

Innovative entrepreneurship and regional economic development – theoretical and empirical aspects

Inovaciono preduzetništvo i regionalni ekonomski razvoj– teorijski i empirijski aspekti

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Article info

Original scientific paper

Received:

3 September, 2025

Revised:

26 December, 2025

Accepted:

10 January, 2025

Published online: 24 April, 2026

DOI:

<https://doi.org/10.71159/bizinfo260007K>

UDC/ UDK:

005:001.895

332.14:330.342

Abstract

The goal of this paper is to estimate the impact of innovative entrepreneurship on regional economic development by applying the methodology of quantile regression analysis over the period from 2011 to 2022. The Pesaran–CIPS test is used to analyze the stationarity of the time series. The results of the quantile regression analysis show a statistically significant and positive impact of business-sector research and development expenditures, as well as the share of small and medium-sized enterprises that have introduced at least one innovation in their operations, on regional economic development. The obtained results can be used for analytical and predictive research related to the analysis of the impact of innovative entrepreneurship on the regional economy. In addition, they may be useful for representatives of regional government bodies in designing regional strategies for innovation and scientific and technological development, thereby improving the quality of regional innovation policy.

Keywords: scientific and technological development, innovations; regions; production; quantile regression

Sažetak

Cilj rada je da se proceni uticaj inovacionog preduzetništva na ekonomski razvoj regiona, primenom metodologije kvantilne regresione analize u vremenskom periodu od 2011. do 2022. godine. Pesaran – CIPS test koristi se za analizu stacionarnosti vremenskih serija. Rezultati kvantilne regresione analize pokazuju da postoji statistički značajan pozitivan uticaj troškova istraživanja i razvoja poslovnog sektora i udela malih i srednjih preduzeća koja su uvela najmanje jednu inovaciju u radu na ekonomski razvoj regiona. Dobijeni rezultati se mogu koristiti za analitička i prediktivna istraživanja koja se odnose na analizu uticaja inovacionog preduzetništva na regionalnu ekonomiju. Pored toga, oni mogu biti korisni predstavnicima organa regionalne vlasti pri izradi regionalnih strategija inovacionog i naučno-tehnološkog razvoja, što podiže kvalitet regionalne inovacione politike.

KLjučne reči: naučni i tehnološki razvoj, inovacije, regioni, proizvodnja, kvantina regresija

1. Introduction

The problem relating to discovery factors and sources of economic development has been attractive to all scientist-economists throughout history. A shining example is the protectionist economic policy that arose in mercantilism, which introduced high import tariffs and provided support to producers of national importance (Jakovac et al., 2022). Adam Smith considered that the “basis” of economic progress of a particular socio-economic system is the absolute advantage in factors that create the possibility for the production of a large number of products from

inexhaustible mineral deposits (Uysal, 2019). Expanding on Adam Smith’s theory, David Ricardo introduced the notion of “comparative advantage”. According to David Ricardo, even if a region does not have absolute advantages, it does not mean that the manufacturing of certain products is not beneficial for it. According to the theory of comparative advantage, the time spent producing a unit of a good is the condition by which the competitive ability of a region or country is determined (Bagchi et al., 2023).

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Key figures of institutionalism assigned a particularly important role in economic development to social institutions (Street, 2019). A large number of similar examples from the history of economic science can be cited. However, it should be underlined that economic science has not reached a unique conclusion regarding which factors have the greatest importance for development.

With the emergence of regional journals and the concept of the “regional economy”, the investigation of the determinants of economic development of specific territorial units has gained capital importance. This is explained by the fact that, in the context of the industrial and post-industrial era, the area or territory becomes a complex system with many components and, in terms of its structure and specificity, does not lag behind the state.

With the transition to the fourth industrial revolution, countries and regions have chosen the path of development based on innovation. Innovation-based development opens up new opportunities and stimulates the competitiveness of a country and its regions, as well as resilience and rapid response to various changes they face. The main challenges in the implementation of innovation in the economies of developing countries include insufficiently developed communication among all parties involved, a lack of activities aimed at building capacities for the effective use of modern technologies, and insufficient financial support, etc. (Stefanović et al., 2021).

The creation of innovative entrepreneurship, together with the widespread prevalence of innovative companies, has a key place in the innovation process. The function of the “realization of novelty”, which represents the most significant stage of innovation, is assigned to innovative companies. Novelty is understood as a discovery, invention, or device, while innovation denotes its first use in production or on the market (Podkalicka et al., 2018).

In addition to the role, they play in translating novelty into innovation, innovative companies participate in creating innovative solutions together with scientific research organizations. By gaining control over financial resources, entities involved in innovative business become capable of performing long and expensive research, which is often difficult to realize in scientific organizations that are government-owned and not sufficiently supported by funding sources (Krstić et al., 2020).

The positive impact of national innovative entrepreneurship on activities in regional socio-economic systems has undoubtedly gained a secure place in research. No less important is the provision of instruments (adequate econometric techniques and indicators of innovative entrepreneurship) that allow a complex and objective estimation of the impact of innovative entrepreneurship on economic development. This scientific paper attempts to solve this problem by applying quantile regression analysis to panel data characterizing innovative business. In a number of studies that attempted

to perform a similar analysis, there is a lack of evidence regarding the specifics of data with a panel structure. In addition, the number of indicators characterizing innovative business was insufficient.

In order to fill the existing gaps in research concerning the impact of innovation, including innovative entrepreneurship, on regional economic development, we believe that the choice of the quantile regression analysis method, due to the significance of the selected indicators, is the most objective approach to solving the scientific problem. This statement represents the basic hypothesis of the study. Therefore, by applying the quantile regression method, it is possible to obtain objective estimations for indicators characterizing innovative business and its impact on the economic development of regions.

The object of the research is innovative entrepreneurship as a factor of regional economic development. The aim of the research is to determine the degree of impact of innovative entrepreneurship on the economic development of the region. Achieving this goal requires solving the following tasks: 1) selecting and analyzing scientific papers that investigate the impact of innovation and innovative entrepreneurship on regional development; 2) selecting and scientifically explaining the indicators that show, on the one hand, specific aspects of the operation of innovative entrepreneurship and, on the other hand, the economic development of the region; and 3) assessing the influence of innovative entrepreneurship on the economic development of the region using econometric instruments.

2. Literature review

Innovations represent a notable factor of economic development both at the state and regional levels. Economists consider that, in the contemporary world, the innovative economy provides a competitive advantage (Steil et al., 2021). The activities and efforts of researchers prove the existence of a dependency of development on the pace of scientific and technological progress. Highlighted within the Endogenous Growth Theory, the assumption of scientific and technological novelties as internal (endogenous) sources of persistent (sustainable) development has enabled the elaboration of an array of long-term development models. These are models in which development is reproduced through investments in technology and equipment, on the one hand, and in human capital, on the other (Mazzucato, 2020; Pelsa & Balina, 2022). Models with investments in the education sector have a special place (Lederman & Maloney, 2003). In addition, social output growth is measured according to expenditures on scientific research and experimental development works (Romer, 1990).

Smotritsky and Chernykh (2021) consider the modern economic model, based on a continuous process of regenerating innovative business, to have no alternative in ensuring sustainable and competitive growth and development of the national economy. It should also be noted that Aganbegyan et al. (2020) share a similar

opinion. Nevertheless, opposite, “polar” views can also be encountered. Simachev and his co-authors (2021) note that the positive connection between production and innovativeness is not always considered permanent.

According to the World Economic Forum (WEF), innovations are key factors of competitiveness in the most mature stage of economic development (WEF, 2014). Thus, for a country or region in the initial stage of development, the so-called basic factors are of crucial importance: institutions, infrastructure, healthcare, and primary education. In this type of economy, the influence of intellectual capital is minimal. Therefore, such economies must focus on building physical and technological infrastructure. A country or region with a low level of development must improve basic education and professional training. At the same time, if it wants access to high technologies, it must open its borders to the inflow of foreign investment. For economies in a more mature stage of development, the key factors are higher education and training, technological equipment, and so on. The most mature phase of development is characterized by innovation as a factor of development and by the creation of an innovation-driven economy. These are economies under the constant influence of intellectual capital. They are mainly the economies of the most developed countries in the world. In order to develop, they invest significant resources in science and support creativity and innovation, especially in advanced technologies (Tanasković & Ristić, 2019).

The transition to an innovation paradigm is an objective necessity in the context of sustainable regional economic development. According to many researchers, Serbia and Croatia significantly lag behind countries that represent technological leaders in the world in terms of innovation activity. Serbia and Croatia ranked 52nd and 43rd, respectively, according to the Global Innovation Index in 2024 (Dutta et al., 2024). The top 10 is dominated by high-income countries: Switzerland, Sweden, the USA, Singapore, the UK, South Korea, Finland, the Netherlands, Germany, and Denmark. According to the Global Innovation Index, Switzerland ranks first in three indicators: innovation linkages, knowledge creation, and creative goods and services. According to the indicators of knowledge diffusion and online creativity, it is in second position, while according to the business environment indicator, it is in third place.

As a rule, microeconomic units – subjects of innovation activity and organizations of innovation infrastructure – become direct local “points” implementing innovations and realizing appropriate investment projects. These include companies and individual entrepreneurs operating in industry, agriculture, and the service sector. The entrepreneurial sector is treated as one of the crucial actors of innovation activity at the regional level, since entrepreneurship represents a real sector of the economy that creates products and is interested in their realization on the market (Ivanov & Metlyakhin, 2022; Ognjanović 2025). In the context of the transition to an innovation-driven economy, special attention should be focused on

the role that innovative entrepreneurship has in ensuring the economic development of regions.

Innovative entrepreneurship represents an activity that entrepreneurs realize on a systematic basis, together with the development of novelties and their transformation into innovations (Ivanov & Metlyakhin, 2022). Among the researchers studying the impact of innovative entrepreneurship on regional economic development, representatives of the Harvard School, the Austrian School, and the theory of endogenous economic growth can be mentioned.

The studies by Poljunin (2012) and Zhilnikov (2014) examined the impact of innovative companies on the regional economy. As L.V. Polunin notes, the urgent need to develop an innovation policy at the regional level has matured. In a transformed economic system, innovation should unquestionably be given a key place in creating GDP and the competitive ability of the regional economy. In Zhilnikov’s paper (2014), entitled “Analysis of the Impact of Regional Innovation Activity on GDP”, an attempt was made, using regression analysis, to estimate the significance of the influence of innovative activity of enterprises on the economic development of regions in Russia. Therefore, Zhilnikov selected indicators that represent, on the one hand, innovation activity (average spending on research and development, average proportion of innovative goods, services, and work), and on the other hand, economic development (average gross domestic product). The results of the regression analysis enabled him to conclude that the innovation activity of companies significantly affects the economic development of the region.

Xu and Li (2021) significantly contributed to the debate on the relationship between innovative entrepreneurship and regional economic development. Their analysis is based on a spatial regression model and was conducted on a sample of 31 provinces in China during the period from 2001 to 2016. The dependent variable is regional gross domestic product as an indicator of economic growth, whereas the independent variables include: the number of entrepreneurs in relation to the number of employees, the level of education (average number of years of education of the workforce), the share of imports and exports in GDP, etc. The results of the analysis showed that innovations are key drivers of economic development in the central and eastern provinces of China, which are economically and functionally developed. These regions are characterized by a high degree of entrepreneurship, an educated and qualified workforce, inclusive social development, etc. On the other hand, innovations negatively affect the economic growth of the western regions of China, which are predominantly rural in character and have pronounced depopulation characteristics.

Furthermore, the research conducted by Svetlana Rastvortseva (2016) covered 83 regions in Russia in the period from 2002 to 2014. The aim of the research was to determine whether there is a connection between innovation and economic growth. Innovation, as a key

explanatory variable, was estimated through indicators such as the number of registered patents per 1,000,000 inhabitants and the number of graduates from higher education institutions. Economic growth is expressed through the average growth rate of the region's real gross domestic product. In conducting the analysis, regression analysis of panel data and the Tinbergen and Alt procedure were used as the methodological framework. The results show that higher education has a key role in economic development because investments in knowledge, training, and creativity contribute to the growth of economic efficiency. Increasing the number of graduates from higher education institutions by 1% leads to an increase in regional GDP ranging from 0.057 to 0.082 percent. Also, increasing patent activity by 1% leads to regional GDP growth ranging from 0.026 to 0.034% after two years.

Vasilić (2022), together with colleagues, analyzed the innovation performance of regions in Serbia and identified existing regional disparities. For the purposes of this analysis, Vasilić used the values of innovation performance indicators for 2021, obtained according to the European Commission's "Regional Innovation Scoreboard" methodology, within which the performance of innovative entities is observed through four areas and twelve dimensions. The Belgrade region, classified as a "Moderate Innovator", significantly outperformed the other three regions, which belong to the "Growing Innovator +" group, in most indicators. The most pronounced disparities were observed in the dimensions of human resources, digitalization, ICT, linkages, and employment impact, while the smallest differences among all four observed regions were identified in the dimensions of sales impact and intellectual property.

Research has shown that innovative entrepreneurship can be viewed as one of the most important factors of economic development. Innovation-based development opens up new opportunities and stimulates the competitiveness of the regional economic system, as well as its resilience and rapid response to change. In a transformed economic system, innovations should be given a key place in creating GDP and ensuring the competitive ability of the regional economy.

3. Methodology

On the preparation of the article, various methods were used. By applying the method of systematization, scientific papers that exposed specific aspects of the influence of the innovation factor (innovative entrepreneurship) on the development of the regional economy were selected and studied in detail. Likewise, the use of this method allowed us to select statistical indicators that provide information about the development of innovative entrepreneurship, as well as the economy of the regions. Particular attention should be paid to the method of econometric modeling, which was additionally used to formulate the quantile regression model illustrating the dependence between indicators of regional economic development and innovative entrepreneurship.

To estimate the role of innovative entrepreneurship in the development of the regional economy, it was decided to perform panel quantile regression, which enables the determination of the response of one variable to another, as well as the degree of impact of each explanatory variable on different parts of the distribution of the dependent variable. This methodology enables the conditional distribution of the dependent variable to be observed, i.e., modeled, through quantiles or percentiles of the distribution, where the quantile (or percentile) represents an arbitrarily determined proportion of observations within that distribution. The application of quantile regression allows the effects of explanatory variables to be assessed not only at the mean value, as provided by classical regression estimation methods, but also in other parts of the distribution of the dependent variable. Modeling macroeconomic data with quantile regression enables the preservation of information that would otherwise be lost due to the "aggregation" of data based on modeling with classical linear regression models, and which can illustrate how independent variables affect different fractions of the distribution of the dependent variable (Ognjanović, 2018).

The first task in conducting the quantile regression analysis was the classification of indicators illustrating, on the one hand, specific aspects of the activity of innovative entrepreneurship and, on the other hand, the level of regional economic development. Since, in quantile regression analysis, the regressand must be represented by a unique number, regional gross domestic product was accepted as the most comprehensive indicator reflecting the level of development of the regional economy. The indicator "regional gross domestic product" enables the estimation of the proportion and efficiency of regional economic development.

First of all, it is necessary to discuss the indicators characterizing the activity of innovative entities, and then a range of aspects referring to the essence of the given term. The following approaches directed toward this type of entrepreneurship were identified: the technical approach, according to which the basic task of innovative entrepreneurship is reduced to the processing of substances; the economic approach, in which innovative entrepreneurship is considered an economic organization whose activity is directed toward the commercialization of products; and the complex approach, which encompasses the previous two approaches. Through these approaches, it is possible to determine statistical indicators that reflect this type of entrepreneurship to the highest degree. As part of the research, a decision was made to support the complex approach because it includes both the technical and economic components of innovative entrepreneurship, thus indicating the many aspects of the considered term.

The indicators characterizing innovative entrepreneurship in the spheres of science and economy can be grouped into indicators reflecting the "drivers" of innovation activities and indicators reflecting the results achieved by innovation organizations. The first group includes research and development costs of the business sector and

the share of small and medium-sized enterprises that have introduced at least one innovation in their work process, while the second group includes the number of international publications and intellectual property (see Table 1).

The choice of the indicator “share of small and medium-sized enterprises that have introduced at least one innovation in work” is conditioned not only by the specificity of innovative entrepreneurship and the elaboration of innovative solutions, but also by their creation on the basis of the innovative activity of organizations implementing scientific and technical innovations. The peculiarity of choosing the indicator “research and development costs of the business sector” lies in the following: this indicator most comprehensively characterizes the expenditures of innovative activity of enterprises because it includes both current and capital expenditures. The significance of choosing this indicator is also reflected in its ability to indicate the future development of innovators. The importance of the indicator “volume of intellectual property” lies in its ability to indicate the achieved results of innovation organizations.

Including only these indicators in the model would be incorrect because innovations, including innovative entrepreneurship, are not the only determinants of the economic development of the region. It is more appropriate to consider the output of innovative entrepreneurship through the basic factors of regional

economic growth corresponding to indicators that reflect sustainable fixed assets and labor force.

In this research, annual data for the period from 2011 to 2025 were used. The data used for the analysis were obtained from the following databases: the European Statistical Office, the European Commission, the Statistical Office of the Republic of Serbia, and the Croatian Bureau of Statistics. The data relate to six statistical (administrative) regions in Serbia and Croatia: the Region of Southern and Eastern Serbia, the Region of Šumadija and Western Serbia, the Region of Vojvodina, the Belgrade Region, Pannonian Croatia, and Adriatic Croatia.

The names of the selected indicators (variables) and their descriptions are given in Table 1. The panel model, constructed on the basis of the information presented in Table 1, is as follows:

$$\ln \text{GDP}_{it} = \beta_0 + \beta_1 \ln \text{RDBS}_{it} + \beta_2 \ln \text{SMEI}_{it} + \beta_3 \ln \text{IP}_{it} + \beta_4 \ln \text{VFA}_{it} + \beta_5 \ln \text{NER}_{it} + \beta_6 \ln \text{PO}_{it} + \varepsilon_{it}, \quad (1)$$

where:

i – units of cross-section ($i = 1, 2, \dots, 6$);

t – time ($t = 2011, 2012, \dots, 2022$);

β_0 – the constant;

$\beta_1 \dots \beta_6$ – the regression coefficients and

ε_{it} – the error term.

Table 1. The explanation of indicators (variables) in the panel model (1)

Label	The explanation	Type of variable	The sources
GDP	The general indicator of the development of a given region (million euro)	The dependent variable or Regressand	European Statistical Office (Eurostat)
SMEI	Share of small and medium-sized enterprises that have introduced at least one innovation in work	The indicator that determine the drivers of innovation activities	Regional innovation scoreboard (EC)
RDBS	Research and development costs of business (or entrepreneurial) sector (as % GDP)	The indicator that determine the drivers of innovation. Activities	Regional innovation scoreboard (EC)
IP	The sum of registered patents trademarks and designs on 1000 billion GDP according to purchasing power standards	The indicators of the results achieved by activities of innovation organizations	Regional innovation scoreboard (EC)
VFA	Value of fixed assets (in thousands of RSD, in thousands of Croatian kunas)	Control variable	Statistical office of the Republic of Serbia and Croatian Bureau of Statistics
NER	Number of employees in the given region (In thousands)	Control variable	Eurostat
PO	The publication outputs (Publication output means the number of works in which at least 1 co-author is a foreigner).	The indicators of the results achieved by activities of innovation organizations	Regional innovation scoreboard (EC)

Source: Authors' research on the basis following sources: European Statistical Office (Eurostat) (2025, April); European Commission (EC) (2025, April); Statistical office of the Republic of Serbia (RZS) (2025, April) and Croatian Bureau of Statistics (DZS) (2025, April)

The empirical analysis was conducted in five stages. In the first stage, the Breusch–Pagan CDLM1 test was applied to examine cross-sectional dependence between the series and within the panel model. This criterion provides efficient estimations when the temporal dimension (T) is larger than the cross-sectional dimension (N). In addition to this criterion, Pesaran's CDLM2 test (Pesaran, 2021)

was also used, as it provides effective results when both T and N tend toward infinity.

During the panel data analysis, the assumption was made that the cross-sectional units (statistical regions (NUTS 2) in Serbia and Croatia) are independent, that is, they do not affect one another. However, in a “non-ergodic world”,

characterized by constant changes, a one-sided quantitative approach is insufficient. Therefore, relying solely on criteria that do not take into account the dependence among cross-sectional units may lead to non-objective and contradictory results.

In the next step, the Pesaran–CIPS unit root test was used (Pesaran, 2007). If the probability value p in the test is greater than 0.1, it follows that the series data are non-stationary, that is, they contain a unit root. If the probability value p is less than 0.1, it follows that the series data are stationary, that is, they do not contain a unit root.

As a complement to unit root tests, cointegration tests are widely used in the literature. Therefore, in the third phase of this research, cointegration tests based on residuals were included. These tests are directed toward controlling the unit root in the residuals through the modeling of cointegration equations. The presence of a unit root in the residuals indicates the absence of cointegration between the variables. Conversely, cointegration between the variables exists if a unit root is not present. The most widely known residual-based cointegration tests are those proposed by Pedroni (2004), Kao (1999), and Westerlund.

Furthermore, in the fourth stage, it was examined whether the variables have a normal distribution in order to select an appropriate estimation method. For this purpose, the statistics of skewness and kurtosis were used. Skewness, or the coefficient of asymmetry, is a measure of the degree of distortion of a distribution, indicating whether the data are asymmetrically dispersed to the left or to the right. For a distribution skewed to the right, the coefficient of asymmetry is greater than zero, whereas for a distribution skewed to the left, the coefficient of asymmetry is less than zero. Kurtosis measures the flatness or peakedness of a variable distribution. A kurtosis value equal to 3 indicates that the data are normally distributed. A kurtosis value greater than 3 indicates that the distribution is more elongated compared to the normal distribution. If the kurtosis value is less than 3, the distribution is flatter compared to the normal distribution (Black, 2010).

In the final stage, if it was determined that the variables do not have a normal distribution and that atypical points are present, the quantile regression analysis of Koenker and Bassett Jr., which is widely used in the statistical analysis of linear and nonlinear models, was applied for coefficient estimation. Quantile regression is used to analyze the relationship between the conditional quantiles of the dependent variable and the independent variables (Canarella & Pollard, 2004). The model enables more accurate and efficient estimation of regression coefficients than the ordinary least squares method when the assumptions of normality and homogeneity of data are not satisfied. The mathematical equation of a panel quantile regression model, in general form, is as follows:

$$Qy_{it}(Q_j|x_{it}) = x_{it}\beta(Q_j) + \varepsilon_{it}(Q_j), \quad (2)$$

where:

$j = 1, \dots, q$;

$i = 1, \dots, N$ and

$t = 1, \dots, T$

In equation (2), the dependent variable y_{it} is expressed in the form of a percentile distribution Q (the value of dependent variable depends on the set of explanatory variables x_{it}) i.e., $y_{it} = Qy_{it}(Q_j|x_{it})$, where is Q_j - fraction of distribution of y_{it} or a quantile (percentile). The effects of the explanatory variables x_{it} , that are expressed by a set of unknown parameters β , depend on Q_j .

4. Results and discussion

According to the research plan presented in the previous section, the first step was to examine whether cross-sectional dependence exists for each variable in the given model (Table 2). According to the results of the three statistical tests, cross-sectional dependence was identified at the 5% significance level for each variable and for the model as a whole.

Table 2. Cross-sectional dependence test results

Variable / Tests	CDLM ₁	CDLM ₂
lnGDP	163.6655 (0.0000)	27.14249 (0.0000)
lnRDBS	72.22243 (0.0000)	10.44734 (0.0000)
lnSMEI	99.26259 (0.0000)	15.38417 (0.0000)
lnIP	64.55320 (0.0000)	9.047135 (0.0000)
lnVFA	69.24407 (0.0000)	9.903567 (0.0000)
lnNER	52.06598 (0.0000)	6.767290 (0.0000)
lnPO	99.49355 (0.0000)	15.42634 (0.0000)
The model	37.7829 (0.0010)	4.160736 (0.0000)

Source: Author's calculations in EViews

To determine the level of stationarity, the Pesaran unit root test (CIPS test) for panel data was applied (Table 3). According to the test results, the variables lnGDP and lnIP are stationary at the level form, i.e. $I(0)$. In addition, the results confirmed that the variables lnSMEI, lnVFA, lnNER, and lnPO become stationary after first- and second-order differencing, i.e. $I(1)$ and $I(2)$. To analyze the long-term equilibrium relationship between the

factors, two tests were applied: the Pedroni and Kao tests. The null hypothesis of these tests assumes the absence of cointegration, whereas the alternative hypothesis assumes the existence of cointegration among the series. Within the framework of the Pedroni test, the group analysis independently sums the numerators and denominators across the series, and the obtained summation is used to calculate four panel statistics: v , ρ , PP , and ADF . In the

intergroup analysis conducted within the Pedroni test, the numerator is divided by the denominator, after which the obtained results are summed across groups in order to calculate the group statistics (rho, PP, and ADF). The t-statistic of the Kao test assumes panel homogeneity and is based on the augmented ADF test. The Kao test statistic is calculated on the basis of estimates obtained by the ordinary least squares method within a regression containing artificial variables. The results of the Pedroni

and Kao tests indicate the existence of a long-term relationship between the variables, i.e., that the variables are cointegrated (Table 4). In order to choose the method for estimating the regression coefficients, it was examined whether the variables in the model have a normal distribution. The values of skewness and kurtosis show that none of the variables are normally distributed (Table 5). Therefore, it can be concluded that the application of panel quantile regression is fully justified.

Table 3. Results of the Pesaran–CIPS unit root test

Variables / Test	Level	First differences	Second differences
lnGDP	-2.87817*		
lnSMEI	-0.11827	-2.90250*	
lnIP	-3.09912*		
lnVFA	-2.14672	-2.14763	-3.58010*
lnNER	-1.20261	-2.79144*	
lnPO	-0.93426	-3.09299*	

Note: * denotes significance at the 0.05 level

Source: Author's calculations in EViews

Table 4. Results of the panel cointegration tests

Panel Cointegration Tests		Statistic	p-value
Pedroni		Panel v-statistic	0.8856
		Panel rho-statistic	0.9977
		Panel PP-statistic	0.0000
		Panel ADF-statistic	0.0000
		Group rho-statistic	0.9999
		Group PP-statistic	0.0000
Kao		Group ADF-statistic	0.0000
		ADF statistic	0.0018

Source: Author's calculations in EViews

Table 5. Results of the normality tests

Variables	Skewness coefficient	Kurtosis coefficient
lnGDP	-0.0491098	2.221905
lnRDBS	-0.7290397	2.179783
lnSMEI	0.2671913	3.183889
lnIP	0.0821499	1.777804
lnVFA	0.1637309	2.832181
lnNER	-0.6103611	2.208975
lnPO	-0.5550647	2.574494

Source: Authors' calculations in Stata

Table 6. Results of the quantile regression analysis

Variables	0.10	0.25	0.50	0.75	0.90
lnRDBS	.324* (.000)	.282* (.000)	.155* (.000)	.097*** (.065)	.026 (.641)
lnSMEI	.451* (.000)	.422* (.003)	.287* (.010)	.277** (.041)	.263*** (.070)
lnIP	.228* (.003)	.242** (.032)	.195** (.029)	.169 (.120)	.326* (.006)
lnVFA	.195* (.000)	.211* (.001)	.352* (.000)	.432* (.000)	.406* (.000)
lnNER	.497* (.002)	.603* (.008)	.721* (.000)	.638* (.004)	.475** (.042)
lnPO	-.005 (.765)	-.015 (.528)	-.071* (.000)	-.073* (.002)	-.049** (.051)

Note: ***, **, and * denote significance at the 0.1, 0.05, and 0.001 levels, respectively

Source: Authors' calculations in Stata

The results of the quantile regression analysis of the impact of innovative entrepreneurship on regional economic development are presented in Table 6. The quantile regression method implies modeling the impact of independent variables on specific percentiles of the dependent variable. In this way, the first quantiles ($Q = 0.10$ and $Q = 0.25$) include regions with the lowest level of economic development, namely Southern and Eastern Serbia and Šumadija and Western Serbia. Regions with a medium level of economic development (Pannonian Croatia and Vojvodina) are included in the quantile $Q = 0.50$. Regions with a high level of development, such as

Belgrade, are included in the highest quantiles ($Q = 0.75$ and $Q = 0.90$).

According to Table 6, the influence of the independent variables on GDP is not identical, but rather conditioned by the quantile (region). It was confirmed that the impact of business-sector R&D expenditures is significant and positive, excluding the indicators of the 90th quantile. In regions where the GDP level is higher than the median, the positive effect of business-sector R&D expenditures is lower. This result can be interpreted as follows. In regions with higher GDP levels, business-sector R&D

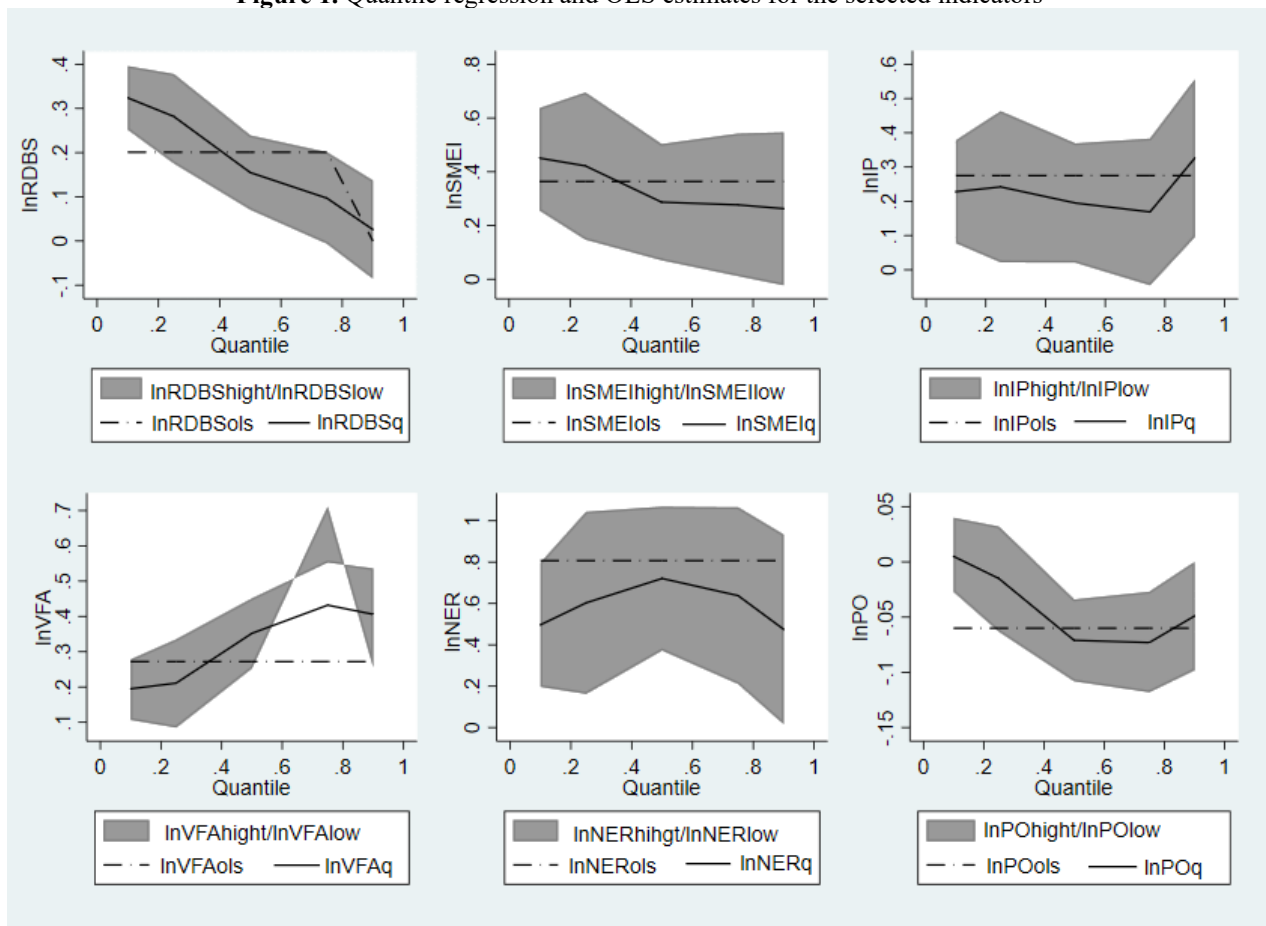
expenditures are directed toward performing a wider range of activities, since their assortment includes a greater number of product lines. Lower specialization directly leads to a decrease in research and development productivity, which consequently reduces the positive impact of R&D expenditures on GDP.

Although the impact of the variable $\ln\text{SMEI}$, which represents the share of SMEs with at least one type of innovation, varies across quantiles, it was observed to have a significant impact on GDP. Furthermore, the impact of intellectual property, represented by the $\ln\text{IP}$ indicator, is positive and significant, excluding the indicators of the 75th quantile. Finally, it was concluded that the variables $\ln\text{VFA}$ and $\ln\text{NER}$ have a significant positive impact on gross domestic product across all quantiles.

As an illustration, Figure 1 presents the quantile regression estimates for the coefficients of the following variables: $\ln\text{GDP}$, $\ln\text{RDBS}$, $\ln\text{SMEI}$, $\ln\text{IP}$, $\ln\text{VFA}$, $\ln\text{NER}$, and $\ln\text{PO}$ for different quantile (Q) values. The

graph (solid lines) shows the variation of these coefficients depending on Q . The dotted line, for comparison, represents the OLS estimates, which do not depend on the value of Q (quantile). The results indicate the presence of heteroscedasticity (volatility, instability) in the selected observations of the $\ln\text{GDP}$ indicator for different levels of independent variables and justify the use of quantile regression instruments, since the classical OLS regression provides inaccurate estimates of the relationship between variables. The coefficients of the value of fixed assets ($\ln\text{VFA}$) are particularly volatile, whereas the coefficients of the logarithm of publication output ($\ln\text{PO}$) are moderately volatile. The coefficients of the following variables are less volatile: the logarithm of the share of small and medium-sized enterprises that introduced at least one innovation in work ($\ln\text{SMEI}$), the logarithm of the sum of registered patents, trademarks, and designs per 1,000 billion GDP according to purchasing power standards ($\ln\text{IP}$), and the logarithm of the number of employees in the observed region ($\ln\text{NER}$).

Figure 1. Quantile regression and OLS estimates for the selected indicators*



Note: * The gray area marks the confidence interval of the quantile regression's estimates.

Source: Authors' creation in Stata

The obtained results are consistent with the findings of a large number of scientific papers (Smotrinskaya & Chernykh, 2021; Golova, 2021; Xu & Li, 2020; Aganbegyan et al., 2020; Ramadani et al., 2019; Tanasković & Ristić, 2019; Matejovsky et al., 2014;

WEF, 2014), as well as with the works of representatives of the Endogenous Growth Theory (Rivera-Batiz & Romer, 1991; Nelson & Romer, 1996), which confirm the positive impact of innovative entrepreneurship on

economic development through investments in technology, equipment, and human capital.

The scientific novelty of the study consists in the application of the quantile regression analysis method to assess the impact of innovative entrepreneurship on regional economic development. In the considered literature, such an instrument has been used to a limited extent due to the lack of completeness in the construction of the panel model, which is addressed within the framework of this study. Taking into account the fact that the panel model includes indicators characterizing not only innovative entrepreneurship, but also other development factors, this method can be used for analytical and predictive research related to the analysis of the impact of innovative factors and innovative entrepreneurship on the economy.

Based on the results of the conducted research, it can be concluded that the hypothesis is confirmed. The application of the quantile regression analysis method to panel data allows obtaining consistent and statistically significant estimates of indicators characterizing innovative entrepreneurship, as well as providing a complex and objective assessment of the impact of innovative entrepreneurship on regional economic development.

5. Conclusion

This research contributed to methodological work by providing instruments for assessing the impact of innovative entrepreneurship on the level of regional economic development. Unlike classical instruments, the quantile regression method enables a more detailed insight into the relationship between indicators that characterize the development of innovative entrepreneurship, on the one hand, and economic development, on the other. This provides a more comprehensive construction of panel models. This method also permits the consideration of individual differences among variables in the model, which allows for unbiased estimates of regression coefficients.

Using quantile regression analysis, the potential contribution of innovative entrepreneurship entities to regional economic development was estimated. The results of this analysis showed the following. The 0.10 and 0.25 quantiles belong to the regions with the lowest GDP per capita; all factors, except PO, are significant at the 0.01 level. In the 0.50 quantile, all variables are significant. In the 0.75 quantile, practically all indicators are significant at the 0.01 level except SMEI. This variable became insignificant. Finally, in the 0.90 quantile, the variables SMEI, IP, VFA, NER, and PO are statistically significant and have a positive effect on GDP, except for PO. Regarding the coefficients, an upward trend was observed for variables such as VFA and IP. In contrast, the coefficients for the variables R&D expenditures and the share of SMEs that introduced at least one innovation in their work show a downward trend.

In future research, the following is planned: 1) identifying problems and prospects for the development of innovative

entrepreneurship using sociological research methods, such as surveys, expert interviews, etc.; and 2) developing a complex mechanism for regional development based on innovative entrepreneurship.

It was observed that the variables characterizing innovative entrepreneurship (research and development costs of the business sector, the share of small and medium-sized enterprises that introduced innovation in their work, and intellectual property) are significant for all quantiles (all regions). Based on these research results, the following recommendations for regional policies and strategies can be proposed:

- increasing investments in R&D in developing regions (informing business entities in underdeveloped regions about the benefits of innovation and R&D activities and demonstrating that such investments are profitable; companies in underdeveloped regions should stimulate greater employee participation in innovation through bonuses or the use of “rights to acquire shares” mechanisms);
- improving innovation financing in developing regions (increasing the availability of funds for financing in the early stages of innovation development, primarily through grant mechanisms; increasing budgetary investments in science);
- developing the intellectual property protection system in developed regions (improving regulations related to the identification, legal protection, and commercialization of intellectual property, and continuously educating all actors in the innovation ecosystem about the importance of intellectual property and its protection);
- and encouraging private companies in developed regions to invest in new technologies (introducing tax incentives and support programs for investments in new technologies, promoting examples of good practice and investment success stories related to new technologies, and similar activities).

The research result indicating that the variable “publication outputs” has a negative effect on GDP suggests that the work of scientific research institutions is not sufficiently oriented toward the needs of the economy. Therefore, modification of the evaluation and scoring system for promotion to the title of researcher should be considered. More specifically, promotion regulations should be modified in a way that additionally rewards all forms of cooperation with the economy, as well as the protection and commercialization of intellectual property.

This study has several limitations that provide directions for future research in this field. The availability of data at the regional level significantly limits the conduct of research, both in terms of the time period covered by the research and the regions included in the sample. In addition, the methodology of panel data analysis limits the number of factors that can be simultaneously analyzed within a single model, which is one of the reasons why some of the frequently analyzed factors in previous studies could not be included in this research paper.

Anowledgment: This research was supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia under Contract No. 451-03-33/2026-03/200124.

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