EKONOMIA I PRAWO. ECONOMICS AND LAW
Volume 23, Issue 2, June 2024
p-ISSN 1898-2255, e-ISSN 2392-1625
www.apcz.umk.pl/EiP

ORIGINAL ARTICLE
received 24.02.2023; revised 21.11.2023; accepted 07.12.2023
Citation: Drozdowski, G., Dziekański, P.(2024). Deconcentration of Infrastructure and Spatial Diversification of Entrepreneurship in Powiats in Poland in 2010-2020. *Ekonomia i Prawo. Economics and Law*, 23(2), 437–458, https://doi.org/10.12775/EiP.2024.022.

Deconcentration of Infrastructure and Spatial Diversification of Entrepreneurship in Powiats in Poland in 2010-2020

GRZEGORZ DROZDOWSKI
corresponding author
Jan Kochanowski University in Kielce, Faculty of Economics and Sociology,
Department of Economics and Finance,
University 15 str., 25-406 Kielce, Poland
grzegorz.drozdowski@ujk.edu.pl
orcid.org/0000-0003-3755-4851

PAWEŁ DZIEKAŃSKI
Jan Kochanowski University in Kielce, Faculty of Economics and Sociology,
Department of Economics and Finance
pawel.dziekanski@ujk.edu.pl
orcid.org/0000-0003-4065-0043

Abstract

Motivation: Green infrastructure, infrastructure and entrepreneurship serve to improve the quality of life, and social equality and reduce environmental risks and ecological shortages, or improve territorial cohesion. Entrepreneurship and infrastructure must be built based on the region's available potential.
Aim: The article aims to analyze the spatial diversity of infrastructure and its impact on entrepreneurship in powiats in Poland in the years 2010-2020. Technique for Order Preferences by Similarity to an Ideal Solution (TOPSIS) was used to construct the synthetic measure. The empirical data was collected by poviats spatial basis for the years 2010-2020.
Results: The results indicate that there is spatial differentiation of entrepreneurship, infrastructure and green infrastructure in counties in Poland. The effects generated by infrastructure and green infrastructure can have a positive impact on the activities

of businesses, as well as minimize the impact of external factors that cause disruptions in regional systems. Infrastructure is very important for the processes of the local economy. It represents an investment proposition and an offering of the conditions necessary for economic activity. It constitutes an element of attractiveness relative to other regions.

Keywords: entrepreneurship, infrastructure, green infrastructure, synthetic measure, district, spatial diversity,
JEL: D19, M13, H61, H71, J58

1. Introduction

The local economy is constantly evolving due to the scale and direction of changes in response to internal interactions and the impact of environmental factors (Batty, Barros, Alves, 2004). Differences in the level of development of the regions are a natural phenomenon. It results from, among other things, access to factors of production (labour, capital, natural resources), the scale and extent of resource use, the level of development to date, and the level of entrepreneurship (Korenik, Zakrzewska-Półtorak, 2011). The differentiation of endogenous potential also concerns demographic aspects, the labour market, the level of entrepreneurship and infrastructure.

Entrepreneurship in the aspect of regional development can be assessed (analyzed) from the point of view of individual persons, enterprises or local government units. It can be seen as a way of organizing human activities and producing and initiating changes in the enterprise, enterprise activity (Grudzewski, Hejduk, Sankowska, Wańtuchowicz 2010).

Infrastructure can improve connectivity and linkages that facilitate the identification of entrepreneurial opportunities and the ability of entrepreneurs to pursue them (Audretsch, Heger, Veith, 2015). Infrastructure and green infrastructure play an important role in the development or improvement of the competitiveness of enterprises. The level of development of the region with elements of infrastructure is a prerequisite for economic development and improvement of the standard of living of the inhabitants. Infrastructure makes the region more or less attractive for residents and investors or business locations. Green infrastructure is identified with different types of areas, covered with vegetation and water and structures performing important climatic, ecological and social functions. Local green infrastructure is more diverse than regional or international. Green infrastructure is a tool for integrating biodiversity protection at a territorial level into sustainable development (Szulczewska, 2018).

The counties have a high level of infrastructural development and are areas considered by potential investors and residents as attractive for conducting business and living.

The article aims to analyze the spatial diversity of infrastructure and its impact on

entrepreneurship in powiats in Poland in the year 2010-2020. To achieve this goal, the authors first used an analysis of the subject literature and statistics using a synthetic measure. Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) was used to construct the synthetic measure. Empirical data were collected on the spatial basis of powiats. The studies were conducted dynamically, setting min {xij} and max{xij} values for the whole study period (2010-2020). The authors, complementing the main objective, decided to formulate a research question: how does the spatial diversification of infrastructure and entrepreneurship in powiats in Poland look like? What is the interdependence between infrastructure and entrepreneurship? The authors see a research gap in the area of grassland infrastructure and its impact on entrepreneurship and the region, as it is not analysed from an economic point of view, especially in the area of powiats (Figure 1).

2. Literature review

The green economy (GE) is a complex construct in terms of attempts to integrate economic, environmental and social concerns (Bailey, Caprotti, 2014). It is interpreted as the "4R" - i. e. reduction, reuse, recycling and recovery. They refer to the reduction of resource consumption preservation of natural capital, and resource recovery (Murray, Skene, Haynes, 2017). It provides better ways of using resources, eliminating environmental pollution and ecological growth of the region, and improving the quality of life of the inhabitants. It also seems to point to a sharing economy (Elimam, 2017). It is an economy built on distributed networks of interconnected individuals and communities. It affects a whole range of aspects related to production and consumption, such as economic, social and environmental perceptions (Drobniak, Janiszek, Plac, 2016). Increasing resource efficiency, promoting sustainable consumption and production, reducing pollution and managing natural resources are driving the transition towards a green economy that affects both regions and businesses (Khoshnava, Rostami, Zin, Štreimikienė, Yousefpour, Strielkowski, Mardani, 2019).

Business development leads to some environmental challenges, i.e. accumulation of waste, and emissions of harmful gases. GE in the enterprise can help develop environmentally friendly operations, manage solid waste and provide solutions to sustainability challenges. GE helps businesses develop 4R strategies, i.e. reducing consumption, reusing materials, recycling waste and remanufacturing products (Mondal, et al., 2023).

The nature of environmental problems varies spatially between countries. The increase in fossil fuel consumption, the rapid growth of urbanisation and energy consumption, and commercial activities have significant impacts on the environment of individual countries (Khezri, Muhamad, 2023). Entrepreneurship researchers are paying attention to the linkages between businesses and the environment, particularly their role in the development towards a more sustainable economic system. This requires interactions between technology, politics, economy, and business, among others. Entrepreneurial activity is an important force for ensuring

economic, social and environmental sustainability (Silajdžić, et al., 2015). Supporting a thriving economy depends on promoting greater entrepreneurial engagement, as there is a strong link between increased entrepreneurial activity and economic growth (Duong, 2023).

Businesses are under increasing pressure to take into account the environmental and resource impact of the ever-increasing production, distribution and consumption of consumer products and the amount of waste (Di Vaio, Hassan, Chhabra, Arrigo, Palladino, 2022). The level of diversity is determined by, among others, natural conditions, accessibility of transport, access to capital, infrastructure equipment, the current level of economic activity, and policies of local government units conducive to the growth of entrepreneurship. The development of entrepreneurship is influenced by natural, social, financial, economic and infrastructural factors. These factors shape the market and social relations. Entrepreneurship plays an important role in the efficient allocation of existing resources. It involves people seeking innovation and discovering new relationships within the existing economic and social system (Skawińska, 2009).

The company, as an element of the economic space, influences the development of regions through the efficient use of available resources, innovative actions or the use of regional resources. Entrepreneurship allows for sustainable, independent and long-term development. In addition, endogenous development provides an opportunity for the periphery to avoid development dependent on growth centres, based, for example, on inflows of investment and transfer of knowledge. The level of entrepreneurial activity varies regionally. The structural characteristics of the regions and the factors present within them mean that the regions differ in the scale of entrepreneurial activity.

Entrepreneurship affects the development of regions through the efficient use of available resources, and innovative actions (Valliere, Peterson, 2009; Miłek, Kantarek, 2017). Businesses perform important economic and social functions. Among the most important benefits for the economy related to the development of entrepreneurship are the fuller satisfaction of the needs of the local community, the creation of new jobs, and the strengthening of the innovativeness of the economy, contributing to the development of the region. It stimulates regional development by making fuller and more comprehensive use of regional resources (Glinka, Gudkova, 2011). Businesses have an impact on the competitiveness of the economy and stimulate its growth. They perform economic, technical and social functions. Other functions performed by companies include shaping the functioning of the labour market, creating opportunities to make fuller use of existing resources, stimulating local development and making a positive impact on the environment.

Infrastructure is very important for the processes taking place in the local economy. It constitutes an investment proposal and an offer of conditions necessary for conducting business activity. It is a prerequisite for increased competitiveness, the basis of economic activity. Infrastructure equipment determines the locational attractiveness of regions (Puzdrakiewicz, 2017). Infrastructure can improve connectivity and linkages that facilitate the identification of entrepreneurial

opportunities and the ability of entrepreneurs to pursue them (Audretsch, Heger, Veith, 2015).

The infrastructure development aims to stimulate economic growth, diversify and industrialise the economy, improve transport systems and address the energy crisis. Infrastructure development remains one of the Sustainable Development Goals (Awad, at all, 2023). Green infrastructure supports housing choice, provides sustainable transport and contributes to creating liveable neighbourhoods. It has implications for climate change, social equity, as well as increased access to green spaces (Reu Junqueira, Serrao-Neumann, White, 2022).

Infrastructure plays a particular role in shaping settlements and socio-economic development. Infrastructure influences the shaping of human, social and cultural capital. It shapes the development of economic initiatives and the attraction of external capital, opportunities for increasing production, improving the lives of residents and shaping multifunctional and sustainable development, increasing territorial cohesion, and achieving the Sustainable Development Goals (Thacker, Adshead, Fay, Hallegatte, Harvey, Meller, O'Regan, Rozenberg, Watkins, Hall, 2019).

Green Infrastructure focuses on taking into account and integrating the protection and enhancement of natural processes in planning projects. Green infrastructure is often seen as synonymous with biodiversity and visually green spaces. It is a strategically planned network of natural and semi-natural areas with other environmental characteristics, designed and managed to provide a wide range of ecosystem services. Its characteristics are the multifunctionality of the individual elements and the whole structure and its spatial coherence, the creation of a network of links (Szulczewska, 2018). Green infrastructure has multiple functions, e. g. biological, climatic and technical, while also being a space that is used by people in a variety of ways (Sutkowska, 2006). To create a social space, it should meet the needs of its users. It is a cost-effective, resilient approach to managing the region that provides many benefits to the community. It has become an important tool for achieving sustainability (Liberalesso, Oliveira Cruz, Matos Silva, Manso, 2020).

3. Methods

The following procedure was used in the analyses of entrepreneurship, infrastructure, green infrastructure and construction of synthetic measurement:

1. Selection of diagnostic variables and their substantive and statistical verification.

Diagnostic variables (Table 1.) describing the areas of analysis are variable over time. They should be kept under review. The observation matrix, which consists of a set of objects and features, is written as Xij:

$$X_{ij} = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1m} \\ x_{21} & x_{22} & \dots & x_{2m} \\ \dots & \dots & \dots & \dots \\ x_{n1} & x_{n2} & \dots & x_{nm} \end{bmatrix} (1),$$

where: X_{ij} – means the j-th variable value for the i-th object, i – the object number (i = 1,2, . . . , n), j – the variable number (j = 1, 2, . . . , m).

Diagnostic features should show sufficient spatial variability, i. e. be a carrier of information. Diagnostic variables were assessed based on the coefficient of variability (limit of 0.10), and correlation coefficient (limit of 0.75) (Malina, 2004).
Variables were also selected based on factor analysis performed in Statistca.

2. Determining the direction of preferences of variables and their division of variables into stimulants and destimulants.

Determination of the nature of variables – stimulants, destimulants. Most variables are self-evident. Their determination results from the experience of the researchers, or in doubtful cases it is worth using the fact that stimulants should be positively correlated with stimulants (similarly it is for destimulants with destimulants) and negatively with destimulants (Grabiński, 1985).

3. Standardization of diagnostic variables according to the zero unitization methods.

Selected diagnostic variables were subjected to a zero unitization procedure using the formula (Walesiak, 2005):

$$Z_{ij} = \frac{max_i x_{ij} - x_{ij}}{max_i x_{ij} - min_i x_{ij}},\ Z_{ij} = o \Leftrightarrow x_{ij} = max_i x_{ij};\ Z_{ij} = 1 \Leftrightarrow x_{ij} = min_i x_{ij},\ when\ x_i \in S, (2),$$

$$Z_{ij} = \frac{max_i x_{ij} - x_{ij}}{max_i x_{ij} - min_i x_{ij}},\ Z_{ij} = o \Leftrightarrow x_{ij} = max_i x_{ij};\ Z_{ij} = 1 \Leftrightarrow x_{ij} = min_i x_{ij},\ \text{when}\ x_i \in D, (3)$$

where: $max_i x_{ij} \neq min_i x_{ij}$, $max_i x_{ij} > min_i x_{ij}$,
S – stimulant, i=1, 2. . . n; j=1, 2. . . m,
D - destimulant, i=1, 2. . . n; j=1, 2. . . m,
max_{xij} – maximum value of the jth variable,
min_{xij} – the minimum value of the jth variable,
x_{ij} – means the value of the jth variable for the ith object,
Z_{ij} – $\in$ [0;1], the abnormal value of the j variable for its object (Kukuła, Bogocz, 2014).

4. Determination of the value of a synthetic measure according to the method Technique for Order Preference by Similarity to an Ideal Solution.

As a result of unitization, we obtain a matrix of values of the characteristics Zij:

$$Z_{ij}=\begin{bmatrix} z_{11} & z_{12} & \dots & z_{1m} \\ z_{21} & z_{22} & \dots & z_{2m} \\ \dots & \dots & \dots & \dots \\ z_{n1} & z_{n2} & \dots & z_{nm} \end{bmatrix}, (4),$$

where Zij is the unitized value of the jth variable for the ith object.
The synthetic measure is based on the method Technique for Order Preference by Similarity to an Ideal Solution (Behzadian, Khanmohammadi Otaghsara, Yazdani, Ignatius 2012). The synthetic measure for the studied objects was determined based on the formula:

$$q_i = \frac{d_i^-}{d_i^- + d_i^+}, \text{ where: } 0 \le q_i \le 1,\ i = 1, 2, \dots, n; \qquad (5),$$

where: qi ∈ [0; 1] – the value of the synthetic measure;
$di-$ - means the distance of the object from the anti-formula (from 0),
$di+$ is the distance of the object from the pattern (from 1).

5. The Linear arrangement of objects.

The typological groups of the studied objects were based on the values of the first, second and third quartiles. The size of the synthetic measure in the first group means the better unit, and in the following groups – the weaker units. The similarity matrix, scatter plot (with correlation value), bag plot, 3D plot, and correlation coefficient are also presented.

The similarity or dissimilarity of units in multidimensional space in the primary criterion studied was expressed by the similarity distance. The farther away from each other, the more dissimilar they are (=1). The similarity matrix established in the PQStat program is expressed by the formula:

$$d(A,B) = \sqrt{(x_{1A} - y_{1B}) + (x_{2A} - y_{2B}) + \dots + (x_{nA} - y_{nB})}, \qquad (6)$$

where: $A=(x_a,y_a)$, $B=(x_b, y_b)$.

The Gini Index is a measure of the concentration of the distribution of the variable under study. It takes a value between 0 and 1 (concentration factor calculated in Ststistica). For the object yi the Gini coefficient is expressed by the formula:

$$G(y)=\frac{\sum_{i=1}^{n}(2i-n-1)y_i}{n^2\bar{y}}, (7),$$

where yi is the value of the i-th observation and y is the mean value of all observations yi (Krukowska, 1981). It should be interpreted in such a way that the higher it is, the greater the inequalities of a given variable are.

Dispersion and bag graphs presented in the aspect of synthetic measurement, 3D graphs allowed to show the differentiation of powiats and an indication of outlying units (the graphs were made in the program Ststistica) (Prus, Dziekański, Bogusz, Szczepanek, 2021; Dziekański, Prus, 2020).

4. Results and Discussion

Business, infrastructure (including green infrastructure) and the environment are interlinked. Their coordinated development helps raise their level respectively. They are also key to the sustainable development of the economy and society (Cui, 2022).

The Synthetic Entrepreneurship Miracle ranged from 0. 11 to 0. 46 in 2010, and from 0.23 to 0. 72 in 2020. The average value of the measure remains at 0. 26 and 0. 35.

For the synthetic infrastructure measure, the values ranged from 0.14 to 0.45 in 2010 and 0.16 to 0.53 in 2020 (with an average of 0.23 and 0.26). The synthetic green infrastructure measure was 0. 28-0. 52 in 2010 and 0.32-0.60 in 2020, respectively, and its average value was 0.36 and 0.38 (Table 2.). A higher value of the synthetic measure means a higher level of the studied phenomenon, with the adopted diagnostic variables and the method of constructing the synthetic measure.
The average value for all synthetic measures (for the surveyed areas) assumes a higher value for the year (2010 to 2020). For the measures of variability (spacing, standard deviation, coefficient of variability), we observe both increase, decrease and equilibrium.

The standard deviation was 0. 06-0. 06 (for the relationship years 2010-2020) for the synthetic enterprise measure, 0.05-0.06 for the infrastructure measure and 0.03-0.03 - for the grassland infrastructure. The spread indicates how large the spread is between the smallest and largest values of the variable in the test area. Its value was respectively 0.35-0.49, 0.31-0.37, 0.24-0.28 (and for quartile range 0.08-0.08; 0.05-0.06; 0.02-0.04).

As Spychała M. (2018) points out, entrepreneurship (share of foreign companies in the total number of enterprises; changes in the size structure of enterprises; percentage of entities engaged in financial or educational activities in the total number of economic entities; as well as the change in the share of employees in services in the total number of employees) is an important factor in the position of counties in the study conducted in terms of development. The authors indicate that there is a close relationship between the level of economic development of a region and the development of entrepreneurship. A higher level of development stimulates entrepreneurship development to a greater extent. Less developed regions cannot reduce barriers to entrepreneurship development (e.g. infrastructural).

Infrastructure development and energy efficiency improvements are key to a high-quality transformation of the economy. Improving energy efficiency is a key

to mitigate climate change. Investment in infrastructure and manufacturing development are key to a country's strategic competitiveness and are inextricably linked (Yu Chen, Boqiang Lin, 2021).

Green infrastructure is a tool that brings economic and environmental benefits through natural solutions that support and enhance investments. Based on biodiversity and ecosystem services, it is becoming part of strategies to adapt to the negative effects of climate change, as Janiszek M. (2015) points out. The development of green infrastructure is a major goal of environmental policy in many countries. Green infrastructure generates local benefits on the ground regardless of the spatial distribution of an area to other locations.

The coefficient of variability in the individual areas shows slight disparities. Its value was respectively for the measures entrepreneurship - 23.2-18.12 (for the years 2010-2020), infrastructure measures 21.94-21.62, and green infrastructure measures 7.24-8.67.

In both 2010 and 2020, we observed a right-sided skew (As>0) for the entrepreneurship measure. The right-hand slant indicates that a smaller number of units have values of these variables less than their mean value. Thus, we observe a greater dispersion of values, and poor concentration (Table 2).

In Figure 2 the division of powiats in Poland (in 2010, 2018, 2019, 2020) was made based on the value of quartiles due to the value of the measure entrepreneurship, green infrastructure, and infrastructure. These were threshold values for the isolated typological groups. Black was used to denote a group of powiats characterized by a higher synthetic measure (a better condition in the main criterion tested), while the lighter colour was smaller (weaker units).

The mutual relations between objects can be expressed by their distances or, more generally, by dissimilarity. The similarity or dissimilarity of units (for the year 2020 of the best and weakest powiat) in the main criterion studied was expressed using Euclidean distance. The further apart the objects are, the more dissimilar they are, and the closer they are, the greater the similarity between them. We see a greater degree of diversity in the measure of entrepreneurship and infrastructure, with the smallest in the case of green infrastructure.

Analysis of scatter plots (Table 3.) shows what kind of relationship we are dealing with (positive or negative). This allows for indicating groups of objects with similar values of the tested criterion, and an indication of outliers (statistically distinguishable). Pearson's correlation coefficient between the value of the synthetic measure in a year-to-year relationship is presented in Figure 3 its value was in the relation between synthetic entrepreneurship and green infrastructure: 0.150, 0.220, 0.217 and 0. 2019 (respectively in 2010, 2018, 2019, 2020). In the case of relations, entrepreneurship and infrastructure measures respectively: 0.044, 0.102, 0.086, 0.096.

The bag chart (figure 4) shows groups of powiats that are statistically similar, including outlying units, whose graphical shape in the following years 2010, 2018, 2019 and 2020 indicates a slight variation.

Visualization of interdependence in three-dimensional space in the aspect of

synthetic measure in the years 2010-2018-2019 and 2018-2019-2020 is presented the Figure 5. In the case of entrepreneurship, we observe a process of divergence. The value of the measure was 0.988 and 0.995. Infrastructure measures 0.975 and 0.959, and green infrastructure measures 0.986 and 0.980.

The Gini indicator (Figure 6) shows inequalities in the synthetic measure of entrepreneurship, infrastructure and green infrastructure. It should be interpreted as meaning that the higher it is (1 is the maximum value of the inequality; black on the map; 0 means no inequality), the greater the inequality in the area under study. The higher the value of the indicator, the greater the degree of concentration of the synthetic measure and the greater its variability.

The role of infrastructure in the process of economic and business development is mainly to create the conditions for productive activity. The lack of transport infrastructure can be a reason for the marginalisation of regions. Finding ways to sort out the interconnected mechanisms between infrastructure systems can increase understanding of sustainability transitions. An important social function of infrastructure is to support urban services such as the provision of energy, water, heating, mobility and sanitation (Loorbach, Franzeskaki, 2010). Linear infrastructure, such as roads, highways and railways, can provide significant social and economic benefits while posing enormous risks to the local environment and biodiversity (Wu, Li, 2022).

Green infrastructure plays a key role in improving the well-being of residents, but equal access to it remains an issue. The use of urban green infrastructure often varies by urban space, with lower-income and minority communities having less access and use. Such inequality in access and corporation leads to greater spatial disparities as a result of access to financial and environmental resources (including natural resources) (Wu, Wei, Liu, García, 2023). Such inequality in access and use leads to greater spatial disparities as a result of access to financial and environmental resources (including natural resources) (Wu, Wei, Liu, García, 2023).

5. Conclusions

Green infrastructure, infrastructure and entrepreneurship serve to improve the quality of life, and social equality and reduce environmental risks and ecological shortages, or improve territorial cohesion. Entrepreneurship and infrastructure must be built based on the region's available potential.

Regions with a high level of infrastructural development, green infrastructure and entrepreneurship are areas considered by investors and residents as attractive places to do business and live.

There is spatial diversity of entrepreneurship, infrastructure and green infrastructure in powiats in Poland. The effects generated by infrastructure, and green infrastructure can have a positive impact on minimising the impact of external factors disrupting regional systems and on the level of local/regional entrepreneurship. They serve to improve the quality of life, social equality and reduce the threat to the environment and ecological scarcity, development of entrepreneurship.

Based on the synthetic measure, the spatial diversity of powiats in terms of green infrastructure, infrastructure and entrepreneurship was indicated. It allows the assessment of a multidimensional phenomenon, as well as the linear ordering of the studied units. The measures obtained depend on the number and type of variables adopted for the test. It makes it possible to compare the subjects analysed, identify weaker and better areas of action, and assess the effectiveness of the policy instruments used to date.

References

Audretsch, D.B., Heger, D. & Veith, T. (2015). Infrastructure and entrepreneurship. Small Bus. Econ. 44, 219–230. https://doi.org/10.1007/s11187-014-9600-6

Audretsch, D.B., Heger, D. & Veith, T. (2015). Infrastructure and entrepreneurship. Small Bus Econ 44, 219–230 https://doi.org/10.1007/s11187-014-9600-6.

Awad A., Mallek R. S., Ozturk I., Abdalla Y. A., (2023). Infrastructure Development's role in environmental degradation in sub-Saharan Africa: Impacts and transmission channels, Journal of Cleaner Production, Volume 414, 137622, https://doi.org/10.1016/j.jclepro.2023.137622.

Bailey, I., & Caprotti, F. (2014). The Green Economy: Functional Domains and Theoretical Directions of Enquiry. Environment and Planning A: Economy and Space, 46(8), 1797–1813. https://doi.org/10.1068/a130102p.

Batty, M., Barros, J., & Alves S. (2004). Cities: continuity, transformation, and emergence, CASA Working Paper Series, no. 72. Centre for Advanced Spatial Analysis, University College, London.

Behzadian, M., Khanmohammadi Otaghsara, S., Yazdani, M., & Ignatius, J. (2012). A state-of the-art survey of TOPSIS applications. Expert Syst. Appl., 39, 13051–13069.

Burzyńska, D., Jabłońska, M. (2016). Zależność między przedsiębiorczością a rozwojem gospodarczym. Przykład regionów przygranicznych Polski Wschodniej. Annales Universitatis Mariae Curie-Skłodowska, Sectio H Oeconomia, 4, 161-170. doi: 10.17951/h.2016.50.4.161.

Chen Y., Lin B., (2021). Understanding the green total factor energy efficiency gap between regional manufacturing—insight from infrastructure development, Energy, Volume 237, 121553, https://doi.org/10.1016/j.energy.2021.121553.

Cui Y., (2022). The coordinated relationship among industrialization, environmental carrying capacity and green infrastructure: A comparative research of Beijing-Tianjin-Hebei region, China, Environmental Development, Volume 44, 100775, https://doi.org/10.1016/j.envdev.2022.100775.

Di Vaio, A., Hassan, R., Chhabra, M., Arrigo, E., & Palladino, R. (2022). Sustainable entrepreneurship impact and entrepreneurial venture life cycle: A systematic literature review, Journal of Cleaner Production, Volume 378, 134469, ISSN 0959-6526, ttps://doi.org/10.1016/j.jclepro.2022.134469.

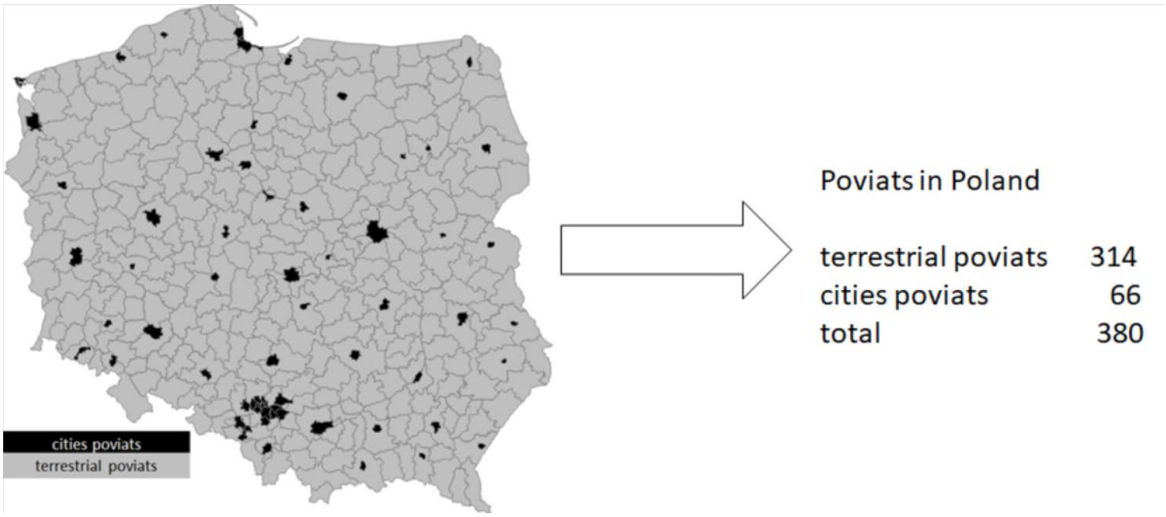
Drobniak, A., Janiszek, M., & Plac, K. (2016). Zielona gospodarka i zielona infrastruktura jako mechanizmy wzmacniania gospodarczo-środowiskowego wymiaru prężności miejskiej, Research Papers of Wrocław University of Economics, nr 443.
Duong C. D., (2023). Entrepreneurship: Nature, nurture, or both? Empirical evidence from a moderated polynomial regression with response surface analysis, The International Journal of Management Education, Volume 21, Issue 3, 100877, https://doi.org/10.1016/j.ijme.2023.100877.
Dziekański, P., & Prus, P. (2020). Financial Diversity and the Development Process: Case study of Rural Communes of Eastern Poland in 2009–2018. Sustainability, 12, 6446.
Elimam, H. (2017). How Green Economy Contributes in Decreasing the Environment Pollution and Misuse of the Limited Resources. Environment and Pollution, 6, 10.
Glinka, B., Gudkova, S. (2011). Przedsiębiorczość, Warszawa: Wolters Kluwer.
Grabiński T., (1985), Metody określania charakteru zmiennych w wielowymiarowej analizie porównawczej, Zeszyty Naukowe Akademii Ekonomicznej w Krakowie, 213, 35–63.
Grudzewski, W.M., Hejduk, I.K., Sankowska, A., & Wańtuchowicz, M. (2010). Sustainability w biznesie, czyli przedsiębiorstwo przyszłości. Zmiany paradygmatów i koncepcji zarządzania, Warszawa: POLTEXT.
Janiszek, M. (2015). Zielona infrastruktura jako koncepcja rozwoju współczesnego miasta . Studia Miejskie, 99-108.
Junqueira J. R., Serrao-Neumann S., White I., (2022). Using green infrastructure as a social equity approach to reduce flood risks and address climate change impacts: A comparison of performance between cities and towns, Cities, Volume 131, 104051, https://doi.org/10.1016/j.cities.2022.10405
Khezri M., Muhamad G. M., (2023). Environmental effects of entrepreneurship indices on ecological footprint of croplands and grazing lands in the economy, Journal of Cleaner Production, Volume 414, 137550, https://doi.org/10.1016/j.jclepro.2023.137550.
Khoshnava, S.M., Rostami, R., Zin, R.M., Štreimikienė, D., Yousefpour, A., Strielkowski, W., Mardani, A. (2019). Aligning the Criteria of Green Economy (GE) and Sustainable Development Goals (SDGs) to Implement Sustainable Development. Sustainability, 11, 4615.;
Korenik, S., & Zakrzewska-Półtorak, A. (2011). Teorie rozwoju regionalnego – ujęcie dynamiczne. Wrocław: Wydawnictwo Uniwersytetu Ekonomicznego we Wrocławiu.
Krukowska, D., (1981). Makrospołeczne determinanty dystrybucji dochodów [In:] W. Wesołowski, K. Słomczyński (ed.), Zróżnicowanie społeczne w perspektywie porównawczej, Wrocław: Zakł. Narod. im. Osolińskich
Kukuła, K. & Bogocz, D. (2014). Zero Unitarization Method and Its Application in Ranking. Research in Agriculture Economic and Regional Studies, 7, nr 3, 5-13.
Loorbach D., Franzeskaki N., Thissen W., (2010). Introduction to the special

section: Infrastructures and transitions, Technological Forecasting and Social Change, 77 (8), pp. 1195-1202, DOI: 10.1016/j.techfore.2010.06.001.
Liberalesso, T., Oliveira Cruz, C., Matos Silva, C, & Manso, M. (2020). Green infrastructure and public policies: An international review of green roofs and green walls incentives, Land Use Policy, Volume 96.
Malina, A. (2004). Wielowymiarowa analiza przestrzennego zróżnicowania struktury gospodarki Polski według województw, Kraków: Wyd. Akademii Ekonomicznej w Krakowie.
Mondal S., Singh S., Gupta H., (2023). Green entrepreneurship and digitalization enabling the circular economy through sustainable waste management - An exploratory study of emerging economy, Journal of Cleaner Production, Volume 422, 138433, https://doi.org/10.1016/j.jclepro.2023.138433.
Murray, A., Skene, K., & Haynes, K. (2017). The circular economy: an interdisciplinary exploration of the concept and application in a global context. J. Bus. Ethics 140, 369–380. doi: 10.1007/s10551-015-2693-2
Prus, P., Dziekański, P., Bogusz, M., & Szczepanek, M. (2021). Spatial Differentiation of Agricultural Potential and the Level of Development of Voivodeships in Poland in 2008–2018. Agriculture , 11, 229;
Puzdrakiewicz, K. (2017). Zielona infrastruktura jako wielozadaniowe narzędzie zrównoważonego rozwoju, Studia Miejskie tom 27.
Skawińska, E. (2009). Kapitał społeczny w rozwoju regionu [In:] W. Janasz, Innowacje w strategii rozwoju organizacji w Unii Europejskiej, Warszawa: Difin.
Silajdžić I., Kurtagić S. M., Vučijak B., (2015). Green entrepreneurship in transition economies: a case study of Bosnia and Herzegovina, Journal of Cleaner Production, Volume 88, 376-384, https://doi.org/10.1016/j.jclepro.2014.07.004.
Spychała, M. (2018). Poziom rozwoju społeczno-gospodarczego powiatów w Polsce. Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu, 527, 242-254. doi: 10.15611/pn.2018.527.21.
Sutkowska, E. (2006). Współczesny kształt i znaczenie zieleni miejskiej jako zielonej przestrzeni publicznej w strukturze miasta – przestrzeń dla kreacji, Teka Komisji Architektury, Urbanistyki i Studiów Krajobrazowych Oddziału PAN w Lublinie, 184–192.
Szulczewska, B. (2018), Zielona infrastruktura — czy koniec historii?, Warszawa: Studia KPZK, Tom CLXXXIX.
Szulczewska, B. (2018). Zielona infrastruktura czy koniec historii? Studia Komitetu Przestrzennego Zagospodarowania Kraju, 189.
Thacker, S., Adshead, D., Fay, M., Hallegatte, S., Harvey, M., Meller, H., O'Regan, N., Rozenberg, J., Watkins, G., & Hall, J.W. (2019). Infrastructure for sustainable development. Nat. Sustain. 2, 324–331
Valliere, D., & Peterson, R. (2009). Entrepreneurship and Economic Growth: Evidence from Emerging and Developed Countries, Entrepreneurship & Regional Development, t. 25, no. 5 [for:] Miłek, D., & Kantarek, I. (2017). Przedsiębiorczość w rozwoju polskich regionów, Nierówności Społeczne a Wzrost Gospodarczy, nr 50 (2).

Walesiak, M. (2005). Problemy selekcji i ważenia zmiennych w zagadnieniu klasyfikacji, Prace Naukowe AE we Wroclawiu, Taksonomia 12, 106-118.
Wu S., Li B. V., (2022). Sustainable linear infrastructure route planning model to balance conservation and socioeconomic development, Biological Conservation, Volume 266, 109449, https://doi.org/10.1016/j.biocon.2022.109449.
Wu Y., Wei Y. D., Liu M., García I., (2023). Green infrastructure inequality in the context of COVID-19: Taking parks and trails as examples, Urban Forestry & Urban Greening, Volume 86, 128027, https://doi.org/10.1016/j.ufug.2023.128027.

Appendix

Figure 1.
Research area — poviats in Poland



Source: own study

Table 1.
A set of variables describing the areas studied: entrepreneurship, infrastructure, green infrastructure procedure and timeline

		Variables	Unit	S/D
Entrepreneurship variables	X1	Investment expenditures in enterprises per capita	PLN	S
	X2	Gross value of fixed assets in enterprises per capita	PLN	S
	X3	Business entities registered per 1000 population	Pcs.	S
	X4	Individuals engaged in business per 1000 population	Person	S
	X5	Industrial output sold (entities with number of employees>9) per capita	PLN	S
	X6	Registered unemployed per 1000 population	Person	S
	X7	Employed per 1000 population	Person	S
	X8	Average gross monthly salaries	PLN	S
Infrastructure variables	X9	Housing units per 1000 inhabitants	Pcs.	S
	X10	Distribution network per 100 km2 - water supply network	km	S
	X11	Distribution network per 100 km2 - sewerage network	km	S
	X12	Distribution network per 100 km2 - gas network	km	S
	X13	Public libraries per 10000 population.	Objects	S
	X14	Outpatient entities (as of December 31) per 10000 inhabitants	Objects	S
	X15	Population per community pharmacy	Person	S
	X16	Municipal and district roads with hard surface per 100 km2	km	S

	X17	Municipal and district roads with a dirt surface per 10000 inhabitants	km	S
	X18	Accommodations per 1000 population	Places	S
Ecology and environment variables	X19	Area of forest land per 100 ha	ha	S
	X20	Total gaseous emissions per km2	t	D
	X21	Waste generated per year per 100 km2	thou. t.	D
	X22	Waste generated during the year recovered per 100 km2	thou. t.	D
	X23	Total legally protected areas per 100 hectares	ha	S
	X24	Total water consumption for the national economy and population per year per 1000 inhabitants	dam3	D
	X25	Share of industry in total water consumption	%	D
	X26	Total treated wastewater discharged per year per 100 km2	dam3	S
	X27	Population using wastewater treatment plants in % of total population	%	S
	X28	Share of recycled waste in the amount of waste generated during the year	%	S
	X29	Total mixed waste collected per year per capita	t	D
	X30	Municipal wastewater treated per 100 km2	dam3	S
	X31	Share of parks, greens and neighbourhood green areas in total area	%	S

Green infrastructure is the sum of ecology and environment and infrastructure, S stimulant, D destimulant
Source: own study.

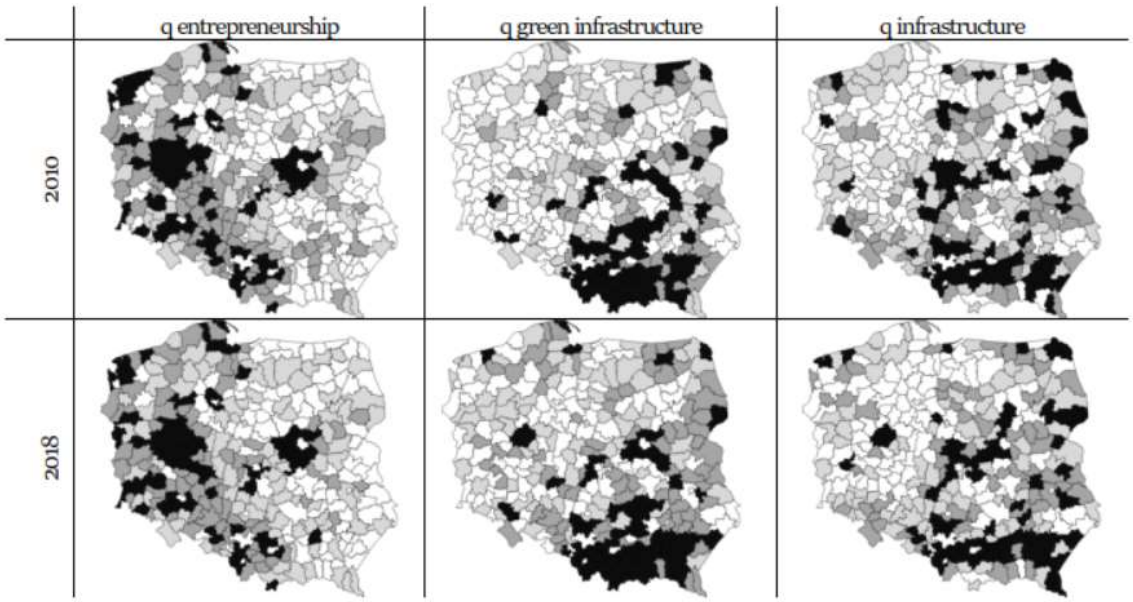
Table 2.
Results of descriptive statistics of synthetic measure: entrepreneurship, infrastructure, green infrastructure

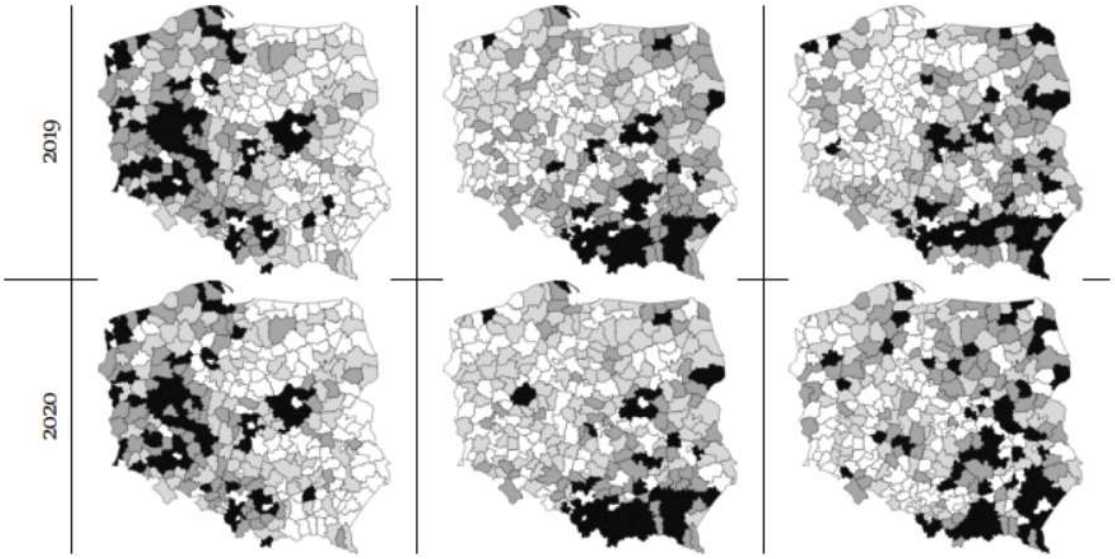
	2010	2018	2019	2020
		q entrepreneurship		
Average	0.26	0.33	0.35	0.35
Minimum	0.11	0.2	0.21	0.23
Maximum	0.46	0.59	0.66	0.72
Gap	0.35	0.39	0.45	0.49
Quartile. (Gap)	0.08	0.08	0.08	0.08
Standard deviation	0.06	0.06	0.06	0.06
Coefficient of variation	23.2	18.46	18.18	18.12
Skewness	0.54	0.85	1.05	1.22
		q green infrastructure		
Average	0.36	0.38	0.38	0.38
Minimum	0.28	0.31	0.31	0.32

Maximum	0.52	0.6	0.6	0.6
Gap	0.24	0.29	0.29	0.28
Quartile. (Gap)	0.02	0.03	0.04	0.04
Standard deviation	0.03	0.03	0.03	0.03
Coefficient of variation	7.24	8.57	8.73	8.67
Skewness	1.22	1.82	1.85	1.86
		q infrastructure		
Average	0.23	0.27	0.27	0.26
Minimum	0.14	0.15	0.16	0.16
Maximum	0.45	0.53	0.54	0.53
Gap	0.31	0.38	0.38	0.37
Quartile. (Gap)	0.05	0.06	0.07	0.06
Standard deviation	0.05	0.05	0.06	0.06
Coefficient of variation	21.94	20.58	20.71	21.62
Skewness	1.16	1.23	1.21	1.2

Source: own study

Figure 2.
Spatial variation of synthetic measure entrepreneurship, green infrastructure, infrastructure





Source: own study

Table 3.
Similarity matrix of synthetic measure entrepreneurship, green infrastructure, infrastructure by 2020 and the weakest and best unit

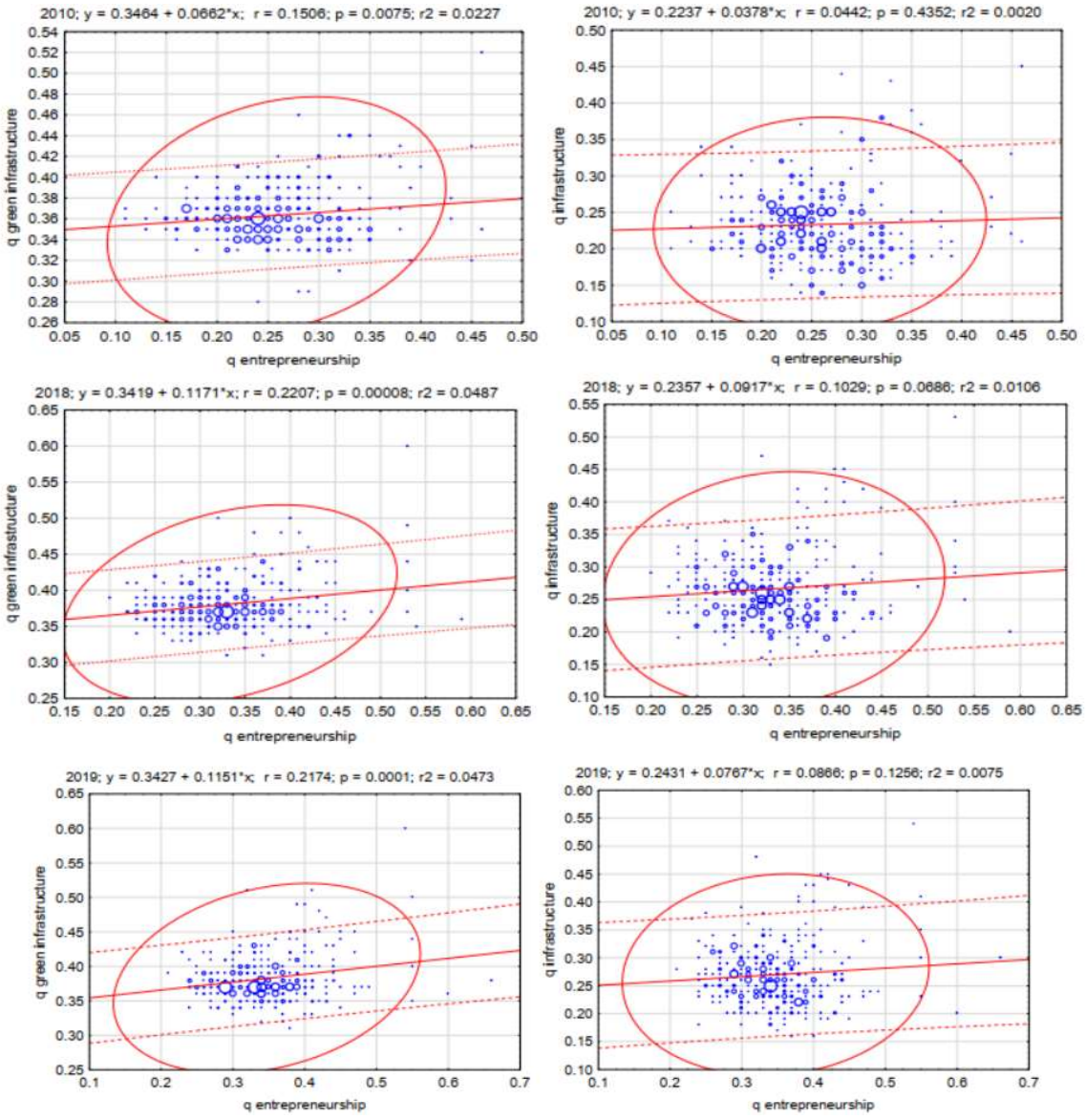
	2010-2018			2018-2019			2019-2020		
by q entrepreneurship	wrocławski	brzozowski	przysuski	wrocławski	brzozowski	przysuski	wrocławski	brzozowski	przysuski
wrocławski	0	0.44	0.47	0	0.53	0.56	0	0.65	0.67
brzozowski	0.44	0	0.04	0.53	0	0.03	0.65	0	0.02
przysuski	0.47	0.04	0	0.56	0.03	0	0.67	0.02	0

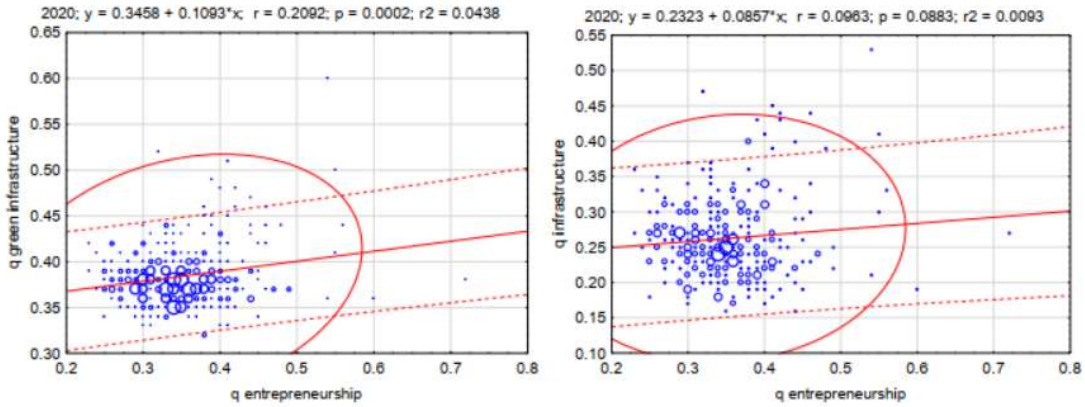
	2010-2018			2018-2019			2019-2020		
by q green infrastructure	pruszkowski	gryfiński	kozienicki	pruszkowski	gryfiński	kozienicki	pruszkowski	gryfiński	kozienicki
pruszkowski	0	0.36	0.38	0	0.40	0.41	0	0.40	0.40
gryfiński	0.36	0	0.01	0.40	0	0.01	0.40	0	0.01
kozienicki	0.38	0.01	0	0.41	0.01	0	0.40	0.01	0

by q infra-structure	2010-2018			2018-2019			2019-2020		
	pruszkowski	leszczyński	złotowski	pruszkowski	leszczyński	złotowski	pruszkowski	leszczyński	złotowski
pruszkowski	0	0.42	0.46	0	0.48	0.50	0	0.50	0.50
leszczyński	0.42	0	0.04	0.48	0	0.03	0.50	0	0.00
złotowski	0.46	0.04	0	0.50	0.03	0	0.50	0.00	0

Source: own study.

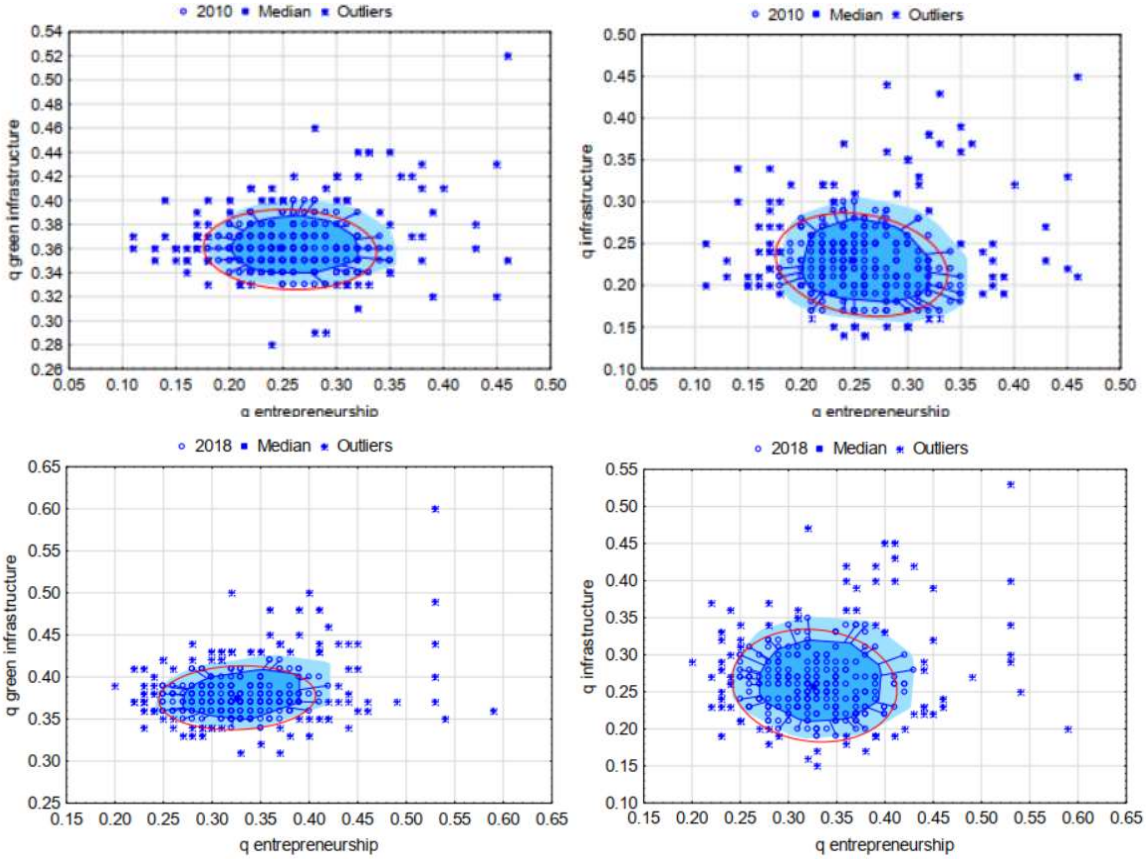
Figure 3.
Variation of synthetic measure entrepreneurship, green infrastructure, and infrastructure in counties in Poland (year-toyear relationship).

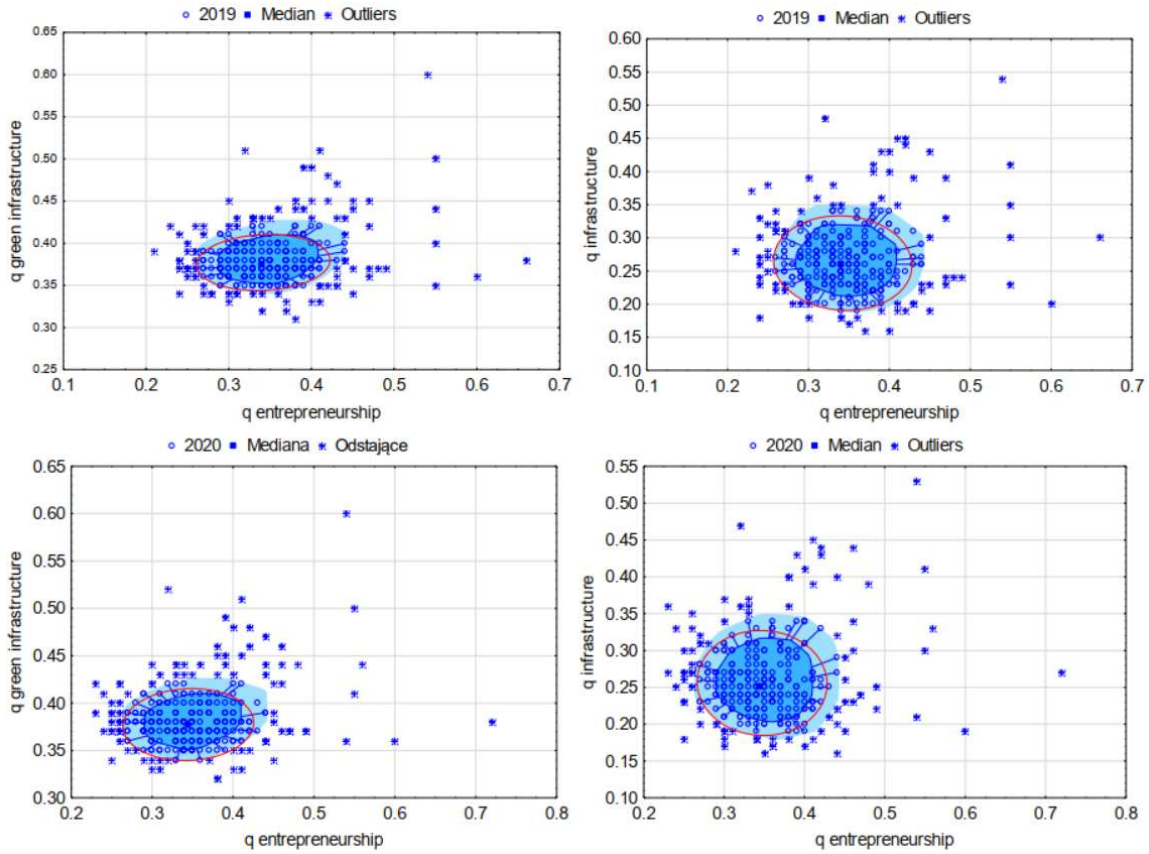




Source: own study

Figure 4.
Diversity of synthetic measure of entrepreneurship, green infrastructure, andinfrastructure in counties in Poland (yearto-year relationship).

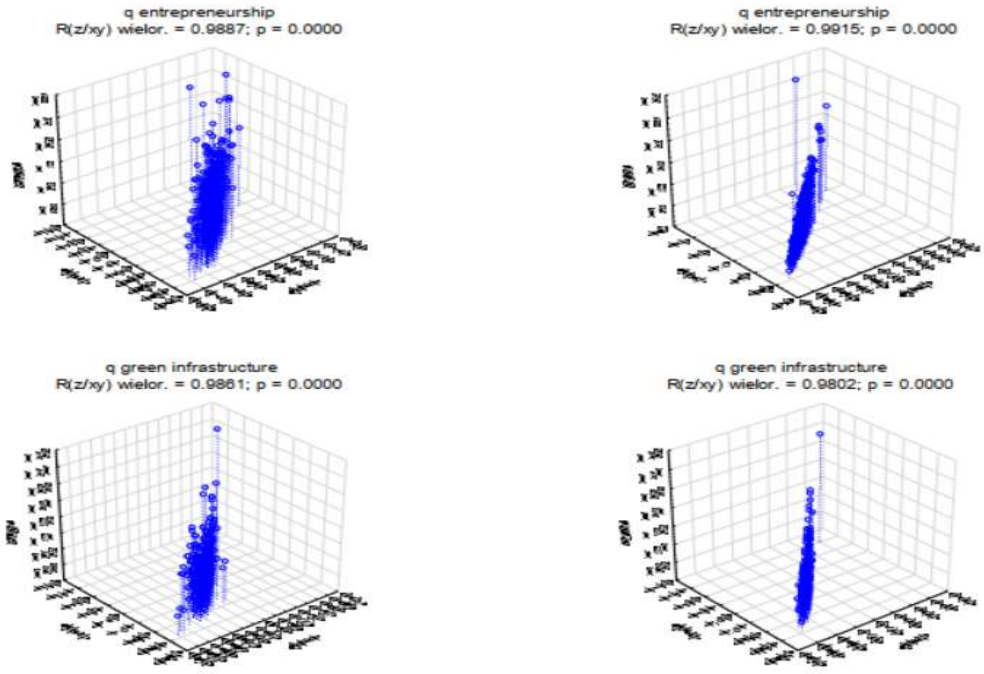


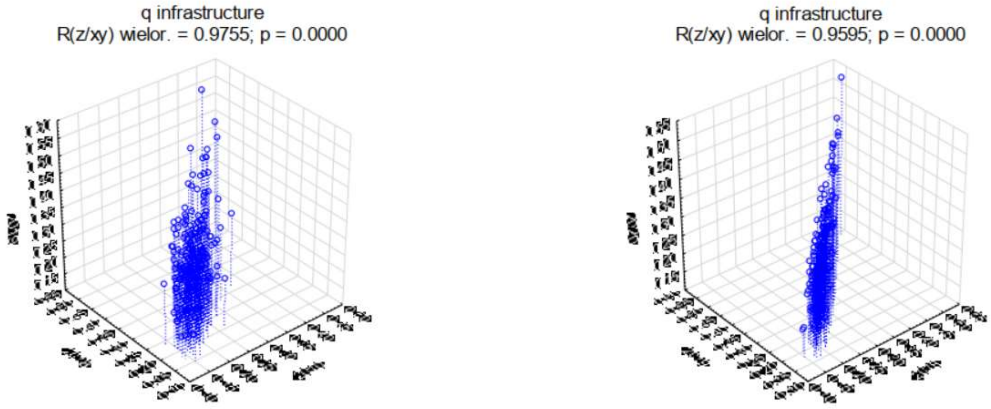


Source: own study

Figure 5.

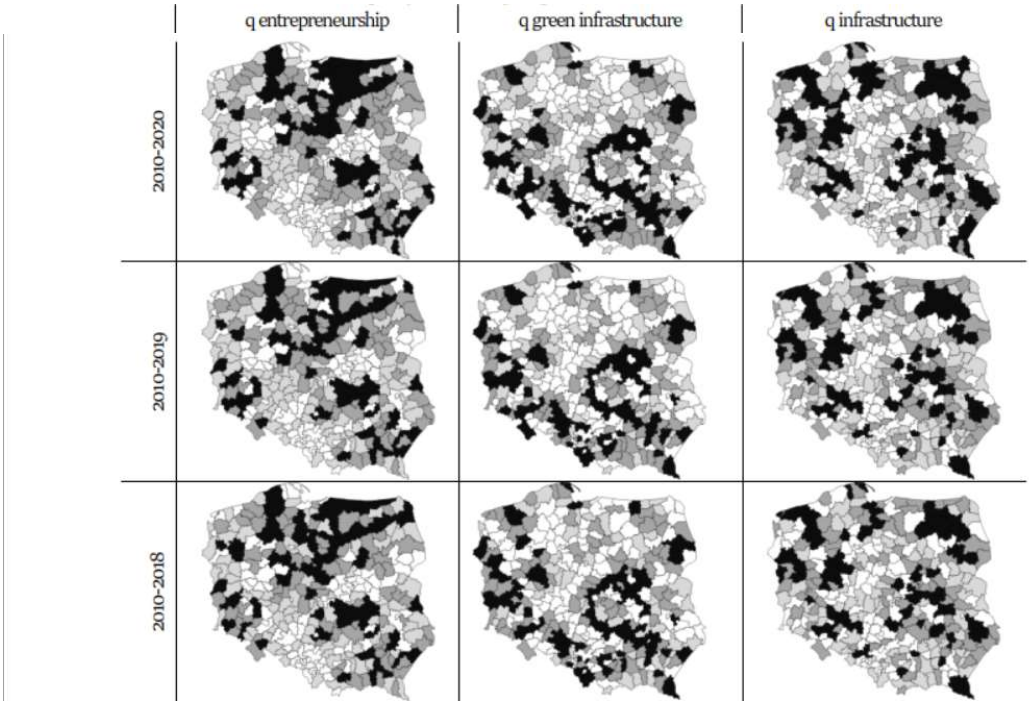
The synthetic measure in the relationship of the years 2010-2018-2019 and 2018-2019-2020





Source: own study

Figure 5.
Spatial variation of the Gini coefficient in poviats in Poland in 2010-2020



Source: own study