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IMPROVING THE COMPETITIVENESS – DETERMINANTS AND SOLUTIONS FOR QUALITY OF LOCAL BUSINESS CONDITIONS

Abstract: *The competitiveness is a multidimensional concept, being analysed at different levels. National and company competitiveness are deeply investigated, however, less attention is given to regional competitiveness. The importance of regional competitiveness arises from the factuality that it creates the quality of local conditions for companies' operations. Following this rational, two main goals of this researchare accepted. First goal is to model the impact of selected determinants on regional competitiveness, using a multiple linear regression model. The second goal is to propose activities that need to be implemented with the aim to improve the competitive performance of the analyzed regions. The model proves the positive impact of international exchange, human resources, and innovation, so future measures and activities at the regional, city and municipal levels need to be focused on strengthening these determinants.*

Keywords: *Regional competitiveness, Innovation, Export, Analysis of variance, Breusch-Pagan LM test, Education*

1. Introduction

The competitiveness is a multidimensional concept, with a large number definitions, levels of analysis or set of determinants (Gugler, 2019). As stated by the definition of World Economic Forum, the competitiveness is *"a set of institutions, policies and factors that determine the level of productivity of a country"* (Schwab & Porter, 2018, p. 11). As competitiveness assumes the capability to operate and survive in a competitive environment, there are three possible levels of the analysis are: micro, meso, and macro (Gorynia, 2019). Speaking from a company/firm pespective, competitiveness is defined as "*the ability of firms to compete, grow, and be profitable*" (Ratten & Dana, 2019), or as "*the ability of a firm to produce and sell products and services at a price lower than the competitors*" (IMD, 2000). On the level of a country or nation, competitiveness is understood as "*the ability of a country or nation to ensure the supportive environment for its companies' operations*" (Adamkiewicz, 2019). Between them, meso level of competitiveness is recognised being related to industry, sector, or region. In our paper, we focus on the meso level connected with the conditions of regions.

The definition of regional competitiveness that is used more often than others in the literature is the one of the European Commission, claiming that *"the competitiveness of a region is its ability to produce goods and services that meet the requirements of the domestic and world market in terms of price,*

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quality, etc., maintaining a high and sustainable level of income, or, more generally, the region's ability to generate, under external competitive pressures, a relatively high level of income and employment" (European Commission, 1999, p. 75). The competitiveness on the regional level is influenced by several factors; among them, those with the biggest influence are the infrastructure, level and quality of education of employed, and the business environment (European Commission, 2004).

Despite its complexity, this concept is very common among politicians, although is controversial in its essence (Kitson et al., 2004). And this exactly the resaon why there are more than one definition of regional competitiveness in the literature (Sánchez et al., 2019; Garcia, 2016; Branum et al., 2013). The competitiveness of region is believed to refer to conditions that allow companies to compete at the markets and to create certain values (Huggins & Reganold, 2008; Huggins et al., 2014; Huggins & Thompson, 2017). The regional competitiveness can be also defined as the ability of a region to generate rising incomes and improve quality of living standards (Meyer-Stamer, 2008), as well as the region's capacity to offer an attractive and sustainable environment for companies and the people living and working there (Dijkstra et al., 2011; Annoni et al., 2017). Sustainability in these definitions refer to the creation of a business environment stimulating for the development of the local economy. This implies fulfilling several important preconditions, and the crucial are the following: predictability and stable economic policy without frequent and sudden changes, efficient administration and transparent communication with local authorities, etc.

Due to the complexity of the concept of regional competitiveness, the basics of definition within the regional competitiveness model are often given. There are several approaches to modelling regional competitiveness, for example based on dual prices (Omoregie &Thomson, 2001). Another attitude is implemented in a pyramid model of regional competitiveness in which it includes basic factors, development factors and success factors (Lengyel, 2004; Gardiner et al., 2004; Lengyel & Lukovics, 2006).

The importance of regional competitiveness lead to formulation of two research aims of the paper. We aim at modelling the influence of international trade, entrepreneurship, human resources, and innovationon the competitiveness of regions.The second goal is to propose and put into practice measures for improving the competitive properties of the analyzed regions.

After the introduction, the second part of paper provides review of the determinants of competitiveness of regions. In the third part, the methodology and information basis of the study are presented and the research hypotheses are defined. The fourth section of the paper is devoted to discussion of the research outcomes. The conclusion makes recommendations for economic policy.

2. Theoretical aspect of regional competitiveness factors

The notion of competitiveness is widespread in the economic literature. Many economists have been explaining it for decades, even centuries. According to classical economic theory, the specialization and division of labor, discussed by Adam Smith, is based on economies of scale and differences in the productivity of countries or regions. According to Smith, the investing in capital and trade facilitates this specialization and increases productivity and the growth production. In addition, the growth is generated due to higher production of output that allows further division of labor and specialization. According to Smith's theory of absolute advantages, which he described in *The Wealth of Nations* in 1776, the benefits of international trade in relation to the autarky (the economic system which does not participate in in international trade) are great. If one area can produce certain goods using less input (labor) in production in relation to another territory or locality, then it will have an absolute advantage in the production of that good and should export it. Also, this area will import those goods in which there are no absolute advantages Gugler, 2019).

David Ricardo takes Adam Smith's idea and explains the benefits of international trade through the theory of comparative advantage. In his model, Ricardo explained that differences in production technologies in different economic systems lead to differences in comparative labor productivity (output per worker). According to the theory of comparative advantage, there are two economic systems (countries or regions), two types of goods and one factor of production. When workers in one economic system are more productive in the production of both types of goods (ie have an absolute advantage) in relation to another economic system and when they are relatively more productive in the production of one good (have lower production costs expressed in "equilibrium prices" of factor) compared to another (goods) in their economic system (i.e. they have a comparative advantage), then they specialize for the production of the good itself where they achieve the highest productivity (i.e. where they have a comparative advantage). Another economic system specializes for the production of the good where it achieves the highest productivity, although it have no absolute advantages in the production of any good compared to the previously observed economic system (Brue & Grant, 2012).

Neoclassical theory emerges after Ricardo's model, with the following assumptions: perfect information, constant yields and full divisibility of all factors of production. Neoclassicists (Eli Heckscher and Bertil Ohlin, John Maynard Keynes, Walt Whitman Rostow et cetera) explain trade and specialization by a factor proportions model. Different availability of factors influences a certain territory to specialize in the production of those goods where a certain factor (capital or labor) is used more intensively, i.e. a factor that the region has more at its disposal. An area that is richer in labor will produce and export labor-intensive goods, and import capital-intensive goods (Garelli, 2004).

Classical and neoclassical theory imply that the exchange takes place between different areas that have different technology and factor availability. These theories could not explain why does trade between similar countries or regions exist and why do different production structures in similar areas exist. Newer perspectives and models reject the theoretical contributions of classical and neoclassical schools and seek "the starting point" of competitiveness of economic systems in endogenous theory of economic growth and new trade theory (Krugman, 1983, 1989; Grossman & Helpman, 1995; Siggel, 2006).

Although numerous theories and explanations of determinants of the competitiveness of region, one of the most methodical approach explains regional competitiveness factors through the pyramid of "increasing the quality of living" and measures it by regional product, labor productivity and unemployment rate (Constantin, 2007).

Factors as sources of competitiveness are defined at the bottom of the pyramid, which include: economic structure, innovation, regional accessibility, the quality of workforce, environment, decision-making centers, social configuration and regional culture. Open competitiveness is the central pyramid section and refers to: technological development of technologies and SMEs, FDI, infrastructure and human capital, institutions and social capital. These factors manifest themselves as factors of labor productivity and employment rates. At the top of the pyramid, there is a target result, which is a higher quality of living. According to Imre Lengyel, there are several key factors of regional competitiveness, with the economic structure as the most important , meaning that the workforce of competitive regions is usually concentrated in the business services sector and/or in the manufacturing industry.

The second factor refers to the innovation, as the innovative environment is necessary for the region to respond to any kind of challenge. The proximity of large cities, the transport networks and the good geographical location, enabling the regional accessibility, make the region more successful than others. The fourth factor refers to the trained strength, showing the share of educated workers in the overall population and being relatively high in competitive regions. Next factor, the social structure is related to the knowledge-intensive economic activities and the growth of economic services affect regional competitiveness. The presence of a corporate headquarters, related to the factor of the centering decisions, is the next determinant of regional competitiveness thanks to such actions as for example creation of the demand for highly qualified employees, strengthening the local knowledge base, or reinforcing the business environment. The last factor concerns the regional identity, meaning that more competitive regions are able to solve problems caused by structural problems in the economy by promoting the regional identity of the community and localism (Lengyel, 2004).

In the continuation of the paper, the factors of regional competitiveness, which from our point of view, play are the key of the successfull economy, the initiating dynamic growth of the economy and the sustainable development of region will be considered.

2.1. International trade and competitiveness of regions

The regional competitiveness is most simply interpreted as as competitive advantage of one region in relation to another, observed through the region's share of the export market. Michael Porter, the guru of competitiveness, also highlighted the importance of export-oriented clusters in achieving a higher quality of living standard at the regional level (Porter, 2015).

However, the focus on regional exports as a factor of competitiveness is controversial. Initially the concept on competitiveness was defined for national economies, not at subnational levels, such as regional, city, or municipal levels. The focusing on regional export is characterized by all the problems and debates related to the notion of competitiveness. Even at the national level, there are significant disagreements over this notion. Thus, Nobel laureate Krugman considers concept of national competitiveness a "secondary" product of political initiatives in the United States and the European Union since the early 1990s, where in both cases the metaphor of competitiveness was used as an "excuse" for unpopular economic policy measures (Alexandros et al., 2016).

Local competitiveness is one of the determinants that affect on the internationalization of companies (Taylor & Jack, 2016), as from one perspective, companies operates locally and local conditions of business operations might support their internationalization, from the other perspective some barriers, mostly related to local demand, might be pushing factors to go abroad. On the other hand, internationalization of companies is often perceived as the driving force of economic growth and competition (Bužavaitė, Ščeulovs & Korsakienė, 2019). Understanding broadly, internationalization refers to any activity of company undertaken abroad (Daszkiewicz, 2015), in particularly to participation of a company in foreign operations, interactions, relationships and networks (Laužikas et al., 2021), namely both export and import activities. In narrow context, internationalization is connected to internationalization of sales (Hewerdine et al, 2014), namely the export activity.

It should not be overlooked that the metaphor of competitiveness, that implies that states compete on the world market as companies do is wrong. First, states and regions in case they are uncompetitive cannot go bankrupt as is the case with firms; then, the efficiency of a state and region cannot be equated with the surplus in foreign trade; world trade is not a zero-sum game and so on (Krstić, 2021).

2.2. The human capital and competitiveness of regions

Human capital refers to the knowledge, skills and competencies which impact individuals' productivity and their economic value (Marvel 2013). The general and specific human capitals are recognized, the general human capital is equally effective across different contexts, whilst specific human capital's effectiveness depends on the particular context (Marvel 2013; Capelleras et al. 2019). The most often, human capital is measured by its investment in formal education, namely in years of schooling or educational attainment (Faggian et al. 2017).

In the long run, human capital enables technological progress and increases productivity. Investing in human capital raises the quality of the workforce with all positive outcomes. The importance of human resources is emphasized in various models of regional competitiveness. Brooksbank and Pickernell ranked the regions of the United Kingdom according to indicators of education (Brooksbank & Pickernell, 1999). Gardiner considers various indicators of regional competitiveness related to knowledge and innovation (Gardiner, 2003). The comparative analysis on human resourses in eight Romanian regions was conducted by Constantin and Banica (Constantin & Banica, 2007).

2.3. Enterpreneuship and competitiveness of regions

The relationship between entrepreneurship and regional competitiveness is believed to exist, however, the discussion on which of the two factors determines the other one, remains to be solved (Guerrero et al., 2016). On the one hand, the level of regional entrepreneurship seems to be a determinant of territorial economic performance as the development of start-up is one of driven forces of regional development (Jonek-Kowalska & Wolniak, 2021). However, this impact looks to be mixed and unconvincing depending on the definitions and measures of entrepreneurship, as well as modelling methods (Szerb et al., 2019). On the other hand, entrepreneurs act in some regional environment, which might be supportive for the them.

Entrepreneurship is a broad concept with several definitions and tracks of understanding (Leković & Berber, 2019). Narrow understanding associates entrepreneurship with the entrepreneurial or start-up process, meaning the process of the creation and development of new companies (Yang et al., 2017). The environment of the organization, including regional environment, is one of groups of factors affecting the start-up process, together with personal and related to the organization itself factors (Naudé et al. 2008).

Entrepreneurs act in and interact with a specific environments: local, regional and national ones. These interrelated economic, social and institutional factors supporting the development of entrepreneurial ventures are reflected in the concept of the entrepreneurial ecosystem (Elnadi & Gheith, 2021). Entrepreneurial ecosystems are characterized by interactions between entrepreneurs and their environment due to benefits at all levels, and benefits for the entrepreneurs, industries, regions and nations. Entrepreneurial ecosystem is related to a particular territory and independent actors and factors interacting within this territory (Stam & van de Ven, 2021). The entrepreneurial ecosystem supports the access to finance, education, R&D transfers, public policies and programs and infrastructure (Yan & Guan, 2019).

Entrepreneurship also refers to different types of ventures which are not equally important for regional development (Szerb et al., 2019). Entrepreneurship which focus on imitating the existing ideas is proven to impact negatively the regional development, while the quality entrepreneurship, which implements radical innovations, exerts a positive influence (Szerb et al., 2019). For regional competitiveness, the activity of productive companies, especially high-growth companies, are of the significant importance (Sleuwaegen & Ramboer, 2020)

2.4. Innovation and competitiveness of regions

Innovation is another wide concept; in broad terms, it is associated with solutions new for a company or with some improvements of the existing products. In the narrow sense, innovation means products or solutions totally new in the market (Lejpras, 2014).

Joseph Schumpeter (1934) was the first researcher who highlighted the role of innovations, and, specifically, the activity of innovators, as the source of business cycles and economic growth. He perceived innovations as new combinations in the economy being a source of profit for innovators and, to some extent, to followers. They included new combinations of goods, new production methods, new markets, new sources of suppliers, and the new organization of industry. Implementing innovation leads an innovator to gain profits, which attracted followers to implement the same innovation. The activity of the followers results in the diffusion of innovation, accompanied by the expansion phase of a business cycle.

From the regional point of view, innovation can be treated as the characteristics of a region. This attitude let to distinuguish the concept of industrial regimes and their two types, the entrepreneurial and routinized one, depending on a manner of innovation implementation. In the entrepreneurial regimes, innovations are introduced mostly by start-up companies, newly created entrepreneurial entrances than by established companies, in consequence in such regimes, the number of new innovative entrances to the market is relatively high. In turn, innovations are introduced mostly by established companies in the routinized regimes, meaning that the number of start-up companies is rather limited (Peneder, 2008).

The observation that innovations are created in a specific environment led to the emergence of the idea of the innovation ecosystem, which means a set of geographically close actors and relations that foster local innovation performance by the creation, dissemination and use of knowledge and technology (Gerli et al., 2021). Geographical dimensions can be analyzed from the point of view of a country or a region. National dimension is reflected in national innovation systems, and it is aimed in the positive impact of quality of public institutions, such as governments, on innovation (Veiga et al., 2020). The regional innovation systems, RIS, reflect these interactions from the point of view of a region (Jucevicius et al., 2017). The idea of the regional innovation system is related to the concept of the triple helix of innovation, which assumes the collaboration of three overlapping sectors, universities, government and industries, that results in innovations. Universities and companies together provide innovative ecosystems with the regulatory and financial support of the innovation policy, and the circulation of people, ideas and innovation between these spheres is necessary. Universities affect the regional systems through their role in the development of human capital and entrepreneurial culture, in the institutional networking and supporting local companies (Ierapetritis, 2019). The main assumption of the RIS's impact on the regional competitive advantage is that geographical proximity of innovation actors leads to the exchange of tacit knowledge (Knickel et al., 2021).

3. Research methodology and hypotheses

Considering the availability of data, as well as the existing literature dealing with the topic of competitiveness, the following variables were selected: (1) Gross domestic product per capita (GDPpc) as a measure of regional competitiveness; (2) Export per capita (EXpc), Export dependence (EXD), and the Import dependence (IMD) as approximations for trade openness; (3) Number of students enrolled in tertiary education per 10,000 inhabitants (S10000), and Number of pupils enrolled in secondary education per 10,000 inhabitants (P10000) as indicators of the level and quality of education (measure of human capital); (4) Gross domestic expenditure on research and development (GERD) as an approximate variable of innovation quality in the NUTS 2 region; and (5) Number of registered companies per 10,000 inhabitants (E10000) with the help we measure entrepreneurial activity in the region. Table 1 lists all used variables, together with the accompanying explanation and data source.

Table 1. Description of the variables used in the regional competitiveness analysis

Variables	Definition	Sources
Gross domestic product per capita (GDPpc)	GDP/Population	Eurostat
Export per capita (EXpc)	Export/Population	Statistical offices and Smart Specialization Platform
Export dependence (EXD)	Export/GDP×100	Statistical offices and Smart Specialization Platform
Import dependence (IMD)	Import/GDP×100	Statistical offices and Smart Specialization Platform
Num. of students enrolled in secondary education per 10,000 inhabitants (S10000)	The number of students enrolled in tertiary education/Population ×10,000	Eurostat
Num. of pupils enrolled in secondary education per 10,000 inhabitants (P10000)	The number of pupils enrolled in secondary education/Population ×10,000	Eurostat
Gross domestic expenditure on research and development (GERD)	Gross domestic expenditure on R&D/GDP×100	Eurostat
Num. of registered companies per 10,000 inhabitants (E10000)	The number of registered companies/Population ×10,000	Eurostat and GEM

The main goal of this paper is to test an econometric model of regional competitiveness, and to investigate which factors have the greatest impact on regional competitiveness. In accordance with this research goal, the following hypotheses were defined and tested:

Hypothesis (H1): There is a linear relationship between regional competitiveness and the selected set of economic variables.

In formulating this hypothesis, we were guided by the research of Robert Huggins and Will Davies and Vytautas Snieska and Jurgita Bruneckienė. Robert Huggins and Will Davies introduced the *European Competitiveness Index*, to measure the competitiveness of 27 European countries and 118 regions (Huggins & Davies, 2006). In the report, they also emphasize the importance of regions, regional aspects of productivity (competitiveness) and the role of social capital and infrastructure in the research of regional competitiveness. Finally, Snieška Vytautas and Jurgita Bruneckienė presented their own model of competitiveness that identifies the basic aspects of regional competitiveness, such as: talent, innovation, connection of subjects and entrepreneurship. These factors can contribute to increasing social inclusion, well-being and sustainable growth (Snieška & Bruneckienė, 2009).

Hypothesis (H2): Export of regions has a positive and statistically significant influence on regional competitiveness.

In defining this assumption, we were guided by the research *Competitiveness, Productivity and Economic Growth across the European Regions* by Ben Gardiner, Ron Martin and Peter Tyler. The mentioned authors analyzed the determinants of regional competitiveness in the EU member states and in the EU candidate countries. The research outcome *Competitiveness,* *Productivity and Economic Growth across the European Regions* showed that trade openness has the influence on the convergence of regional productivity (or competitiveness) between the center and the periphery of EU (Gardiner et al., 2004).

Hypothesis (H3): The level and quality of education as human capital measure has a positive impact on regional competitiveness.

Hypothesis (H4): GERD has a positive impact on the competitive advantages of the observed regions.

Hypotheses H3 and *H4* are set based on the research *Regional Competitiveness, Economic Growth, and Stages of Development* by Robert Huggins, Hiro Izushi, Daniel Proko, and Piers Thompson. The authors analyzed the factors of the competitiveness of regions and found that knowledge and innovation are key factors determining regional differences (Huggins et al., 2014).

To make a comprehensive analysis of regional competitiveness , it is necessary to combine several different data sources. The authors formed new database by combining data from: (1) Eurostat – the Statistical Office of the European Union, which processes and publishes data from EU member states, non-EU countries, and international organizations (Eurostat, 2021); (2) Global Entrepreneurship Monitor – entrepreneurial activity study that explores the connection between growth and development of economy with the entrepreneurship development (Global Entrepreneurship Monitor, 2021); and (3) Smart Specialization Platform of the European Commission, which provides advice to EU countries and regions on the preparation and implementation of their smart specialization strategy (Smart Specialisation Platform, 2021).

The analysis founadation is the Eurostat database, which, among other things, contains data on gross domestic product, population and total domestic expenditure on research and development of NUTS 2 regions. It also contains data on the number of pupils enrolled in secondary education, students enrolled in tertiary education, and registered companies on the level NUTS 2 regions. The Global Entrepreneurship Monitor provides a range of indicators to measure entrepreneurial activity in the world. The Global Entrepreneurship Monitor indicators provide insight into the ways in which entrepreneurship contributes to economic development, then show the institutional conditions that make entrepreneurship, as an important sector in the economy, a vital part of society. Also, Global Entrepreneurship Monitor considers and documents the differences between countries in dynamics and entrepreneurial capacities, than compares the number of entrepreneurial opportunities that individuals receive and the number of of individuals who successfully take advantage of those opportunities, etc (Bosma, 2013).

To test the research hypotheses, the following regions were selected: Belgrade region, Vojvodina, Šumadija and Western Serbia, Southern and Eastern Serbia, Adriatic Croatia, Continental Croatia, Montenegro, Southern Macedonia, Eastern Slovenia, Western Slovenia, Nord-Vest, Centru, Nord-Est, Sud-Est , Sud-Montenia, Bucharest-llfov, Sud-Vest-Oltenia, Vest, Malopolskie, Slaskie,Wielkopolskie,Zachodniopomorskie, Lubuskie, Dolnoslaskie, Opolskie, Kujawsko-Pomorskie, Warminsko-Mazurskie, Pomorskie, Lódzkie, Swietokrzyskie, Lubelskie, Podkarpackie, Podlaskie, Mazowieckie. We accepted 34 European regions, located in East and Central Europe; some of these regions belong to European Union.

4. Research results

After the detailed theoretical consideration of regional competitiveness, the modeling of the influence of certain determinants on the competitiveness of the region by applicating

the multiple linear regression model follows. In the regression model, GDP per capita (GDPpc) is a dependent variable. Independent variables are: EXpc, EXD, IMD, S10000, P10000, GERD, and E10000 (Table 2).

Table 2. The dependent and independent variables in the regression model of regional competitiveness[1] (Author's calculation)

NUTS 2 regions	GDPpc	EXpc	EXD	IMD	S10000	P10000	GERD	E10000
Belgrade region	9.33	7.86	-1.47	-0.63	6.75	5.89	19.40	6.12
Vojvodina	8.79	8.03	-0.76	-0.63	5.73	5.83	18.41	5.91
Šumadia and Western Serbia	8.38	7.57	-0.82	-0.94	4.91	5.94	16.16	8.38
Southern and Eastern Serbia	8.34	7.46	-0.89	-1.11	5.23	5.88	16.67	5.78
Adriatic Croatia	9.45	7.48	-1.97	-1.66	5.92	5.92	18.16	6.22
Continental Croatia	9.52	8.29	-1.24	-0.63	6.04	5.98	19.87	5.97
Montenegro	8.98	6.50	-2.53	-0.63	5.95	6.12	16.97	6.26
Southern Macedonia	8.59	7.98	-0.62	-0.33	5.67	5.85	17.48	6.61
Eastern Slovenia	9.86	9.35	-0.51	-0.63	5.32	6.01	19.51	6.69
Western Slovenia	10.23	9.72	-0.51	-0.63	6.31	6.19	20.21	7.08
Nord-Vest	9.36	7.70	-1.56	-1.51	5.90	5.91	17.80	6.24
Centru	9.30	7.82	-0.71	-1.47	5.49	5.85	18.09	6.14
Nord-Est	8.89	6.63	-2.21	-2.12	5.35	6.06	17.54	5.81
Sud-Est	9.16	7.29	-1.90	-1.66	5.09	5.95	16.70	5.92
Sud-Montenia	9.09	7.85	-1.27	-1.27	4.26	5.86	18.17	5.72
Bucuresti-llfov	10.18	8.53	-1.71	-0.89	6.61	5.81	20.28	5.61
Sud-Vest-Oltenia	9.09	7.70	-1.56	-1.90	5.00	6.03	17.42	6
Vest	9.37	7.82	-0.84	-0.99	5.75	5.90	18.20	6.02
Malopolskie	9.46	7.95	-1.51	-1.47	6.25	5.89	20.58	6.5
Slaskie	9.57	8.92	-0.65	-0.97	5.64	5.76	19.90	6.36
Wielkopolskie	9.62	9.03	-0.60	-0.71	6.05	5.87	19.71	6.57
Zachodniopomorskie	9.37	7.88	-1.47	-2.53	5.57	5.74	18.43	6.5
Lubuskie	9.34	8.06	-1.27	-1.02	4.99	5.79	17.77	6.38
Dolnoslaskie	9.64	8.66	-0.99	-0.97	6.18	5.70	19.92	6.5
Opolskie	9.34	8.06	-1.27	-2.04	5.57	5.80	17.98	6.24
Kujawsko Pomorskie	9.32	7.83	-1.47	-2.04	5.81	5.88	18.77	6.3
Warminsko-Mazurskie	9.17	7.76	-1.43	-2.04	5.41	5.85	18.08	6.2
Pomorskie	9.52	8.56	-0.97	-0.99	6.02	5.86	19.83	6.56
Lódzkie	9.48	7.97	-1.51	-1.56	5.98	5.78	19.45	6.38
Swietokrzyskie	9.21	7.27	-1.97	-3.00	5.53	5.87	18.00	6.21
Lubelskie	9.16	8.57	-0.60	-0.92	5.96	5.90	19.06	6.17
Podkarpackie	9.20	8.07	-1.14	-1.56	5.53	5.94	19.19	6.14
Podlaskie	9.23	7.47	-1.77	-2.41	5.69	5.84	18.17	6.23
Mazowieckie	9.40	8.36	-1.05	-0.20	4.90	5.91	18.90	6.2

Note: [1] The use base in this research consists of data for 34 NUTS2 regions and refers to 2019, with the exception of data on Export per capita, Export and Import dependence of 16 NUTS2 regions in Poland, which were calculated for 2020 using Newton's extrapolation method (see Supplementary material).

Since economic relations are most clearly explained by the relative changes, the absolute values of the dependent and independent variables are logithmized on the basis of the natural logarithm for the purposes of this research. In this way we get the following specification of the econometric model:

$$lnY_i = \beta_0 + \beta_1 lnX_{1i} + \beta_2 lnX_{2i} + \beta_3 lnX_{3i} + \beta_4 lnX_{4i} + \beta_5 lnX_{5i} + \beta_6 lnX_{6i} + \beta_7 lnX_{7i} + u_i, \quad (1)$$

In order for the observed model to be used successfully, it is necessary to assume the following: (1) The relation between one dependent variable and the selected set of independent variables is linear; (2) Regression variables X_j are deterministic, and are independent of relation errors u_i; (3) Errors are mutually independent, identically normally distributed random variables with expected value zero and variance σ^2; (4) Variables X_j are mutually independent (there is no problem of multicollinearity); and (5) There are more observations than decision parameters (independent variables) ($n > k$). Assumptions 1) to 5) are called *Gauss-Markov conditions* (Boran & Hocalar, 2007). The equation of the estimated econometric model is:

$$ln\hat{Y}_i = \hat{\beta}_0 + \hat{\beta}_1 ln\hat{X}_{1i} + \hat{\beta}_2 ln\hat{X}_{2i} + \hat{\beta}_3 ln\hat{X}_{3i} + \hat{\beta}_4 ln\hat{X}_{4i} + \hat{\beta}_5 ln\hat{X}_{5i} + \hat{\beta}_6 ln\hat{X}_{6i} + \hat{\beta}_7 ln\hat{X}_{7i}, \quad (2)$$

The task of econometric analysis is to find estimates of unknown parameters so that the estimated model is "close" to true regression. There are various methods for estimating parameters, and the method of the least-squares is most commonly used. It consists in selecting those estimates of unknown parameters that minimize the sum of the squares of the deviation of the actual (empirical) values of the variable Y_i from its estimated (regression) values, i.e.

$$\underbrace{\min(\hat{u}'\hat{u})}_{\hat{\beta}} = \underbrace{\min}_{\hat{\beta}} \underbrace{\left(Y - X\hat{\beta}\right)'(Y - X\hat{\beta}))}_{S(\hat{\beta})} = \underbrace{min}_{\hat{\beta}} S(\hat{\beta}), \quad (3)$$

where the notation S is introduced for the function of estimator of vector of parameters β ($\hat{\beta}$ is vector of estimates of parameters).

Since at the point where the function $S(\hat{\beta})$ reaches its minimum, all its first partial derivatives are equal to zero, the requirement (3) comes down to solving the following system of equations:

$$\frac{\Delta S(\hat{\beta})}{\Delta \hat{\beta}_j} = 0, j = 1,2, \dots, k. \quad (4)$$

It follows from here

$$X'Y = X'X\hat{\beta}, \quad (5)$$

That is

$$\hat{\beta} = (X'X)^{-1} X'Y \quad (6)$$

As mentioned earlier, the key assumptions of the applying the regression analysis is the one says: independent variables are not perfectly linearly interdependent (multicollinearity of independent variables). There are different methods for identifying multicollinearity of independent variables. Authors applied the so-called *Klein's rule* (Imdadullah et al., 2016; Ullah et al., 2019). According to this criterion, the serious problem of multicollinearity exists if at least one of the zero-order correlation coefficients between regression variables (*Pearsons' r*) is greater in absolute value than the multiple linear correlation coefficient *R*. Zero-order correlation coefficients are elements of the correlation matrix that given by the following expression:

$$R = \begin{bmatrix} 1 & r_{Y1} & r_{Y2} & \dots & r_{Yk} \\ r_{1Y} & 1 & r_{12} & \dots & r_{1k} \\ r_{2Y} & r_{21} & 1 & \dots & r_{2k} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ r_{kY} & r_{k1} & r_{k2} & \dots & 1 \end{bmatrix},$$

$$r_{ij} = \frac{Cov\,(x_i, x_j)}{\sqrt{Var(x_i)}\sqrt{Var\,(x_j)}}, \quad (7)$$

If found at least one r_{ij} such that $r_{ij} > R$ then exists serious problem of multicollinearity. The correlation matrix of variables included in the analysis is:

$$\begin{bmatrix} 1 & 0.6588 & 0.0823 & 0.1005 & 0.5003 & 0.0043 & 0.2222 & 0.4254 \\ 0.6588 & 1 & 0.7561 & 0.4734 & 0.2742 & -0.1024 & 0.1555 & 0.5515 \\ 0.0823 & 0.7561 & 1 & 0.5382 & -0.0307 & -0.1641 & 0.0336 & 0.3567 \\ 0.1005 & 0.4734 & 0.5382 & 1 & 0.1821 & 0.1804 & -0.1874 & -0.1874 \\ 0.5003 & 0.2741 & -0.031 & 0.1821 & 1 & -0.0262 & 0.4567 & 0.3091 \\ 0.0043 & -0.103 & -0.164 & 0.1804 & -0.0262 & 1 & -0.0821 & 0.0716 \\ 0.2222 & 0.1554 & 0.0336 & -0.187 & 0.4567 & -0.0821 & 1 & 0.1504 \\ 0.4254 & 0.5515 & 0.3567 & 0.1398 & 0.3091 & 0.0716 & 0.1504 & 1 \end{bmatrix}$$

The coefficient of determination of the estimated regression model is $R^2 = 0.854522$, so the coefficient of multiple linear correlation is $R = \sqrt{0.854522} = 0.93$. The highest coefficient of simple linear correlation between regression variables is $r_{12} = 0.7561$, and according to *Klein's criterion* ($r_{12} < R$) there is no serious problem of multicollinearity.

The outcomes of the conducted regression analysis are given in Table 3. The estimated regression equation reads:

$$ln\ GDPpc_i = 0.530439 + 0.715602\ lnEXpc_i - 0.618336\ lnEXD_i - 0.055953\ lnIMD_i + 0.063660 lnS10000_i + 0.168136\ lnP10000_i + 0.054706\ lnGERD_i - 0.028641 lnE10000_i$$

Table 3. Outcomes of regression model (Author's calculation – Eviews and SPSS)

Model	Nonstandardized coefficients β_j	Standardized coefficients β_j	Sig. (t-ratio)	p-values	Correlation part
(Constant)	0.530439	-0.000000	0.263045	0.7946	
lnEXpc	0.715602	1.183255	5.666246	0.0000	0.884449
lnEXD	-0.618336	-0.791792	-5.284994	0.0000	-0.757705
lnIMD	-0.055953	-0.092737	-0.945950	0.3529	-0.207460
lnS10000	0.063660	0.081419	0.774794	0.4455	0.295672
lnP10000	0.168136	0.042267	0.509550	0.6147	0.067339
lnGERD	0.054706	0.154080	0.955365	0.3482	0.097259
lnE10000	0.028641	-0.061486	-0.216394	0.8304	0.086348

R-squared	0.862062	S.E. of regression	0.169630
Adjusted R-squared	0.824925	Sum squared resid	0.748136
F-statistic	23.23302	Log likelihood	16.63713
Prob(F-statistic)	0.000000	Mean dependent var	9.293056

As shown in Table 3, the strongest impact on changes in GDPpc has the EXpc (see the column Standardized coefficients β_j), followed

by EXD and S10000. Other variables have a much smaller impact on the change in GDP per capita. For example, E10000 has a 24.9 times smaller impact on the GDP per capita of the region than Exports per capita. In the *Correlations Part* column there is another confirmation of this result. According to the data in this column, if we omit from the analysis EXpc, this could produce decrease in the degree of explained variability (variability of GDPpc) by 78.2% (0.884449 × 0.884449 × 100), while if we omit E10000 would result in a decrease in the explained variability of the dependent variable by only 0.74% (0.086348 × 0.086348 × 100).

The values in the column Nonstandardized coefficient β are interpreted as the relative change in the value of GDP per capita caused by the relative unit increase of the independent variable. Thus, if EXpc increase by one percent, with unchanged values of other independent variables, it will result in an increase in GDP per capita by 0.71% and vice versa. This also emphasizes the great importance of export orientation. Increasing variable S10000 by one percent, on average, will increase GDP per capita by 0.06%, if ceteris paribus is worth it. Also, P10000 has a positive effect, so it can be seen that increasing the observed variable by 1% increases GDPpc by 0.18%, assuming that the other regression variables remain unchanged. Taking into account the above result, implicates the conclusion that the hypothesis of the connection between GDP per capita and Export is validated.

When formulating the above conclusions, the data from the Sig column (or *t* ratio) were ignored. Statistical significance for the influence of IMD, S10000, P10000, GERD, and E10000 has not been confirmed, as it exceeds the limit of 5%. This would mean that the impact on Gross domestic product per capita (of the analyzed NUTS2 regions) is strictly confirmed for EXpc and EXD.

After expressing the estimates of parameters (regression coefficients) with a single number, it is common to calculate interval estimates of parameters in further analysis. In general, the interval estimate of the parameter β_j (j = 1,2, ..., k; k =7) is an interval that will include the actual value of the regression parameter with a given reliability (or probability). If the reliability of the estimation is marked with (1-γ), then the estimation interval for t_j (size of a test or t ratio of the parameter β_j) is:

$$P(-t_{\gamma/2} < t_j < t_{\gamma/2}) = 1-\gamma, \qquad (8)$$

where $t_{\gamma/2}$ is the reliability coefficient (or the critical value of the Student's *t* distribution with a given level of significance $\gamma/2$ = 0.025 i df = [n - (k + 1)] degree of freedom). The interval for estimating the parameter β_j is obtained when expression for the size of test is included in expression (8), i.e.

$$P\ (\hat{\beta}_j < -t_{\gamma/2}SE(\hat{\beta}_j) < \beta_j < \hat{\beta}_j + t_{\gamma/2}\ SE(\hat{\beta}_j)) = 1-\gamma\ , \qquad (9)$$

With a reliability or probability of 95% ($1-\gamma$ = 0.95) the interval estimation of the parameter EXpc is obtained from (9) by including following values: $\hat{\beta}_1$ = 0.715602, and $SE(\hat{\beta}_1)$ = 0.126276. For $1-\gamma$ = 0.95, n = 34, and k = 7 reliability coefficient $t_{(\gamma/2)}$ is $t_{(\gamma/2)}$ = $t_{0.025}(26)$ = 2.0555. Then:

$$P(\hat{\beta}_1 - t_{\gamma/2}SE(\hat{\beta}_j) < \beta_1 < \hat{\beta}_1 + t_{\gamma/2}SE \times (\hat{\beta}_1) = 1-\gamma$$

$$P\ (0.715602 - 2.0555 \times 0.126276\ ) < \beta_j < (0.715602 + 2.0555 \times\ 0.126276) = 0.95$$

$$P\ (0.456039 < \ \beta_1 < \ 0.975166) = \ 0.95,$$

which means that for increasing EXpc by the one thousand euros, with unchanged (or the constant) values of other independent variables and with a probability of 0.95, Gross domestic product per capita will be increased between 0.46 and 0.97 thousand euros. The obtained limits of intervals are shown in Table 4.

Table 4. Interval estimates of parameters in the spatial model of regional competitiveness (Author's calculation)

Variables	Coefficients	95%		Length of interval estimates(1)
		Low	High	
(Constant)	0.530439	-3.608108	4.668985	
lnEXpc	0.715602	0.456039	0.975166	0.72
LnEXD	-0.618336	-0.858784	-0.377888	-0.62
lnIMD	-0.055953	-0.177159	0.065253	-0.06
lnS10000	0.063660	-0.104519	0.231840	0.06
lnP10000	0.168136	-0.507181	0.843454	0.17
lnGERD	0.054706	-0.063250	0.172662	0.05
lnE1000	-0.028641	-0.286874	0.229591	0.03

Note: (1) The interval length is calculated by using the formula:

$$The\ length\ of\ interval = \frac{Low + High}{2}$$

The biggest increase in GDPpc is related to the variables EXpc and P10000. The weakest correlation (the length of the estimation interval) exists in the case of E10000 and GDPpc. This analysis confirms earlier conclusions about the important role of export and education (or quality or level of human capital) for increasing gross domestic product per capita (see *Hypotheses H2* and *H3*).

The examination of the adequacy of the regression model of regional competitiveness is determined on the basis of the technique of analysis of variance (Krol & Sokolov, 2018). In accordance with this method, the regression model is well adapted to the observations from the sample if a large part of the variations (or total variability) of the dependent variable is interpreted by the regression model. The deviation of the empirical (real) value of the dependent variable Y_i can be divided into the deviation interpreted by regression and uninterpreted or residual deviation:

$$(Y_i - \bar{Y}) = (Y_i - \bar{Y}) + (Y_i - \hat{Y}_i), \quad (10)$$

The equation (10) is valid for each observation from the sample. To derive the dispersion measure (estimated regression variance or $\hat{\sigma}^2$), the equation (10) is squared, and the obtained equations are summed for all observations ($i = 1,2, ..., n$). The resulting equation:

$$Y'Y - n\hat{Y}^2 = (\hat{\beta}'X'Y - n\hat{Y}^2) + (Y'Y - \hat{\beta}'X'Y), \quad (11)$$

$$\underbrace{\sum_{i=1}^{n} (Y_i - \bar{Y})^2}_{ST} = \underbrace{\sum_{i=1}^{n} (\hat{Y}_i - \bar{Y})^2}_{SP} + \underbrace{\sum_{i=1}^{n} (Y_i - \hat{Y}_i)^2}_{SR}, \quad (12)$$

is called the equation of variance analysis. Its components are *ST*, *SP*, and *SR*. *ST* is the total sum of squares. *SP* is the sum of squares interpreted by the model. *SR* is the residual or unexplained sum of squares. If the sums of the squares are divided by the corresponding degrees of freedom, we come to the middle of the squares which are independent estimates of the components of variance.

The results of the analysis of variance for the regional competitiveness model in the software package "Eviews" are presented in Table 5. The interpreted sum of the squares *SP* is 4.63. The unexplained sum of squares *SR* is 0.79. Furthermore, the mean of the squares of the unexplained deviations $\frac{SR}{n-1-k}$ is equal to $\frac{0.788055}{26}$. This is the estimated regression variance $\hat{\sigma}^2 = 0.03$. The second root from the estimated variance is the estimate of the standard deviation of the regression $\hat{\sigma} = \sqrt{0.03} = 0.17$.

The estimation of the standard deviation of the regression is interpreted as the average deviation of the empirical from the regression values of GDP per capita expressed in units of measurement of the dependent variable. The corresponding relative measure of dispersion is the coefficient of variation $\hat{V} = 0.02$. In the regression model of regional competitiveness, the average deviation of the empirical from the regression values of GDP per capita ($\hat{\sigma}$) is 0.17 thousand euros, i.e. relatively 0.02%. Analysis of variance (ANOVA) shows that the estimated regression (regression model of regional competitiveness) equation adequately represents the empirical data (Table 5).

Table 5. Analysis of variance (ANOVA) in the regional competitiveness model (Author's calculation – Eviews)

Model	Sum of Squares	Df	Mean Square	F-Value	Pr. > F
Regression	4.675	7	.668	23.2331	.000[b]
1 Residual	.748	26	.028		
Total	5.423	33			

Considering the coefficient of determination R^2 as a descriptive statistic that measures the influence of specified factors in explaining the variations of the dependent variable, it can be concluded that the higher the coefficient of determination, the factors covered by the regression model are more important for explaining the variability of the analyzed phenomenon. In this research, the coefficient of determination R^2 je 0.85. This means that the model is very reliable, because it can explain 85% of all variations of the variable it describes. The corrected coefficient of determination is 0.81. From the obtained result it is concluded that there is very strong linear relationship between regional competitiveness and the selected set of regression variables. Based on the above research results, it is can be concluded that *Hypothesis H1* has been confirmed.

Once we have determined the coefficient of determination, the question arises as to whether the selected regression model is statistically significant for explaining variations in GDP per capita or not? In econometrics, the test of the significance of all regression variables is the Wald test. In Wald's test, the null hypothesis is formulated as follows:

$$H_0: \beta_j = 0, \quad (13)$$

Assuming that the null hypothesis is true, the Wald test magnitude test belongs to the χ^2 distribution with the number of degrees of freedom equal to the number of constraints. The Wald's test size is:

$$F = \frac{(SR_R - SR)/\,p}{SR\,/(n-(k+1))}, \quad (14)$$

In the equation (14) SR_R is the sum of the squares of the residual deviations for the regional competitiveness model with parameter constraints, and SR is the sum of the squares of the residual deviations for the regional competitiveness model without the parameter constraints. If the hypothesis is tested:

$$H_0: \beta_1 = 0,\ \beta_2 = 0,\ \beta_3 = 0,\ \beta_4 = 0,\ \beta_5 = 0,\ \beta_6 = 0,\ \beta_7 = 0,$$

then the Wald test is shown in Table 6.

Table 6. Wald test (Author's calculation – Eviews)

Wald test: Equation: Untitled			
Test Statistics	Value	Df	Probability
F-statistics	23.20770	(7, 26)	0.0000
Chi-square	162.4539	7	0.0000
Null Hipothesis Summary: C(2) = 0, C(3) = 0, C(4) = 0, C(5) = 0, C(6) = 0, C(7) = 0, C(8) = 0			
Normalized Restriction (= 0)		Value	Std. Err.
C(2)		0.807906	0.083395
C(3)		-0.653517	0.110386
C(4)		-0.071919	0.066507
C(5)		0.128804	0.081614
C(6)		0.113051	0.328499
C(7)		-0.005562	0.041163
C(8)		-0.056643	0.128176
Restrictions are linear in coefficients.			

Since the empirical significance level (or Probability) is a small number compared to any usual significance level α, the null hypothesis is rejected. Therefore, it is concluded that the regression model with all seven independent variables is statistically significantly related to GDPpc capita as an approximate variable of the competitiveness of region.

Given that there are variations in the data, the manifestation of *outliers* is possible (for example, Western Slovenia in relation to other regions), and model was also tested for heteroskedasticity. The analysis of the scattering diagrams, brings the conclusion that the heteroskedasticity does not exist, because the squares of the residuals do not change systemically depending on the variables values included in model (see Apendix). The above is also verified by using Breusch-Pagan LM test for heteroskedasticity testing. Breusch-Pagan LM test is performed as follows. In the first step, the residuals of the initial regression model are calculated by the method of least squares After that, in the second step, the auxiliary regression equation is estimated in which u_i^2 (the squares of residuals) are dependent variables, and the regression variables are the regression variables of the initial model:

$$u_i^2 = \delta_0 + \delta_1 lnX_{1i} + \delta_2 lnX_{2i} + \delta_3 lnX_{3i} + \delta_4 lnX_{4i} + \delta_5 lnX_{5i} + \delta_6 lnX_{6i} + \delta_7 lnX_{7i}\ , \quad (15)$$

$$H_0: \delta_i = 0, i = 1,2,\dots,7$$
$$H_1: \exists \delta_i \neq 0, i = 1,2,\dots,7$$

The null hypothesis of Breusch-Pagan LM test assumes homoskedasticity, i.e. invariance of variance that cannot be rejected based on of the test results (Table 7), because the level of significance (Prob. Chi-Square) is high in relation to the usual levels of significance α. The size test of Breusch-Pagan LM test reads: $LM = nR^2$, it is distributed according to the χ^2 distribution with r degrees of freedom and amounts 14.07. The obtained value of the test size of the Breusch-Pagan LM test (13.22935) is less than the critical value $\chi_\alpha^2(7)$. In this case, the null hypothesis on existence of homoskedasticity cannot be rejected. The value of "Prob." is also higher than the significance level (0.0667> 0.05). It follows that the conclusion is the same: the hypothesis of the existence of homoskedasticity cannot be rejected, i.e. in the model, there is no heteroskedasticity.

Tabela 7. Breusch-Pagan LM Test (Author's calculation – Eviews)

F-statistics	2.365723	Prob.F(7,26)		0.0519
Obs*R-squared	13.22935	Prob.Chi-Square(7)		0.0667
Scaled explained SS	24.64230	Prob.Chi-Square(7)		0.0009
Test Equation:				
Dependent Variable:Resid^2				
Method: Least Squares				
Sample: 1 34				
Included observations				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
(Contant)	0.266800	0.589186	0.452829	0.6544
lnEXpc	-0.081790	0.036953	-2.213349	0.0359
lnEXD	0.125697	0.034231	3.671982	0.0011
lnIMD	-0.015488	0.017256	-0.897587	0.3776
lnS10000	0.022725	0.023943	0.949113	0.3513
lnP10000	0.072750	0.096142	0.756694	0.4560
lnGERD	0.010571	0.016793	0.629512	0.5345
lnE10000	-0.033088	0.036763	-0.900037	0.3764

4. Conclusion

This paper presents a theoretical overview of regional competitiveness and a number of accompanying questions about its measurement. In that sense, it is pointed out that the competitiveness of the economy at the national level is only a reflection of competitive abilities, i.e. potentials and limitations at the regional and local level, so the question of the competitiveness of region arises, which is less analyzed and is more difficult to define. The simplest is to interpret regional competitiveness as a competitive advantage of one region over another, seen (observed) through the region's share of the export market.

After theoretical considerations and identification of different determinants that economists assume to significantly affect regional competitiveness, in the continuation of the paper we check the above with a spatial regression model for selected determinants. The importance of trade openness, innovation, entrepreneurship and human capital derives from the previously described research of different bibliographic units. International exchange has a positive effect on the competitiveness and development of countries. For a small country, such as Serbia, the necessary precondition for development is that it have a high degree of openness and integration, because as such it is too weak to resist the tendencies and rules of the game in international economic relations dictated by large developed countries or large and strong integrations. Innovation, entrepreneurship and human resources are becoming increasingly important as key factors of competitiveness and the “foundations” of creating a knowledge society.

In the model of regional competitiveness Gross domestic product per capita is a dependent variable, and as independents are analyzed: Exports per capita, Export dependence, Import dependence, Number of students enrolled in tertiary education per 10,000 inhabitants, Number of students enrolled in secondary education per 10,000 inhabitants, Gross domestic expenditure on research and development and the number of registered companies per 10,000 inhabitants. The model proves the positive impact of international trade, human resources, and innovation on the competitiveness of the region, and future measures and activities at the regional, city and municipal levels need to be focused on (1) increasing exports; (2) improving the quality of education; and (3) development and application of new technologies.

(1) *Increasing exports*. The poor export results of Montenegro, Nord-Est, Swietokrzyskie, Sud-Est, and Southern and Eastern Serbia (see Table 8 in the Apendix) say that they failed to build their the competitive advantage or, better said, they lost the comparative advantage (cheap labor), and and a new source of production and export growth did not appear. Gone are the days when these regions could base their development only on comparative advantages and it is time to adopt the new approach and ask the question: how to build the competitive advantage? Here are some suggestions to economic policy makers: the reduce and/or abolish the tax burden on start-ups over a period of time, enable higher tax deduction for the taxes on personal income, make loans more accessible to entrepreneurs (Ulaşan, 2015; Hye & Lau, 2015).

(2) *Increasing the quality of education.* Economies in the analyzed areas requires a proactive and innovative, highly productive workforce, and with developed skills of teamwork, critical thinking, flexibility and adaptability. Therefore, it is necessary to invest a lot in the transformation of the educational system, then apply effective tools and teaching methods that are adapted to the so-called “Generation Z”. In our opinion, the education systems in the analyzed areas are not sufficiently adapted to such persons, which results in reduced motivation for learning and unsatisfactory outcomes. In order to achieve the highest possible extent of the engagement of members of the

"Generation Z", we believe that it is necessary for schools and colleges to use different types of online games that have their application exclusively in teaching. One of the key benefits of gamification in education is that it introduces students to a "enchanting obsession state" in which the student is highly focused on the current task (Gómez, 2020; Fox et al., 2018).

(3) *The development and application of new technologies*. To create and direct new technologies, sectors and markets, the competent state institutions in the analyzed regions must be "armed" with the intelligence which is necessary for designing and making important decisions. In our opinion, countries regions and cities should be the promoters of the most radical, most innovative types of innovation, because they do not lead all innovations to the growth of the entire economy. Equally important is the establishment of public sector organizations that imagine opportunities, engage in the most risky and uncertain early research and control the process of commercialization of innovations. The role of these organizations in the development of new technologies should not be limited to subsidizing the innovative activities of private companies. They need to be able to spread new ideas quickly. They are able to shape the market and drive technological progress, thus acting as a catalyst for change – a "spark that ignites fire" (Mazzucato, 2018).

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Apendix

Table 8. Ranking of NUTS2 regions according to Export per capita (Statistical Office of the Republic of Slovenia, 2021; Statistical Office of Montenegro, 2019; MAKStat Database, 2021*;* National Institute of Statistics, 2019*;* Smart Specialisation Platform, 2021; Republic Statistical Office, 2019; Croatian Chamber of Commerce, 2019)

Rank	*NUTS 2 regions*	*Export per capita*	*Rank*	*NUTS2 regions*	*Export per capita*
1	Western Slovenia	16590	**18**	Zachodniopomorskie	2653
2	Eastern Slovenia	11503	**19**	Belgrade region	2586
3	Wielkopolskie	8340	**20**	Sud-Montenia	2567
4	Slaskie	7477	**21**	Kujawsko-Pomorskie	2522
5	Dolnoslaskie	5752	**22**	Centru	2493
6	Lubelskie	5278	**23**	Vest	2493
7	Pomorskie	5218	**24**	Warminsko-Mazurskie	2345
8	Bucuresti-llfov	5074	**25**	Nord-Vest	2217
9	Mazowieckie	4266	**26**	Sud-Vest-Oltenia	2217
10	Continental Croatia	3989	**27**	Šumadia and Western Serbia	1930
11	Podkarpackie	3200	**28**	Adriatic Croatia	1780
12	Opolskie	3154	**29**	Podlaskie	1759
13	Lubuskie	3152	**30**	Southern and Eastern Serbia	1739
14	Vojvodina	3061	**31**	Sud-Est	1461
15	Southern Macedonia	2934	**32**	Swietokrzyskie	1435
16	Lódzkie	2894	**33**	Nord-Est	755
17	Malopolskie	2822	**34**	Montenegro	668

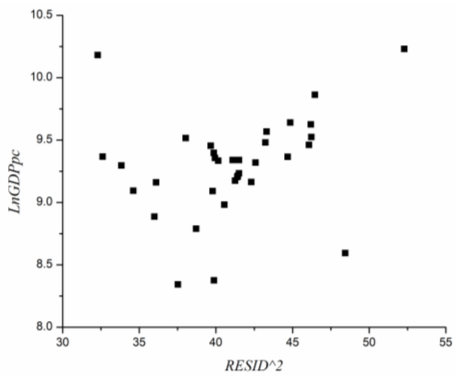

Figure 1. Scatter plot – Relationship of variables RESID^2 and LnGDPpc
Source: Author's calculation – OriginPro 8.5

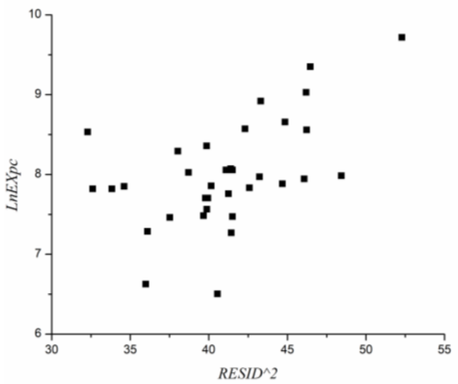

Figure 2. Scatter plot – Relationship of variables RESID^2 and LnEXpc
(Author's calculation – OriginPro 8.5)

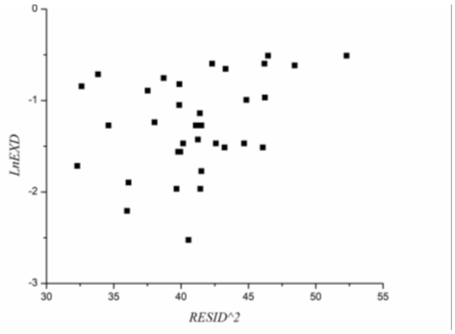

Figure 3. Scatter plot – Relationship of variables RESID^2 and LnEXD
(Author's calculation – OriginPro 8.5)

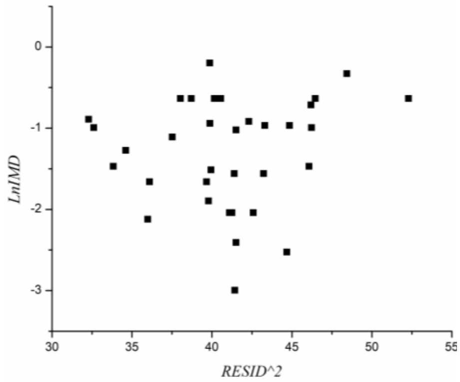

Figure 4. Scatter plot – Relationship of variables RESID^2 and LnIMD
(Author's calculation – OriginPro 8.5)

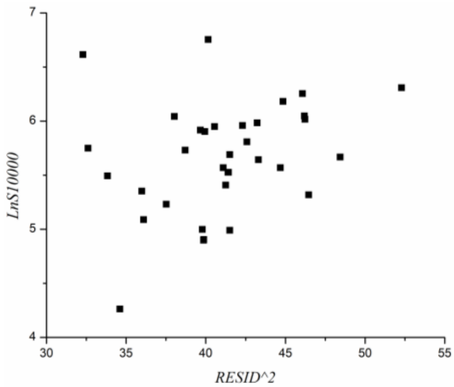

Figure 5. Scatter plot – Relationship of variables RESID^2 and LnS10000
(Author's calculation – OriginPro 8.5)

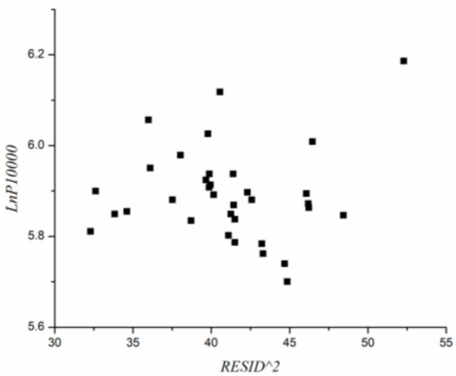

Figure 6. Scatter plot – Relationship of variables RESID^2 and LnP10000
(Author's calculation – OriginPro 8.5)

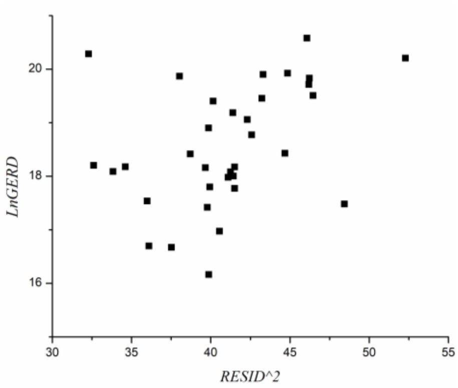

Figure 7. Scatter plot – Relationship of variables RESID^2 and LnGERD (Author's calculation – OriginPro 8.5)

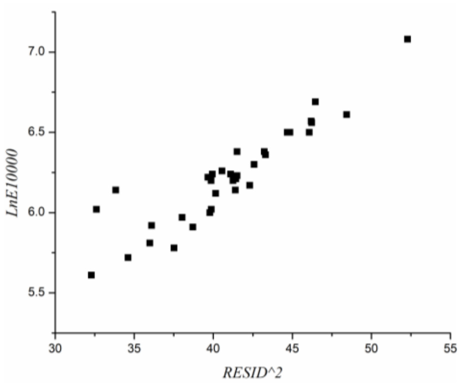

Figure 8. Scatter plot – Relationship of variables RESID^2 and LnE10000 (Author's calculation – OriginPro 8.5)

Supplementary material

In this paper, we apply the well – known approximation method of Newton's polynomial interpolation. We use Newton's polynomial interpolation method to predict exports and imports per capita of 16 NUTS 2 regions in Poland. The calculation is based on data for 2005, 2010 and 2015.

***

Newton's polynomial of degree n, which extrapolates the data $(x_k, f(x_k))$, $k=0,1,2\ldots n$, has the following form:

$P(x) = f[x_0] + f[x_0, x_1](x-x_0) + f[x_0, x_1, x_2]\,(x-x_0)(x-x_1)+\ldots+f[x_0,x_1, \ldots x_n]\,(x-x_0)(x-x_1)\ \ldots.\ (x-x_{n-1})$

For the initial divided differences, it is valid that:

$f[x_0]=f(x_0)$, $k=0,1,2\ldots n$

Other divided differences are visible from the so-called Table of Divided Differences.

Table of Divided Differences

x_k	$f[x_k]$	$f[x_k, x_{k+1}]$	$f[x_k, x_{k+1}, x_{k+2}]$	…	$f[x_0, \ldots , x_n]$
x_0	$f[x_0]$				
		$f[x_0, x_1]$			
x_1	$f[x_1]$		$f[x_0, x_1, x_2]$		
		$f[x_1, x_2]$			
…	…	…	…	…	$f[x_0, \ldots , x_n]$
x_{n-1}		$f[x_{n-2}, x_{n-1}]$			
	$f[x_{n-1}]$		$f[x_{n-2}, x_{n-1}, x_{n-2}]$		
x_n		$f[x_{n-1}, x_n]$			
	$f[x_n]$				

I
Extrapolation - NUTS2 of the Malopolskie Region
1. Export per capita

We need to determine a Newtonian polynomial whose diagram passes through the following points: T_0 (0, 2606), T_1 (5, 2618), T_2 (10, 2626), T_3 (15, 2688), where is x_0= 0 (or 2000.), $f(x_0)$ = 2606 (or export per capita in 2000.), x_1= 5 (or 2005.), $f(x_1)$ = 2618 (or export per capita u 2005.), x_2 = 10 (or 2010.), $f(x_2)$ = 2626 (or export per capita u 2010.), x_3 = 15 (or 2015.), $f(x_3)$ = 2688 (or export per capita in 2015). Finally, we need to calculate the value of exports per capita for x_4 = 20 (2020.).

The procedure for solving is as follows:

We include the given points in the Table of Divided Differences.

I	x_k	$f(x_k)$	$f(x_k, x_{k+1})$	$f(x_k, x_{k+1}, x_{k+2})$	$f(x_k, x_{k+1}, x_{k+2}, x_{k+3})$
0	0	2606			
			(2618-2606)/(5-0)=2.4		
1	5	2618		(1.6-2.4)/(10-0)= -0.08	
			(2626-2618)/(10-5)=1.6		(0.88+0.08)/(15-0)=0.064
2	10	2626		(10.4-1.6)/(15-5)= 0.88	
			(2678-2626)/(15-10)=10.4		
3	15	2678			

$P(x) = f[x_0] + f[x_0, x_1](x-x_0)+ f[x_0, x_1,x_2](x-x_0)(x-x_1) + f[x_0, x_1,x_2,x_3](x-x_0)(x-x_1)(x-x_2)=$
$= 2606 + 2.4(x\text{-}0)+ ((-0.08)(x\text{-}0)(x\text{-}5)) + (0.064(x\text{-}0)(x\text{-}5)(x\text{-}10))$
$= 0.064x^3 – 1.04x^2 + 6x + 2606$

We calculate the value for x_4 = 20

$f(x_4)=f(20)$= 0.064*8000–1.04*400 + 6*20 + 2606=2822

2. Imports per capita

We need to determine a Newtonian polynomial whose diagram passes through the following points: T_0 (0, 2137), T_1 (5, 2391), T_2 (10, 2552),T_3 (15, 2900), where is x_0= 0 (or 2000.), $f(x_0)$ = 2137 (or import per capita in 2000.), x_1 = 5 (or 2005.), $f(x_1)$ = 2391 (or import per capita in 2005.), x_2 = 10 (or 2010.), $f(x_2)$ = 2552 (or import per capita in 2010.), x_3 = 15 (or 2015.), $f(x_3)$ = 2900 (or import per capita in 2015.). Finally, we need to calculate the value of import per capita for x_4 = 20 (2020. godina).
The procedure for solving is as follows:

We include the given points in the Table of Divided Differences.

I	x_k	$f(x_k)$	$f(x_k, x_{k+1})$	$f(x_k, x_{k+1}, x_{k+2})$	$f(x_k, x_{k+1}, x_{k+2}, x_{k+3})$
0	0	2137			
			(2391-2137)/(5-0)=50.8		
1	5	2391		(32.2-50.8)/(10-0)= -1.86	
			(2552-2391)/(10-5)=32.2		(3.74-1.86)/(15-0)=0.125
2	10	2552		(69.6-32.2)/(15-5)= 3.74	
			(2900-2552)/(15-10)=69.6		
3	15	2900			

$P(x) = f[x_0] + f[x_0,x_1](x-x_0)+ f[x_0,x_1,x_2](x-x_0)(x-x_1) + f[x_0,x_1,x_2,x_3](x-x_0)(x-x_1)(x-x_2)=$
$= 2137+ 50.8 (x-0)+ ((-1.86) (x-0)(x-5)) + (0.125 (x-0)(x-5)(x-10))=$
$= 0.125x^3-3.735x^2+66.35x+2137$
We calculate the value for x_4=20
$f(x_4)=f(20)= 0.125*8000-3.735*400+66.35*20+2137=2970$

II
Extrapolation – other NUTS2 regions in Poland

Table. Exports and imports per capita in 2020

Regions	*Export per capita*	*Import per capita*
Slaskie	7477	5356
Wielkopolskie	8340	7478
Zachodniopomorskie	2653	965
Lubuskie	3152	4059
Dolnoslaskie	5752	5857
Opolskie	3154	1526
Kujawsko-Pomorskie	2522	1408
Warminsko-Mazurskie	2345	1251
Pomorskie	5218	5004
Lódzkie	2894	2731
Swietokrzyskie	1435	518
Lubelskie	5278	3860
Podkarpackie	3200	2117
Podlaskie	1759	967
Mazowieckie	4266	9910