, conditions for entrepreneurship facilitating the ability to bring new knowledge into the market in a timely and effective manner (Myszkowska 2015) or the level of tertiary education expenditure (Radulescu et al. 2018).

The economic effects of successful implementation of the smart growth priority are much less frequently examined in the literature. M. Radulescu et al. (2018) found an empirical evidence for the positive impact of some of the Europe 2020 strategy objectives on CEE countries' economic performance and competitiveness in 2004–2015 and pointed to the particular importance of tertiary education, school dropout ratio and employment rate. Priede and Neuert (2015) showed the evidence that higher R&D investment implemented under Europe 2020 strategy resulted in higher EU economies' competitiveness expresses as the number of patents and the share of high-tech goods in total export. The literature provides examples of research where implementation effects of only one smart growth target (mainly R&D expenditure and human capital resources) are investigated. Kacprzyk and Doryń (2017) found no evidence of a positive impact of R&D expenditure on economic growth in both the old and new EU member states in the period 1993–2011. In turn, Szarowska (2017), in a survey of 20 EU members for the period 1995–2013, proved the positive impact of public R&D expenditure on economic growth and the insignificant impact of these outlays made by private entities. A statistically significant impact of R&D expenditures on EU members' economic growth in the period 2000–2013 was also confirmed in a survey

carried out by Freimane and Bāliņa (2016). Results of the recently published studies assessing the impact of human capital on EU countries' economic performance are more explicit. They confirmed a positive impact of qualified human capital on growth through innovation (Barcenilla-Visús and López-Pueyo 2018) and revealed a positive and statistically significant relationship between GDP per capita and innovative capacity of human capital (evidenced by the number of patents) and qualification of employees with secondary education (Pelinescu 2015). They showed additionally that this impact (in the period 1995–2015) was far more significant in more developed EU economies (Kokotovic 2016). The positive impact of the amount of human capital on the EU members' per capita income was also proved at the regional level (Laskowka and Dańska-Borsiak 2017). It was shown that past regional human capital was a key factor explaining current regional disparities in innovation and economic development of EU countries (Diebolt and Hippe 2018).

However, the literature lacks more comprehensive research examining the strength of the relationship between the state of implementation of the smart growth targets in EU countries and their GDP per capita. This study is an attempt to fill this gap. The aim of the study is also to investigate whether the strength and nature of this impact differs in relation to new and old member countries. The study, first of all, examines the progress of individual countries in achieving the smart growth targets in relation to the intended national and general EU objectives. Secondly, the overall position of individual EU countries in terms of implementing the smart growth assumptions in the period 2000–2017 is assessed. A synthetic indicator (i.e. Smart Growth Summary Index) is used for this purpose. Thirdly, the relationship between the state of smart growth priority implementation and GDP per capita is indicated, which is then verified in a panel survey conducted separately for new and old EU member states. Econometric models (fixed effect models) are estimated not only for the entire 2000–2017 period but also for 2010–2017 sub-period, i.e. the period of the official implementation of the Europe 2020 strategy.

Implementation of the Smart Growth Targets in EU Countries in 2000–2017

Strengthening innovation is one of the headline targets of the smart growth priority under the Europe 2020 strategy (and the previous Lisbon strategy). This aim was assumed to be obtained through the increase in gross domestic expenditure on research and development activity to 3% of GDP by 2020. Individual member states determined also their national target to be reached by 2020 (specified in National Reform Programmes), differing from the general EU level. Three out of 28 EU countries set the national target at a higher level (Austria, Finland and Sweden), six countries at the level of 3% (Estonia, Slovenia, Belgium, Denmark, France and Germany) and the rest at a much lower level ranging from 0.5 to 2.7% of GDP.

In 2017, the R&D expenditure in the EU (EU-28) reached 2.07% (against 1.77 in 2000 and 1.92 in 2010). Despite the gradual progress in the period 2000–2017, the successes of individual countries have varied considerably (Fig. 1).

Countries with the highest level of the R&D expenditure, i.e. Finland and Sweden, which already in 2000 spent over 3% of GDP on R&D, did not achieve the intended target of 4% in 2000–2017. In recent years, the proportion of R&D expenditure to their

Fig. 1 Gross domestic expenditure on research and development activity (R&D) in EU member states in 2000, 2010 and 2017 (% of GDP). Target 2020 for UK has not been specified in National Reform Programme. Source: Eurostat database

GDP has even slightly decreased. Austria, Denmark and Germany (respectively in 2014, 2015 and 2017) exceeded the level of 3% of GDP, achieving the general EU target (Denmark and Germany also their national targets). France and Belgium, countries with a high R&D expenditure in 2000 (around 2% of GDP), showed an improvement in this scope. In 2017, they increased their R&D investment to 2.5 and 2.3% of GDP, respectively, not achieving the 2020 target yet. In the group of other old member states, fully obliged to implement the assumptions of the Lisbon strategy and then the Europe 2020 strategy in the field of R&D investment, a small progress in the period 2000–2017 was generally observed. In Greece, Spain, Italy and Portugal, the level of investment in R&D in 2017 increased to 1–1.5% of GDP, and in the Netherlands, an increase to about 2% of GDP was reported. The exceptions were Ireland and the UK, where changes in R&D expenditure were much smaller, and Luxembourg, where a systematic decrease was observed.

In the group of the new member states in the period 2000–2017, R&D investment level was significantly lower. At the beginning of the period, these countries were not full members of the EU yet and did not fully implement the priorities of the Lisbon strategy implemented at that time. In 2000, they were also characterised by a clearly differentiated level of expenditure on research and development. Only the Czech Republic and Slovenia had an R&D investment level of 1–1.2% of GDP. In other countries, this level was in the range of 0.2–0.8% of GDP. Until 2017, most countries in this group have managed to increase research and development expenditure. The highest level of investment on R&D in 2017 was observed in Slovenia, the Czech Republic and Hungary, where it amounted to 1.8, 1.7 and 1.4% of GDP, respectively. In turn, the highest progress in the period 2000–2017 was recorded in Poland and Estonia, where these expenditures, measured as the percentage of GDP, have more than doubled. A decrease in R&D expenditure was observed only in Croatia. Until 2017, only the Czech Republic and Cyprus were able to achieve the assumed national targets, but they were set at a low level of 1% and 0.5% of GDP, respectively. The other new EU member states have not been able to achieve the national target (set at a level ranging from 1 to 3% of GDP) yet.

It can be assumed that differentiated level of investment in R&D, as well as the successes of individual countries in achieving the 3% EU target resulted, first of all, from the persistent structural differences between EU countries, and secondly, from clear disparities in the sources of financing R&D activity. An evaluation of the Eurostat data from the period 2000–2017 shows that the highest percentage of GDP for research and development is maintained by countries where expenditure on R&D in approx. 60–70% is incurred by the business sector. An improvement in R&D intensity in many countries, e.g. Poland and Estonia, was accompanied by increasing importance of the enterprise sector and a drop in the contribution of the government sector in financing R&D.

The smart growth priority target aimed at improving education quality was assumed to be obtained through reducing the percentage of early leavers from education and training to 10% by 2020. In Italy, Spain, Bulgaria and Romania, the national targets were established at a higher level than the general EU level (ranging from 16 to 11%). The rest of the current EU members have decided to reach the number of early school leavers at 10%, and even at a much lower level, e.g. Croatia—4%, Poland—4.5% and Slovenia—5% (Fig. 2).

In the subsequent years, the number of early leavers from education and training aged 18–24 systematically decreased, and in 2017, the percentage of such persons in the European Union accounted for 10.6% (against 17.0% in 2000 and 13.9% in 2010). By 2017, the level defined as the national target was achieved in most member states. The exceptions were Bulgaria, Hungary, Malta, Slovakia and Romania as well as Spain and Portugal.

In 2017, the lowest percentage of people leaving education and training too early was recorded in Croatia (3.1%), Slovenia (4.3%) and Poland (5.4%), whereas the highest one in Spain (18.3%), Romania (18.1%), Malta (17.7%) and Italy (14.0%). Taking into account the progress of individual countries, one can state that the highest decrease in the number of early leavers was observed in Southern European countries, i.e. Malta, Spain, Portugal and Italy. These countries have not reached the EU level of

Fig. 2 Early leavers from education and training aged 18–24 in EU member states in 2000, 2010 and 2017(%). Target 2020 for UK has not been specified in National Reform Programme. Source: Eurostat database

10% yet, but during the period 2000–2017, they reduced the percentage of early school leavers by 36, 11, 31 and 11 percentage points respectively. In addition to the well-known initiatives implemented at EU and national levels (such as “Youth on the move”), a difficult situation on the labour market in these countries related to the high unemployment rate among young people (discouraging from dropping out of education too early) may have had an impact on the significant results of these countries.

Ensuring a high level of education, raising qualifications and adapting them to the requirements of labour markets, is an important goal of the EU smart growth priority. This aim was assumed to be implemented (and monitored) by increasing the share of population aged 30–34 with tertiary education. The general EU target for 2020 was determined at the level of 40%. Individual member states have set their national target at a very differentiated level from 26% (Italy) to 66% (Luxembourg).

In the period 2000–2017, an increase in the percentage of persons having completed tertiary education was observed in all member states. In 2000, the average share of the population aged 30–34 with tertiary education in all 28 EU members amounted to about 23%; in 2010, 33.8%; and in 2017, it grew to 39.9%. A dynamic growth of people with tertiary education or its equivalent may be strongly related to the decreasing percentage of population aged 18–24 who completed secondary education and did not continue studying (early leavers), discussed above.

The highest growth in 2017 against 2000 was recorded in Poland (33 percentage points), Luxembourg (32 percentage points), Latvia and Cyprus (25 percentage points). By 2017, 17 EU countries had reached or exceeded the level of 40%, also achieving a slightly higher national target. In 2017, Ireland, France and Luxembourg exceeded the level of 40%, but did not reach their assumed national target of 50–66%. Germany has not implemented the 42% target so far. Among the countries that declared a tertiary rate below 40%, Hungary, Malta, Romania and Italy have achieved their intended goal. It has not been done in Croatia, Slovakia and Portugal yet (Fig. 3).

Fig. 3 Tertiary educational attainment of persons aged 30–34 in EU member states in 2000, 2010 and 2017(%). Target 2020 for the UK has not been specified in National Reform Programme. Source: Eurostat database

In 2017, the highest share of persons aged 30–34 with tertiary degree (over 50%) was recorded in Ireland, Luxembourg, Lithuania, Sweden and Cyprus. The lowest tertiary educational attainment ratio (below 30%) was observed in Italy, Romania and Croatia.

Tertiary education statistics available in Eurostat (for the period 2013–2017) confirm that three-fifths of all tertiary students in Sweden, Slovakia, the Baltic Member States and Poland were women. Women were also in a majority among tertiary students in all of the other EU member states except for Greece and Germany. Across the EU-28, about 30% of all students in tertiary education were studying social sciences, journalism, business, administration or law and about 25%—mathematics, information technologies, engineering and construction. The number of graduated in the latter fields (which are key for the implementation of the intelligent growth priority) was highest in Germany (35%) and Austria (30%).

According to the Europe 2020 strategy assumptions, an increase in human capital resources plays a supporting role in the implementation of the smart growth priority. This aim is to be achieved, among others, by increasing labour force participation (especially of women, youth and elderly people) and monitored by employment ratio for population aged 20–64. The general EU goal for 2020 was set at the level of 75%. Individual national targets were specified at the level ranging from 62.9% (Croatia) to 80% (Denmark, Sweden and the Netherlands) (Fig. 4).

Despite the difficulties in the EU labour markets caused by the crisis started in 2007, resulting in a decrease in employment dynamics in the period of 2008–2014, a gradual improvement in the average level of employment in the group of 28 analysed countries can be observed. In 2000, the average employment rate amounted to about 66%. At the beginning of the implementation of the Europe 2020 strategy, it was around 68%, and in 2017, it increased to over 72%.

Among the countries that declared the highest employment rate, Sweden has achieved this goal so far, reaching in 2017 the value of the employment ratio at the level of 82%. The employment rate in Denmark and the Netherlands amounted to 77% and 78% respectively. Employment levels above 75% in 2017 were also recorded in the Czech Republic, Germany, Estonia, Austria, Lithuania and the UK. In the first three cases, the employment rate exceeded the national reference value. A high employment rate of persons aged 20–64, reaching almost 75%, was observed also in Finland and

Fig. 4 Employment rate of persons aged 20–64 in EU member states in 2000, 2010 and 2017(%). Target 2020 for UK has not been specified in National Reform Programme. Source: Eurostat database

Latvia. Among the countries that declared an employment rate below 75%, only Ireland, Croatia, Latvia and Poland have achieved their intended goal. In the period 2000–2017, the lowest progress in the labour force participation was observed in Greece, Italy and Croatia. In 2017, the employment rate in these countries amounted to 57.8%, 62.3% and 63.6% respectively.

The Overall Progress in Implementing the Smart Growth Priority vs. GDP Per Capita Changes of EU Countries in 2000–2017

Smart Growth Summary Index Dynamics in 2000–2017

Methodology

Analysing the position of individual EU countries in implementing the four discussed objectives, it is difficult to make their explicit overall assessment. Identifying leaders and countries clearly lagging behind in implementing the idea of smart growth requires the introduction of an aggregate indicator. For that reason, a composite indicator, i.e. Smart Growth Summary Index (SGSI) for selected years (for the period 2000–2017) is applied. It is calculated on the basis of the already mentioned methodology proposed by Z. Hellwig (1968). Under this method, the Euclidean distance of each country from the development pattern (reference country) is determined. The calculated composite index takes values in the range (0–1), but sometimes the value may be negative, which means that country is definitely worse than others. The closer the synthetic index is to one, the closer the analysed country is from the reference country. It is a classical method of linear ordering of countries and allows for the creation of their “ranking” in terms of several variables (in this case—in terms of four main “smart growth” objectives) (Skrodzka 2016; Tusińska 2015).

For each selected year and for each EU country (i) the *SGCI* was calculated according to the following procedure:

- a) Among four single indicators (j) reflecting the level of smart growth, i.e. employment rate of persons aged 20–64, gross domestic expenditure on R&D, tertiary education attainment of persons aged 30–34 and early leavers from education and training aged 18–24, the first three were identified as stimulants and the last one as a destimulant indicator.
- b) Normalisation of values of the above indicators with the use of the following formula was carried out:

$$z_{ij} = \frac{x_{ij} - \bar{x}_j}{s_j} \quad (i = 1, 2, \dots, n; j = 1, 2, \dots, m) \quad (1)$$

where

x_{ij} — i -th value of j -th indicator

$\bar{x}_j$ — mean of j -th indicator

s_j — standard deviation of j -th indicator

c) Development pattern $z_0 = [z_{01}, z_{02}, \dots, z_{0j}]$ was determined, where:

$$z_{0j} = \begin{cases} \max_i(z_{ij}) & \text{for stimulants} \\ \min_i(z_{ij}) & \text{for destimulants} \end{cases} \quad (2)$$

d) Calculation of the Euclidean distance of i -th country from the development pattern was conducted:

$$d_{i0} = \sqrt{\sum_{j=1}^m (z_{ij} - z_{0j})^2} \quad (i = 1, 2, \dots, n) \quad (3)$$

e) The value of SGSI for country i was calculated:

$$\text{SGSI}_i = 1 - \frac{d_{i0}}{d_0} \quad (i = 1, 2, \dots, n) \quad (4)$$

where

$$d_0 = \overline{d_0} + 2s_0, \quad (5)$$

$$\overline{d_0} = \frac{1}{n} \sum_{i=1}^n d_{i0}, \quad (6)$$

$$s_0 = \sqrt{\frac{1}{n} \sum_{i=1}^n (d_{i0} - \overline{d_0})^2} \quad (7)$$

f) On the basis of the SGSI value, a ranking of the investigated countries in selected years was obtained.

Results

Table 1 contains the values of SGSI for individual EU countries in 2000, 2004, 2008, 2012 and 2017. Analysing the value of this aggregated indicator, one can state a high degree of differentiation of EU countries in terms of the level of implementation of smart growth targets, especially between the so-called old and new members. The average value of the indicator for the EU-15 group in the period 2000–2017 was at the level of about 0.5, while the average for the EU-13 group amounted to about 0.35.

Among the new member states, the highest values of the SGSI (i.e. above the average value for this group and oscillating around the EU-15 average) were recorded by Estonia, Lithuania, Slovenia and the Czech Republic. In each of these countries, there was also a significant increase in the level of smart growth in the analysed period. However, the highest increase in this indicator occurred in Poland (from 0.25 in 2000 to 0.44 in 2017). In the EU-13 group, the lowest level of implementation of smart growth priorities was observed in Malta and Romania (even negative values of the indicator

Table 1 Smart Growth Summary Index (SGSI) for 28 EU member states in the period 2000–2017

Country	SGSI					Rank				
	2000	2004	2008	2012	2017	2000	2004	2008	2012	2017
EU-13										
Bulgaria	0.19	0.22	0.30	0.22	0.21	26	24	18	22	22
The Czech Republic	0.40	0.37	0.35	0.47	0.48	16	16	16	15	15
Estonia	0.42	0.45	0.51	0.61	0.50	14	14	12	7	12
Croatia	0.24	0.26	0.25	0.17	0.16	23	21	21	23	24
Cyprus	0.40	0.41	0.42	0.41	0.38	15	15	15	16	17
Latvia	0.29	0.29	0.35	0.38	0.37	19	19	17	18	18
Lithuania	0.43	0.45	0.46	0.49	0.53	13	13	14	13	8
Hungary	0.28	0.29	0.22	0.29	0.29	20	20	24	19	21
Malta	– 0.08	0.00	0.01	0.12	0.11	28	28	28	28	26
Poland	0.25	0.20	0.29	0.40	0.44	22	25	19	17	16
Romania	0.23	0.15	0.15	0.13	– 0.01	24	27	27	26	28
Slovenia	0.45	0.52	0.54	0.63	0.59	12	12	7	5	6
Slovakia	0.26	0.23	0.23	0.28	0.29	21	22	23	20	20
EU-13	0.29	0.30	0.31	0.35	0.34	-	-	-	-	-
EU-15										
Belgium	0.59	0.56	0.53	0.55	0.50	6	9	11	12	13
Denmark	0.72	0.82	0.75	0.76	0.69	3	3	3	3	2
Germany	0.61	0.60	0.59	0.62	0.50	4	7	5	6	11
Ireland	0.51	0.57	0.56	0.49	0.52	10	8	6	14	9
Greece	0.32	0.32	0.27	0.14	0.17	17	18	20	25	23
Spain	0.32	0.32	0.24	0.12	0.12	18	17	22	27	25
France	0.58	0.62	0.54	0.58	0.51	8	6	9	8	10
Italy	0.19	0.23	0.18	0.15	0.06	25	23	25	24	27
Luxembourg	0.47	0.54	0.49	0.57	0.50	11	11	13	9	14
Netherlands	0.60	0.64	0.62	0.67	0.65	5	4	4	4	3
Austria	0.54	0.54	0.53	0.56	0.61	9	10	10	11	5
Portugal	0.18	0.17	0.16	0.23	0.30	27	26	26	21	19
Finland	0.84	0.83	0.83	0.79	0.62	1	2	2	2	4
Sweden	0.84	0.84	0.89	0.88	0.79	2	1	1	1	1
United Kingdom	0.59	0.62	0.54	0.56	0.54	7	5	8	10	7
EU-15	0.53	0.55	0.51	0.51	0.47	-	-	-	-	-

Source: Eurostat database; own calculations

were reported). In these countries, as well as in Croatia, the value of SGSI has declined in the last decade.

Eleven countries from the EU-15 group were characterised by a high level of implementation of smart growth priorities. The SGSI level in these countries remained relatively stable, above the average for the whole group. In Scandinavian countries, the

value of the index was the highest and fluctuated between 0.7 and 0.9. The average for the EU-15 was clearly understated by four other countries: Portugal, Greece, Spain and above all, Italy. It turns out that the level of smart growth in these countries was even lower than the average in the EU-13 group. It is worth noting that the SGSI of these countries (with the exception of Portugal) dropped drastically in the last years.

Taking into account the ranking of all 28 countries for the period 2000–2017, it can be concluded that the top leaders in the implementation of the smart growth assumptions remained unchanged. The first three positions were occupied by Sweden, Finland and Denmark. The Netherlands and Germany also had a high and stable position in the ranking. In the last decade, also new EU member states appeared in the top ten: Slovenia (5–7th in the period 2008–2017), Estonia (7th in 2012) and Lithuania (8th in 2017). Malta, Romania, as well as, Italy and Spain were classified as the weakest in the ranking.

Changes in GDP per capita of EU member states in 2000–2017

The countries listed above as leaders in implementing the smart growth targets were also leaders in terms of GDP per capita (i.e. Luxembourg, Belgium, Denmark, Germany, Ireland, the Netherlands, Austria, Sweden and Finland) (Fig. 5).

Already in 2000, most of the EU-15 countries (except Greece, Spain and Portugal) had a level of GDP per capita above the average for all 28 countries. At that time, future new EU members (except Cyprus) had a level of per capita income of 20–90% of this average.

In 2000–2017, in most EU-15 countries (except Ireland), there was a decline in GDP per capita expressed as a percentage of the EU average. This was undoubtedly due to the lower GDP growth rate compared to the new EU members. In the EU-13 group (except Cyprus), a gradual increase in GDP per capita was observed. In 2017, GDP per capita of the Czech Republic, Cyprus, Malta, Slovenia and Slovakia oscillated around 70–90% of the EU average. It was higher than in Greece and Portugal and approached the level of Italy and Spain. It is worth adding here that the latter countries showed the

Fig. 5 GDP per capita of EU economies in 2000, 2010 and 2017 (EU average = 1). Source: WDI database; own calculations

lowest progress in meeting the smart growth targets, while the new member states showed a rapid progress in this area.

It can be intuitively assumed that the progress of individual countries in achieving the smart growth objectives corresponded to some extent to changes in the position of these countries in terms of GDP per capita. This hypothesis seems to be confirmed in Fig. 6.

For 22 of 28 EU countries, a positive/negative change in the Smart Growth Summary Index corresponded to a positive/negative change in the country's position in terms of per capita income in the period 2000–2017. The above regularity, i.e. the impact of the degree of implementation of smart growth targets on the level of GDP per capita, is verified in the next part of this study.

Implementation of Individual Smart Growth Targets and GDP Per Capita Level of EU Members in the Light of the Panel Analysis for 2000–2017

Methodology

Empirical analysis covered 28 EU member states in the entire period 2000–2017 and additionally for the period after 2010, when the smart growth tasks were precisely defined in NRPs and implemented as the crucial elements of the Europe 2020 strategy. The study however was decided to be conducted separately for the group of old members (EU-15 group) and new members (EU-13 group). The reason for this

Fig. 6 EU countries' change in the SGSI and GDP per capita in the period 2000–2017. Source: Eurostat and WDI databases; own calculations

approach was the fact that there was and still is a clear disproportion in implementing the individual smart growth targets between these two groups (confirmed by significant differentiated values of the Smart Growth Summary Index discussed above).

Panel models were used to examine whether the state of implementation of the particular smart growth targets affected the level of per capita income of the individual EU member states. The existence of individual effects of the countries was assumed. Fixed and non-random nature of the above effects was also adopted, and the use of the correct model (and estimator) was confirmed by conducting the Breusch-Pagan test and the Hausman test. The study uses fixed effects models in the following general form:

$$Y_{i,t} = \gamma_i + \beta' X_{i,t} + \varepsilon_{i,t} \quad (8)$$

$$i = 1, \dots, N; t = 1, \dots, T;$$

with the assumptions: $\varepsilon_{i,t} \sim IID(0; \sigma_\varepsilon^2)$; $\forall i = 1, \dots, N \forall t, s = 1, \dots, T E(X_{i,t} \varepsilon_{i,s}) = 0$,

where γ_i - individual (non-random, constant in time) effect of the country i ; β - a vector of structural parameters; $Y_{i,t}$ - explained variable (GDP per capita of country i in period t); $X_{i,t}$ - a vector of regressors; $\varepsilon_{i,t}$ - random term.

The dependent variable in the models is a natural logarithm of GDP per capita (expressed in Purchasing Power Parity, constant prices, 2011) of the country i and in period t . Data was obtained from the World Bank's World Development Indicators (WDI) database (2019). In the vector X_i logarithmised values of the following explanatory variables are included:

- $N_{i,t} + g + \delta$ - population growth of country i in period t increased by 0.05 (where 0.05 represents the sum of the technical development rate common for all countries g and depreciation rate δ^1), data obtained from the World Bank WDI Database (2019);
- $S_{i,t-1}$ - savings rate of country i (reflecting the accumulation of physical capital), equal to the investment rate, approximated as gross fixed capital formation in relation to GDP in the previous year ($t-1$), data obtained from the World Bank WDI Database (2019);
- $EMPL_{i,t}$ - employment rate (%) of persons aged 20–64; data obtained from the Eurostat database (2019);
- $GERD_{i,t-1}/GERD_{i,t-2}$ - research and development expenditure (% of GDP) of country i in the period $t-1$ or $t-2$; data obtained from the Eurostat database (2019);
- $EDU_1_{i,t}$ - early leavers from education and training ratio (as % of population aged 18–24); data obtained from the Eurostat database (2019);
- $EDU_2_{i,t}$ - tertiary education attainment ratio (as % of population aged 30–34); data obtained from the Eurostat database (2019).

The estimated regressions therefore correspond to the traditional approach of the Solow's model, which has been however expanded by including additional variables illustrating the level of implementation of the particular smart growth targets, i.e. R&D expenditure (GERD), employment rate (EMPL) and quality of human capital (EDU_1 and EDU_2).

¹ The value of 0.05 is consistent with the theory of R. Solow and confirmed by empirical studies.

Model (8) can therefore also be written in the following form:

$$\ln(\text{PKB}_{\text{pc_PPP}})_{i,t} = \gamma_i + \beta_1 \ln(N_{i,t} + g + \delta) + \beta_2 \ln(S)_{i,t-1} + \beta_3 \ln(\text{EMPL})_{i,t} + \beta_4 \ln(\text{GERD})_{i,t-1} + \beta_5 \ln(\text{EDU_1})_{i,t} + \beta_6 \ln(\text{EDU_2})_{i,t} + \varepsilon_{i,t} \quad (9)$$

The set of explanatory variables does not include the lagged values of GDP per capita, which means that the panel models are static. The choice of such a specification (and consequently-estimation method) results from the fact that growth regressions in the form of dynamic models are usually applied for testing the real convergence hypothesis. The main objective of this study is to identify whether and to what extent implementation of the smart growth targets had an impact on GDP per capita of the EU members, not to assess the rate of convergence within the analysed countries. In addition, no binary variables were introduced into the models. Therefore, estimation of the individual effects of panel units (countries) was abandoned. Models were estimated using a within estimator (FE). For each model, the Wald test for diversification of the constant in groups was additionally carried out.

Results

Estimation results and diagnostic tests of the models build for the particular groups are presented in Table 2. It can be stated that in each of them, the signs of the received estimates proved to be in line with expectations. They confirm the direction of the relationship between explanatory variables and the level of GDP per capita assumed at the beginning of the research and resulting from the Solow model and other theoretical concepts cited in this study.

The results of the estimation of each model indicate the following:

- a) a negative impact of the population growth (N) and the increase in the number of early leavers (EDU_1) on the level of per capita GDP (GDP_pc_PPP) and
- b) a positive effect of the savings rate (S), employment level (EMPL), number of people having completed tertiary education (EDU_2), as well as expenditure on R&D (GERD) on the income level (GDP_pc_PPP) of the analysed countries.

In the light of the results obtained for the group of new EU member states in 2000–2017, one of the six explanatory variables, approximating expenditure on the R&D (GERD), did not significantly affect the level of GDP per capita. The parameter β_4 (in the light of the Student's t test) turned out to be insignificant from a statistical point of view. Other explanatory variables showed a differentiated impact on the dependent variable PKB_pc_PPP . The obtained estimation results indicate a significant, positive impact of the EMPL and EDU_2 variables. This means that the increase in the employment rate and the number of young people having completed tertiary education contributed most to GDP per capita level of the new EU members. In the whole analysed period, a small negative but statistically significant impact of the number of early school leavers (EDU_1 variable) on the GDP per capita level was also proved. After 2010, when these countries were obliged to implement the assumptions of smart growth, the impact of individual explanatory variables on the level of GDP per capita

Table 2 Estimation results of model (9) for the EU-15, EU-13 and EU-11 in the period 2000–2017 and 2010–2017; dependent variable: $\ln(\text{GDP_pc_PPP})$; estimator: FE

Variables/model diagnostics	EU-13		EU-15		EU-11	
	2000–2017	2010–2017	2000–2017	2010–2017	2000–2017	2010–2017
Const	5.26768 (0.6309)***	5.1613 (0.4282)***	5.6889(0.5430)***	6.9860 (0.6996)***	6.41 (0.6978)***	6.41 (0.6978)***
$N_{it} + g + \delta$	- 0.16076 (0.0693)**	- 0.999 (0.0499)**	- 0.1463 (0.0511)***	0.0383 (0.0446)	- 0.0936 (0.0576)	- 0.0936 (0.0576)
S_{it-1}	0.1353 (0.0396)***	0.0353 (0.0346)	0.1613 (0.0427)***	0.2130 (0.0424)***	0.0846 (0.05693)	0.0846 (0.05693)
EMPL_{it}	0.9191 (0.1333)***	1.1363 (0.1056)***	0.9325 (0.1222)***	0.8224 (0.1539)***	0.8687 (0.1594)***	0.8687 (0.1594)***
GERD_{it-1}	0.0317 (0.0275)	0.0222 (0.0225)	0.0013 (0.0279)	0.0089 (0.0386)	-	-
EDU_{it}	- 0.0856 (0.0266)***	- 0.0049 (0.0214)	- 0.0829 (0.0213)***	- 0.1234 (0.0228)***	- 0.1039 (0.0223)***	- 0.1039 (0.0223)***
EDU_{it}	0.3474 (0.0261)***	0.1655 (0.0470)***	0.0679 (0.0263)**	0.09889 (0.0361)***	0.0566 (0.0287)*	0.0566 (0.0287)*
GERD_{it}	-	-	-	-	0.2039 (0.0385)***	0.2039 (0.0385)***
Number of observations	221	104	255	120	176	176
Model diagnostics:						
LSDV R^2	0.9342	0.9821	0.9772	0.9926	0.9743	0.9743
Within R^2	0.8056	0.8623	0.5254	0.7445	0.5506	0.5506
Wald test ¹	53.049	94.7742	269.017	238.214	270.79	270.79
test statistics	(9.466e-056)	(7.1193e-044)	(1.6856e-135)	(1.49312e-069)	(2.1075e-094)	(2.1075e-094)
(p value)	111.49	173.478	612.811	135.273	505.921	505.921
Breusch-Pagan test ²	(4.61897e-26)	(1.2869e-039)	(2.7377e-135)	(2.8877e-031)	(4.8936e-112)	(4.8936e-112)
test statistics	32.3456	19.5466	38.5211	41.1541	41.2888	41.2888
(p value)	(1.4007e-005)	(0.0033)	(8.8835e-007)	(2.7009e-007)	(2.5997e-007)	(2.5997e-007)
Hausman test ³						
test statistics						
[p value]						

The numbers in brackets denote the value of standard error. ***/**/* means significance at 1%/5%/10%.

¹ Null hypothesis H_0 : groups have a common constant (test for diversification of the constant in groups)

² Null hypothesis H_0 : Error variance in a unit = 0

³ Null hypothesis H_0 : GLS estimator is consistent (random effects model is more preferred)

Source: own calculations using GRET

changed only slightly. The exception was the EDU_1 variable. In the model for the period 2010–2017, this variable did not have a significant impact on the dependent variable (the parameter β_5 turned out to be statistically insignificant). This could be due to the fact that in 2010–2017 in most countries of this group, the early leavers rate was lower than the required 10% (in 2010, the average value of this rate in the EU-13 group was 10.5 and it fell to 8.1 in 2017), and therefore, its negative impact did not show.

Estimation results of the model for the old member states and the period 2000–2017, similarly to the EU-13, indicate a significant impact of the employment rate (EMPL variable) on the level of GDP per capita (estimated parameter β_3 was 0.93). A significant and positive impact was also noted in the case of savings rate. The estimated parameter for the S variable was higher than in the model for the EU-13 group and amounted to 0.16. In the EU-15 group, the impact of human capital resources on the level of GDP per capita turned out to be much lower (estimated parameter for the EDU_2 variable was only 0.07). Similarly to the results obtained for the new EU countries, in the EU-15 group in the period 2000–2017, the decrease in the number of early school leavers (improvement of the human capital quality) had a positive effect on the level of GDP per capita, although this impact was rather low. The model estimates do not indicate the impact of previous R&D investments on GDP per capita (parameter β_4 was not statistically significant). Estimation results of the model for the period 2010–2017 turned out to be rather similar. Only a slightly higher, positive impact of the savings rate and a higher negative impact of the EDU_1 variable on the dependent variable was found. During the implementation of the Europe 2020 strategy, similarly to the entire period, R&D expenditure proved to have no impact on the level of GDP per capita of the EU-15 countries.

In the light of the obtained results, investment in R&D turned out to be insignificant in shaping the level of GDP per capita of EU countries. This fact was a bit surprising especially in the context of the old member states that spent a high percentage of GDP on R&D. It undermined the majority of theoretical concepts discussed in the introduction of this paper, but confirmed the results of some empirical (and cited above) studies conducted previously for UE countries. Therefore, the mentioned problem was decided to be investigated in an additional econometric survey. At the beginning, the attempts to modify models by introducing 2–3-year lags of the GERD variable were made, supposing that the previously assumed 1-year lag might have not been sufficient (the effects of investments in R&D were visible after a much longer period of time). However, this approach did not bring the expected results (the parameter for the GERD variable was still statistically insignificant). Therefore, it has been hypothesised that the positive impact of R&D expenditure on GDP per capita takes place only when it exceeds a certain, fairly high level in economy. In order to verify it, model (9) was estimated for 11 EU members with the highest level of R&D expenditure in the period 2000–2017 (with average level higher than 1.5% of GDP). In this group (UE-11), there were Belgium, Denmark, Germany, France, Luxembourg, the Netherlands, Austria, Slovenia, Finland, Sweden and the UK. Finally a 2-year lag of the GERD variable was also applied in the model.

Results of the study are included in the last column of Table 2. In this case, R&D investment showed a high, positive impact on the level of GDP per capita (a structural parameter for the GERD variable was statistically significant at 1%). In this group of countries, an increase in R&D expenditure by 1% resulted in an increase in GDP per

capita by 0.2%. In addition, GDP per capita of the EU-11 group was dependent on the total number of employees (parameter for the EMPL variable amounted to 0.9) and to some extent on the quality of human capital (parameter for the EDU_1 and EDU_2 variable amounted to -0.1 and 0.06 respectively).

Conclusions

The results of the survey conducted in the period 2000–2017 indicate a varied degree of advancement of EU member states in implementing the smart growth targets. This is most likely due to the fact that during the period under analysis, EU countries still showed a high degree of differentiation in terms of their economic and technological potential, as well as their socio-economic development. The new member states started from a completely different “points” than much richer and more integrated countries of the “former fifteen”, which had already implemented some of the smart growth assumptions as part of the previous Lisbon strategy. Considering the four objectives pursued under the smart growth priority, it can be stated that by 2017, the implementation of three of them (i.e. an increase in the employment rate of people aged 20–64, an increase in the number of people having completed tertiary studies and a drop in the percentage of early school leavers) to a large extent has already been successful. The average value of the above indicators for the EU as a whole clearly moved towards the goals of the Europe 2020 strategy. Many EU members have already achieved not only their national targets, but also the general goals intended at the EU level. As the analysis shows, the biggest barrier of implementing the smart growth priority remained the insufficient effort of individual countries to invest in the innovativeness of economy. Countries with a high level of R&D expenditures (about 3% of GDP and higher) did not make a spectacular progress in this field in the period 2000–2017, and the countries with a low initial level of these expenditures, despite higher dynamics of positive changes, have been able to achieve the level of R&D financing only at the level of about 1.5% of GDP so far.

The assessment of the overall level of the smart growth targets’ implementation, expressed in the Smart Growth Summary Index calculated in this paper, leads to the conclusion that convergence between the 28 EU countries in the period 2000–2017 has accrued. The new EU members, having a relatively lower initial degree of implementation of the discussed objectives, showed a much higher dynamic in this field. Thus, they were catching up with the UE-15 group.

In the light of the empirical study, an increase in human capital resources, resulting from the effective implementation of the smart growth target related to a higher employment rate among people aged 20–64, largely determined the GDP per capita of EU countries. Despite clear differences between the new and old member countries, the countries’ efforts to increase professional activation of the population, especially women (e.g. through special mechanisms facilitating reconciliation of work with family responsibilities, programmes for the increase of entrepreneurship among women, flexible forms of employment), had a positive economic effect. In the EU-13 group, these effects were more visible in the period 2010–2017. It can be justified by the fact that the inclusion of these countries in the Europe 2020 strategy and the need to meet its

requirements, to some extent, intensified the activities of decision-makers in this area to date.

Positive changes in the quality of human capital in the individual EU countries (under the smart growth priority monitored by the percentage of early school leavers and the percentage of people with tertiary education), contrary to the expectations arising from the theoretical concepts, did not have a large impact on their GDP per capita in the period 2000–2017. Although in both the new and old UE members, a negative impact of the phenomenon of leaving school too early on GDP was observed; the significance of this relationship was rather small. According to the obtained results, a much stronger relationship between the resources of qualified labour force and GDP was observed, especially in the new member states. It is worth mentioning that the percentage of people with tertiary education or its equivalent increased much faster in these countries than in the EU-15. This was accompanied by structural changes, faster productivity growth and an increase in the innovativeness of economy, which undoubtedly had a positive impact on GDP per capita growth. Probably in richer EU countries, these processes also took place; however, their scope and dynamics were lower.

The results of the conducted research indicate that investment in R&D did not automatically affect the level of GDP per capita. This impact was spread over time, which is explained by the complicated and arduous process of creating both product and organisational innovations. The shape and efficiency of the individual national innovation systems also undoubtedly influenced the speed of obtaining the R&D investment effects. The conducted research proved that R&D expenditure stimulated the level of GDP per capita only in the countries where its level was sufficiently high (in the light of the study, higher than 1.5% of GDP). The experience of innovation leaders in Europe, i.e. the Scandinavian countries, shows that a high level of R&D expenses is usually accompanied by a high degree of diversification of their funding sources. In addition, public and private R&D expenditure should be rather complementary (in this way, the crowding-out effect may be avoided), which is possible when public expenditure on R&D has a rather indirect form (e.g. tax reliefs). A high level of investment in R&D in 11 selected EU countries was undoubtedly due to large involvement of private entities. Enterprises usually invest in applied research and experimental development. Investment in this type of research is usually less risky than basic research and brings faster and more measurable economic effects. This can largely explain why only in the countries with high R&D expenditure, and thus—with high involvement of enterprises in financing it—a significant impact of these expenses on the level of GDP per capita was observed. Thus, the countries implementing the smart growth priority should move towards such a structure of R&D expenditure. It gives a greater chance that R&D investment will result in positive changes in GDP per capita in the future.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

References

- Balcerowicz, L., & Rzońca, A. (Eds.). (2015). *Puzzles of Economic Growth. Directions in Development*. Washington: World Bank.
- Barcenilla-Visús, S., & López-Pueyo, C. (2018). Inside Europe: human capital and economic growth revisited. *Empirica*, 45(4), 821–847. <https://doi.org/10.1007/s10663-017-9394-2>.
- Barro, R. (1997). *Makroekonomia*. Warszawa: PWE.
- Begg, I. (2010). Europe 2020 and employment. *Intereconomics*, 3, 146–151.
- Diebolt, C., & Hippe, R. (2018). The long-run impact of human capital on innovation and economic development in the regions of Europe. *Journal of Applied Economics*, 51(5), 542–563. <https://doi.org/10.1080/00036846.2018.1495820>.
- Dziawgo, L., & Dziawgo, E. (2016). Ecological evolution of financial market: ecologically responsible investment. In N. H. Bilgin, H. Danis, E. Demir, & U. Can (Eds.), *Business Challenges in the Changing Economic Landscape* (pp. 167–178). Cham: Springer.
- European Commission (2010). Communication from the Commission. Europe 2020. A strategy for smart, sustainable and inclusive growth, COM (2010) 2020 final; <http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:2020:FIN:EN:PDF>. Accessed 25 Sempther 2019.
- European Semester 2019. https://ec.europa.eu/info/publications/2019-european-semester-country-reports_en. Accessed 10 October 2019.
- Freimane, R., & Bāliņa, S. (2016). Research and development expenditures and economic growth in the EU: a panel data analysis. *Economics and Business*, 29(1), 5–11. <https://doi.org/10.1515/eb-2016-0016>.
- Fura, B., Wojnar, J., & Kasprzyk, B. (2017). Ranking and classification of EU countries regarding their levels of implementation of the Europe 2020 Strategy. *Journal of Cleaner Production*, 165, 968–979.
- Hellwig, Z. (1968). Zastosowanie metody taksonomicznej do typologicznego podziału krajów ze względu na poziom ich rozwoju oraz zasoby i strukturę wykwalifikowanych kadr (Application of the taxonomic method to the typological division of countries in terms of their development level and resources and structure of qualified personnel). *Przegląd Statystyczny (Statistical Review)*, 4, 307–326.
- Kacprzyk, A., & Doryń, W. (2017). Innovation and economic growth in old and new member states of the European Union. *Economic Research-Ekonomska Istraživanja*, 30(1), 1724–1742. <https://doi.org/10.1080/1331677X.2017.1383176>.
- Klikocka, H. (2019). Assumptions and implementation of smart growth and inclusive growth targets under the Europe 2020 Strategy. *European Research Studies Journal*, 22(2), 199–217.
- Kokotovic, F. (2016). A panel regression analysis of human capital relevance in selected Scandinavian and SE European countries. *UTMS Journal of Economics*, 7(1), 13–24.
- Kukuła, A.J.(2017). Chances for the implementation of the Europe 2020 Strategy (2010–2020). *Annals of Social Sciences*, 9(45):3, 19–38.
- Laskowska, I., & Dańska-Borsiak, B. (2017). The importance of human capital for the economic development of EU regions. *Comparative Economic Research*, 19(5), 63–79. <https://doi.org/10.1515/cer-2016-0038>.
- Lucas, R. (1988). On the mechanics of economic development. *Journal of Monetary Economics*, 22(1), 3–42.
- Machlup, F. (1962). The production and distribution of knowledge in the United States. *Princeton University Press*, 278.
- Mankiw, N. G., Romer, D., & Weil, D. N. (1992). A contribution to the empirics of economic growth. *Quarterly Journal of Economics*, 107, 407–437 https://eml.berkeley.edu/~dromer/papers/MRW_QJE1992.pdf. Accessed 23 September 2019.
- Mazur-Wierzbicka, E. (2019). Smart growth as a challenge for Poland in the light of the Europe 2020 strategy. *Journal of Economics and Management*, 37(3), 87–106. <https://doi.org/10.22367/jem.2019.37.05>.
- Myszkowska, M. (2015). The competitiveness landscape in Central and Eastern Europe. *Economics of the 21st Century*, 4(8), 9–19.
- Pasimeni, P. (2012). Measuring Europe 2020: a new tool to assess the strategy. *International Journal of Innovation and Regional Development*, 4(5), 365–385.
- Pasimeni, P. (2013). The Europe 2020 Index. *Social Indicators Research*, 110, 613–635.
- Pelinescu, E. (2015). The impact of human capital on economic growth. *Procedia Economics and Finance*, 22, 184–190. [https://doi.org/10.1016/S2212-5671\(15\)00258-0](https://doi.org/10.1016/S2212-5671(15)00258-0).
- Priede, J., & Neuert, J. (2015). Competitiveness gap of the European Union member countries in the context of Europe 2020 Strategy. *Procedia - Social and Behavioral Sciences*, 207, 690–699. <https://doi.org/10.1016/j.sbspro.2015.10.139>.

- Radulescu, M., Fedajev, A., Sinisi, C. I., Popescu, C., & Iacob, S. E. (2018). Europe 2020 implementation as driver of economic performance and competitiveness. Panel analysis of CEE countries. *Sustainability*, 10(2), 1–22. <https://doi.org/10.3390/su10020566>.
- Rebelo, S. (1991). Long run policy and long run growth. *The Journal of Political Economy*, 9(3), 500–521.
- Romer, P. M. (1990). Endogenous technological change. *Journal of Political Economy*, 98(5), 71–102.
- Rusca, R. (2011). Towards Europe 2020: building an innovative and cohesive Europe-the cohesion policy towards Europe 2020. Dipartimento Sviluppo e Coesione. www.fesr.regione.emilia-romagna.it/pagine/le...towards-europe-2020/at.../file. Accessed 27 September 2019.
- Rzeszotarska, G. (2016). The Europe 2020 Strategy- a tool to implement the concept of smart growth in the EU. *Research Papers of Wrocław University of Economics*, 416, 145–152. <https://doi.org/10.15611/pn.2016.416.15>.
- Schumpeter, J. A. (1934). *The theory of Economic Development: an inquiry into profits, capital, credit, interest rate and the economic cycle*. Cambridge, Massachusetts: Harvard University Press.
- Schumpeter, J. A. (1939). *Business cycles: a theoretical, historical and statistical analysis of the capitalist process*. New York-London: McGraw-Hill Book Company.
- Skordzka, I. (2016). The synthetic measure of the level of smart growth in the European Union countries. *Optimum. Studia Ekonomiczne*, 5(83), 113–122. <https://doi.org/10.15290/ose.2016.05.83.07>.
- Solow, R. M. (1957). Technical change and the aggregate production function. *The Review of Economics and Statistics*, 39(3), 312–320.
- Stec, M., Grzebyk, M. (2018). The implementation of the Strategy Europe 2020. Objectives in European Union countries: the concept analysis and statistical evaluation. *Quality & Quantity*, 52(2), 119–133, <https://doi.org/10.1007/s11135-016-0454-7>.
- Szarowská, I. (2017). Does public R&D expenditure matter for economic growth? GMM approach. *Journal of International Studies*, 10(2), 90–103. <https://doi.org/10.14254/2071-8330.2017/10-2/6>.
- Szymańska, A., & Zalewska, E. (2018). Towards the goals of the Europe 2020 Strategy: convergence or divergence of the European Union countries? *Comparative Economic Research*, 21(1), 67–82. <https://doi.org/10.2478/cer-2018-0004>.
- Talmaciu, A. M., & Cismas, L. M. (2016). National competitiveness through the Europe 2020 Strategy and Human Development Index in CEE countries. A panel data analysis. *Timisoara Journal of Economics and Business*, 9(2), 115–128. <https://doi.org/10.1515/tjeb-2016-0008>.
- Tusińska, M. (2015). The fundamentals of innovativeness – a comparative analysis of European Union countries. *Journal of Economics and Management*, 20(2), 23–37.
- Walheer, B. (2018). Decomposing the Europe 2020 Index. *Social Indicators Research*, 140, 875–905.
- Yi, H. (2013). Clean energy policies and green jobs: an evaluation of green jobs in U.S. metropolitan areas. *Energy Policy*, 56, 644–652.
- Żelazny, R. (2017). Determinants and measurement of smart growth: evidence from Poland. *Journal of International Studies*, 10(1), 34–45. <https://doi.org/10.14254/2071-8330.2017/10-1/2>.
- Żelazny, R., & Pietrucha, J. (2017). Measuring innovation and institution: the creative economy index. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, 12(1), 43–62. <https://doi.org/10.24136/eq.v12i1.3>.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.