
Gravitation Effects and the Economic Development of Poviats in the Mazowieckie Voivodeship 2010–2019

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Abstract:

Purpose: The article aims to show differences in the level of economic development of poviats in the Mazowieckie Voivodeship and the role of gravitation effects and other factors in this development.

Design/Methodology/Approach: The analysis spans the years 2010-2019. The level of economic development was quantified using a synthetic measure of development calculated by the taxonomic method. The role of gravitation effects and other determinants of poviats' economic development were determined using econometric methods and cross-section and time-series analysis.

Findings: The conducted econometric analysis showed that economic development of poviats is strongly stimulated by gravitation effects and processes increasing the gross value of fixed assets, investment, a growing number of natural persons undertaking the business activity, and a declining rate of unemployment.

Practical Implications: The above analysis influencing the economic development of poviats in the Polish Mazowieckie voivodeship was carried out in the economic growth and development theory framework. Its findings show that the development of research in this area drove the evolution of views about which factors play a pivotal role in economic development, from traditional ones such as the availability of labor and the degree of its utilisation to the stock of real capital.

Originality/Value: The primary purpose of this study is to show differences in the level of economic development of poviats. The economic development of the units under consideration is quantified using a synthetic measure of development (SMD) calculated by the taxonomic method which is an original method for such an analysis.

Keywords: Economic development, local development, gravitation effects, poviat.

JEL classification: Q01, C43, C44,

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1. Introduction

Economic development processes are essential for the economy and social life as they determine the living quality of national and regional populations. Assessing the level of economic development is vital for formulating policies fostering economic development.

The primary purpose of this study is to show differences in the level of economic development of poviats³. They comprised the Mazowieckie voivodeship between 2010 and 2019 and assessed the role of gravitation effects and other factors in this process. The economic development of the units under consideration is quantified using a synthetic measure of development (SMD) calculated by the taxonomic method. At the same time, gravitation effects are estimated based on the economic potentials of the poviats and the distances between their capital towns. The factors potentially determining the economic development of the poviats were selected taking account of the findings of economic theory and the availability of statistical data. Their significance was established based on cross-section and time-series data and appropriate econometric data methods.

The article is structured as follows. Part 2 provides an insight into the nature of economic development and its determinants from the economic theory perspective. Part 3 contains a review of Polish empirical studies on the poviat economies. Part 4 explains the research methodology used, and Part 5 presents different levels and pace of poviats' economic development between 2010 and 2019 and the impact of gravitation effects. In Part 6, econometric regression analysis is conducted to capture the importance of certain factors in economic development, including gravitation effects. The key conclusions from the research are presented in Part 5.

2. Literature Review

2.1 Economic Development and its Determinants

Economic studies, including those dealing with the lower tiers of subnational government, point to several significant characteristics of economic development. First and foremost, they describe it in terms of evolution "from simpler, less perfect forms or states to more complex and better ones" (Domański, 2004, p. 8) driven by "positive changes brought by quantitative growth and qualitative progress in economic, social and natural environments" (Markowski, 2008, p. 13).

³According to the system of administrative and statistical division of the EU countries, which is called NUTS, the Polish territory is divided into seven macroregions (NUTS 1), 16 voivodeships (NUTS 2), 73 subregions (NUTS 3), 380 poviats (NUTS 4) and 2479 gminas (NUTS 5). The analyses in the paper refer to poviats in the Mazowieckie voivodeship.

Economic development is a vital component of the broader notion of development. It is commonly understood as improving quantitative, qualitative, and structural changes in the principal macroeconomic parameters, mainly those characterising production and production factors.

Studying the determinants of economic development is essential for both economic theory and practice. It allows not only to recognise better reasons for economic development and describe research progress in this area but also can indicate the ways to encourage and accelerate this process. Unsurprisingly, the analyses of economic development have a prominent place among the studies of national subnational economies. Polish researchers Gałązka (2017), Markowski (2008), and Bagdziński (1994) have also contributed to the theory of regional and local economic development and its factors.

The literature contains several significant classifications of factors that have a role in economic development. One of them (Warczak, 2015, p. 118) divides them into endogenous (determined by local resources, economic potential, the volume of investments, infrastructure, and policies) and exogenous, which are not controlled by local authorities. The classification by Bagdziński gives prominence to economic, social, technical and technological, environmental, and political factors (Bagdziński, 1994, p. 18). The literature on economic growth and development emphasises the existence of traditional and modern economic development factors to highlight their different roles at particular stages of this process (Woźniak, 2019, p. 333).

The reason for setting apart the traditional drivers of economic development and growth has to do with classical economics, according to which labour, capital, and land are prerequisites to the accumulation of wealth, and neoclassical economics, which has added scientific and technical knowledge reflecting technological progress to their list (Solow, 1956; Tokarski, 2005, pp. 20-27).

According to neoclassical economics, a rising volume of the abovementioned resources augments potential production and thereby the chances for economic development. It is indicated that the accumulation of capital enabling the expansion of real capital stock increases the capital-to-labour ratio and labour productivity and thereby increases potential production. A similar effect is observed for technological progress, which increases the productivity of labor and capital.

The modern determinants of economic development and growth include qualitative and spatial factors that enable more efficient use of local resources and improve the competitiveness of local economies. One of the most important among the former is human capital embodied in workers, their education, competencies, and health, whose key role was highlighted by Schultz and Becker in the 1960s (Schultz, 1961; Becker, 1962). It is argued that better workers' education and skills ensure more excellent management processes' effectiveness and stimulate economic development.

Other qualitative economic development factors are technological innovations, whose importance was recognised by Schumpeter several decades ago. Schumpeter argued that industries absorbing technological innovations contributed to the faster growth of the entire economy (Schumpeter, 1961).

External demand for locally made products is essential among the spatial factors driving the economic development of subnational government units. The theoretical underpinning of its function is provided by North's economic base theory, which points to the unit's exporting industries as the base for its economic development (North, 1955).

The category of spatial factors also includes gravitation effects because the economic development of subnational government units also depends on the links between them (trade volumes, capital and population flows, etc.) (Malaga, 2009). It is assumed that gravitation effects are stronger between adjacent units with more robust economies than between the economically weaker and more distant ones (Mroczek, Tokarski, and Trojak, 2014; 2015; Filipowicz, 2018).

The concept of gravitation effects as a factor in economic development has been based on the models of foreign trade created by Tinbergen in the 1960s, which assumed trade flows between countries to be directly proportional to their fundamental economic indicators and inversely proportional to the distance between them (Tinbergen, 1962). Underlying the importance of gravitation effects, one must also note that nowadays and because of globalisation, the role of distance is minor and less important.

The interesting debate on the role of spatial factors in local economic development stresses the linkages between urban and rural areas. Bosworth and Finke underlined the tendency to commercial counterurbanisation in modern developed countries, which is very important for economic development in urban and rural areas (Bosworth and Finke, 2020).

In the literature, various models have been developed in which the channels of interactions between urban and rural areas were explained in detail as well as their effects on the economic development of both areas (Bosworth and Venhorst, 2018; Overman, Rice, and Venables, 2010). Although the mentioned processes are not at the centre of the analysis of our paper, they are of great importance for the economic development of local economies and our research results.

This necessarily short review shows that various factors determine subnational government units' economic development. The following empirical analysis focuses on the traditional factors because of the limited availability of statistical data on Polish poviats, which in this study's object.

2.2 A Review of Empirical Research

Studies on the economic development of poviats in the Mazowieckie voivodeship are relatively few compared with the number of investigations into the economic differences between voivodeships and subregions.⁴ The central theme of the works on Polish poviats has been comparisons between their labor markets, even if they frequently also addressed factors in economic development. Some of them appear to be especially important in the context of this study.

Concerning publications on economic development, worth mentioning here is the study by Czyż, who used the model of potentials (economic potentials of territorial areas are also used in the analysis of gravitation effects) to analyse different levels of economic development among Polish subregions (Czyż, 2002), a study of divergence in the development of Polish subregions authored by Wójcik and Herbst (Wójcik, 2006; Herbst and Wójcik, 2012), and, last but not least, an analysis by Harańczyk of the economic development of Poland's subregions utilising a variety of economic, demographic, infrastructure and social indicators as well as synthetic measures of development (Harańczyk, 2007).

The collective work edited by Kryńska (ed., 2011) provides a spatial analysis of the labour market and economic development in the Mazowieckie voivodeship. One of its chapters analysed variation of the poviats' labour markets between 2004 and 2008, mainly in terms of unemployment rates and wage levels, and then sought associations between the sectoral structure of employment and the level of economic development in the voivodeship's subregions measured by per capita GDP. A negative relationship was found between the level of wages and unemployment rates in the poviats and between the unemployment rate and GDP per capita (Kwiatkowski and Rogut, 2011).

Tokarski (2008) compared all poviat labor markets in Poland between 1999 and 2006 using the rate of registered unemployment. His research showed considerable differences in the level and pace of changes in the poviats' unemployment rates, which the author attributed to poviats having different shares of employment in agriculture, industry, construction, and market and non-market services. The conclusion was supported by estimating the regression function parameters by the Least Squares Method.

Dykas and Misiak (2014) endogenised several vital economic variables (labor productivity, real wages, the rates of registered unemployment rates, and their increases). They used the 2002-2011 statistical data to determine whether unemployment rate increases in poviats were associated with the rate of poviat GDP

⁴*Research on voivodeships and subregions is more frequently undertaken in the literature because statistical data on them are much richer.*

growth and the previous level of unemployment. They found that an increase in unemployment rates was a declining function of both GDP growth rates and previous unemployment rates. An interesting contribution of this work is that the authors developed their method to estimate poviats' GDPs, dividing the voivodeship GDP among the poviats according to their contribution to sold production of industry, the value of fixed assets, and investments.

An interesting study comparing poviat labor markets in Poland has been conducted by Sojka (2013). The author constructed synthetic taxonomic measures using statistical data on the poviats of the Śląskie voivodeship from 2006 and 2010 and 8 diagnostic variables representing various structures of unemployment, employment, and wages similar to those proposed by Hellwig to show the condition of the poviat labour markets. Based on the measures, the markets were ranked into four categories: excellent, good, moderate, and poor. The categories were created using the boundaries of the intervals of the synthetic measures calculated from their arithmetic means and standard deviations. Comparing poviats ranked using synthetic measures and unemployment rates found few similarities.

Kwiatkowska and Kwiatkowski analysed the labour markets in Polish poviats in the context of economic development. They used data from the Local Data Bank and Statistics Poland publications from 2011-2019 to show differences in the levels of unemployment and indicators of mobility between employment and unemployment. Based on this research, nine groups of poviat labor markets were created. The econometric analysis involving a logit model with binomial variables carried out by authors found a strong relationship between a group's allocation to a better or worse group and its economic development factors (the value of capital goods, sold production of industry, the level of entrepreneurial activity, the distance between a poviat and a town with a population of more than 100,000) (Kwiatkowski and Kwiatkowska, 2020).

The first deeper study of spatial economic development in Poland vis-à-vis gravitation effects has been undertaken by Mroczek, Tokarski, and Trojak (2014), who extended Solow's model of economic growth to account for their impact. The empirical analysis they carried out using data from the years 1999-2011 showed that the role of gravitation effects as factors in the economic development of Polish voivodeships was directly proportional to their average capital-labor ratios and inversely proportional to the distance between their capital cities. Moreover, the authors estimated labour productivity elasticities concerning gravitation effects to assess their influence.

Filipowicz and Tokarski (2015) studied gravitation effects and the economic development of Polish poviats. Its course was represented using 2002-2012 statistical data and a taxonomic measure of development (TMD), which was constructed using several partial variables. The influence of gravitation effects was estimated by considering poviats' gross fixed assets per capita and the distances

between poviats. Gravitation effects were also examined in respect of their impact on the TDM and its constituent variables.

Filipowicz (2018) studied the contribution of gravitation effects to differences in economic development between voivodeships and groups of poviats. Using the 2002-2014 data, the Least Squares Method, the Generalised Method of Moments, and a logistic model, the estimated domestic and foreign gravitation effects for voivodeships and groups of poviats, as well as their influence on appropriate TDMs and the variables used to construct them.

The novelty of our research in the paper as compared to the empirical studies mentioned refers to the following elements:

- we estimate the levels of economic development of poviats in the Mazowieckie voivodship using synthetic measures of development consisting of three diagnostic variables,
- we estimate gravitation effects for poviats in the Mazowieckie voivodship,
- We construct a simple econometric model to assess the significance of a few essential factors determining the economic development of poviats, including gravitation effects.

3. Data and Methods

The research process presented below is carried out using a three-step approach. First, differences in the economic development of poviats comprising the Mazowieckie voivodeship are evaluated using the SMD. Then, the indicators of gravitation effects were calculated for poviats. Lastly, econometric methods were applied to identify factors influencing their economic development.

GDP per capita, the fundamental measure of economic development, is not available for the level of Polish poviats. Moreover, we are aware of the criticism directed at per capita GDP. It is worth noting that the research by Villaverde and Maza (2012) supported the conclusion that regional variations in development, whatever indicator is employed, are closely related to variations in per capita GDP. Therefore, the economic development of poviats was assessed in our paper using Hellwig's taxonomic method (Hellwig, 1968), which allows SMDs to be arranged. An SMD consists of diagnostic variables, which in this specific research are represented by three factors stimulating economic development (hence stimulants), namely:

- per capita electricity consumption (kWh) - it is assumed that the higher electricity consumption, the higher living standards of the local population, and the level of economic development,

- per capita industrial production sold by entities employing >9 workers – it is assumed industrial production is still essential for the local economy in countries at medium levels of development,
- average monthly gross wages in entities employing >9 workers – it is assumed that higher real wages imply higher living standards.

The data about the last two variables refer to entities employing more than nine workers because only such data are available.

The variables were normalised using a zero unitarisation method, allowing comparable variables with the same range of variation to be obtained (Kukuła, 2000). Normalisation is performed using the following formula:

$$z_{ijt} = \frac{x_{ijt} - \min x_j}{\max x_j - \min x_j};$$

where:

z_{ijt} – normalised variable j -th for the i -th poviats,

x_{ij} – partial variable j -th for the i -th poviats,

$\min x_j$ – the minimum value of partial variable j -th in the set of poviats in the sample years,

$\max x_j$ – the maximum value of partial variable j -th in the set of poviats in the sample years.

Following normalisation, values in the [0,1] interval were obtained. A higher value of the SMD denotes a better position of a poviats in terms of economic development and vice versa.

The SMDs were calculated for each year using the following formula:

$$SMD_i = \frac{1}{3} \sum_{j=1}^3 z_{ij} \quad (j = 1, 2, 3);$$

where:

SMD_i - an SMD for i -th poviats in a given year,

z_{ij} – normalised variable j -th for an i -th poviats in a given year.

All variables z_{ij} were assigned the same weight of 1/3.

Because some data were not available, 8 poviats (Ciechanowski, Kozienski, Łosicki, Mławski, Pułtowski, Sokołowski, and Zwolenki as well as the city of Płock) were omitted from analysis. The mentioned poviats can be characterised as areas with strongly developed infrastructure, especially in the energy, oil, and gas sectors. As a result, our analysis refers to 34 poviats.

Step 2 estimated gravitation effects for each poviat in the Mazowieckie voivodeship, assuming that such effects only occurred between the poviats. The calculation of gravitation effects is based on formulas developed by Mroczek, Tokarski and Trojak (2014). First, the impact of individual gravitation effects occurring between poviats i -th and j -th was assessed:

$$g_{ijt}^k = \frac{WBS_{it} \cdot WBS_{jt}}{d_{ij}^2}$$

where:

WBS_{it} – the gross per capita value of enterprises' fixed assets in PLN (constant prices, 2010=100) in poviat i -th in year t ,

WBS_{jt} – the gross per capita value of enterprises' fixed assets in PLN (constant prices, 2010=100) in poviat j -th in year t ,

d_{ij} – the distance between the capital towns of poviats i -th and j -th expressed in geographical minutes (mingeo) converted into decimal values.

To calculate it, the towns' geographic coordinates and a formula for the distance between two points on a coordinate plane based on the Pythagorean theorem were used:

$$d_{ij} = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2},$$

where:

x and y – geographical latitude and longitude of the capital towns.

Subsequently, the overall impact of gravitation effects on poviat i -th (G_{it}^k) was determined:

$$G_{it}^k = \sqrt[34]{\prod_{j=1 \wedge j \neq i}^{33} g_{ijt}^k}$$

As a result, the relative importance of gravitation effects for the economic development of the Mazowieckie poviats was estimated. All the data about poviats in the Mazowieckie voivodeship used in this paper come from the Statistics Poland, Local Data Bank.

At the last step, an econometric model was constructed to assess the significance of factors determining the economic development of poviats. The model's explanatory variables were selected considering economic theory's findings and the available statistics on poviats. As a result, the following were selected to represent the fundamental factors contributing to differences in the economic development of poviats:

- the volume of enterprises' investment outlays,
- the number of natural persons running businesses (sole entrepreneurs),
- the rate of registered unemployment,
- gravitation effects.

All these variables were expressed in relative terms to enable comparisons between poviats. The nominal variables were adjusted for 2010 prices to observe changes in time. The econometric analysis used cross-sectional time series (panel) data (specifically, 2010-2019 annual data on 34 poviats) and a power function converted to a logarithmic form, i.e.:

$$\ln \text{SMDit} = \alpha_0 + \alpha_1 \ln \text{INWit} + \alpha_2 \ln \text{OS FIZit} + \alpha_3 \ln \text{SBit} + \alpha_4 \ln \text{GREit} + \varepsilon_{it}$$

where:

SMDit – a per capita SMD for the i-th poviat in year t,

INWit – per capita investment outlays in the i-th poviat in year t (PLN, 2010 prices),

OS FIZit – the number of sole entrepreneurs per 1000 of the working age population in the i-th poviat i in year t,

SBit – the rate of registered unemployment in the i-th poviat as of the end of year t (%),

GRE – gravitation effects in the i-th poviat in year t,

ε_{it} – a random term,

α_0 – a constant term,

$\alpha_1 - \alpha_4$ – the parameters on the explanatory variables.

The LSM estimated the model parameters ($\alpha_0, \alpha_1, \dots, \alpha_4$), and the resulting estimates, denoting an increase or decrease in the poviat's SMD following a 1% increase in the explanatory variable, *ceteris paribus*, were interpreted using an elasticity approach. The econometric analysis was performed using annual data for 34 poviats from 2010 to 2019 and a logged power function. The parameters of the function were estimated by the Least-Squares Method (LSM).

4. Results

4.1 Differences in Poviats' Economic Development and Gravitation Effects

In central-eastern Poland, Mazowieckie has the largest area of all Polish voivodeships. Warsaw, the capital city of Mazowieckie and the country, is the most potent economic center in the country, with a large concentration of capital and well-developed metropolitan functions. The Mazowieckie voivodeship comprises 42 poviats, only 34 of which are analysed in this paper for the lack of necessary statistics on 8 of them.

Based on the SMD, the poviats were divided into quartile groups A, B, C, and D. Group A included poviats with the highest level of economic development (with an

SMD greater than the third quartile) and Group D the economically least developed poviats (with an SMD lower than the first quartile). Group B included poviats with SMD between quartile three and median. Group C comprised poviats whose SMDs were between median and quartile 1:

Group A: $SMD_i > \text{quartile 3 SMD}$

Group B: $\text{quartile 3 SMD} > SMD_i > \text{median SMD}$

Group C: $\text{median SMD} > SMD_i > \text{quartile 1}$

Group D: $SMD_i < \text{quartile 1 SMD}$.

Table 1. *SMD values for poviats in 2010 and 2019*

2010		2019	
Poviats	SMD	Poviats	SMD
Group A			
Piaseczyński	0.67	Warsaw	0.873
Warsaw	0.66	Piaseczyński	0.720
Pruszkowski	0.51	Nowodworski	0.718
Nowodworski	0.49	Warsaw West	0.696
Grodziski	0.46	Otwocki	0.647
Warsaw West	0.46	Grodziski	0.635
Otwocki	0.44	Pruszkowski	0.621
Sochaczewski	0.38	Sochaczewski	0.605
Group B			
Ostrołęka (town)	0.36	Ostrołęka (town)	0.552
Żyrardowski	0.34	Grójecki	0.494
Grójecki	0.31	Żyrardowski	0.493
Legionowski	0.31	poviat of Siedlce	0.486
Wołomiński	0.29	Ostrowski	0.427
Garwoliński	0.27	Wołomiński	0.423
Miński	0.25	Legionowski	0.401
Town of Siedlce	0.24	Garwoliński	0.382
Przasnyski	0.22	Przasnyski	0.377
Group C			
Płocki	0.21	Miński	0.370
City of Radom	0.21	Sierpecki	0.367
Ostrowski	0.20	Ostrołęcki	0.365
Płoński	0.20	Siedlecki	0.355
Sierpecki	0.20	Płoński	0.352
Ostrołęcki	0.19	Makowski	0.333
Białobrzzeski	0.18	Płocki	0.332
Gostyniński	0.16	city of Radom	0.330
Group D			
Makowski	0.16	Wyszkowski	0.325

Wyszowski	0.16	Węgrowski	0.311
Siedlecki	0.16	Gostyniński	0.275
Lipski	0.15	Lipski	0.274
Węgrowski	0.15	Żuromiński	0.271
Żuromiński	0.13	Białobrzegi	0.260
Przysuski	0.09	Radomski	0.250
Radomski	0.09	Przysuski	0.212
Szydłowiecki	0.08	Szydłowiecki	0.182

Source: Calculated by the authors based on the Statistics Poland data, Local Data Bank, 2010-2019.

Table 1 reveal substantial differences in the Mazowieckie poviats' SMDs in 2010. The highest SMD obtained for the Piaseczyński powiat is more than eight times higher than in the Szydłowiecki powiat, which is the lowest. The same is shown by a relatively high coefficient of variation of the SMD (55.48%). Other observations that can be made are as follows. All poviats in Group A belong to the Warsaw conurbation, while those in Group D are situated in the southern part of the voivodeship and distant from Warsaw (Szydłowiecki, Radomski, and Przysuski).

Although the 2019 range of SMDs is still vast, it is slightly narrower than in 2010. The highest SMDs obtained for the powiat of Warsaw is almost five times higher than that calculated for the Szydłowiecki powiat, where its level is the lowest. The coefficient of variation of SMDs in 2019 is noticeably lower (39.06%). The only change in the composition of Groups A and D is that in 2019 they had one new powiat each, i.e., Sochaczewski in Group A and Białobrzegi in Group D. This shows that both these groups were relatively resistant to changes in the years under consideration.

Higher SMDs in 2019 indicate that the Mazowieckie poviats improved their economic status from 2010. The arithmetic mean SMD increased over the nine years from 0.28 to 0.43 in 2019, reflecting a rising level of economic development (in absolute terms) in all poviats. Table 2 shows considerable differences among poviats regarding increases in SMDs. By 2019, their highest levels occurred in the Radomski, Szydłowiecki, and Przysuski poviats that in 2010 belonged to group D, and the lowest in the Warsaw poviats and those contiguous to the capital city.

Between 2010 and 2019, the mean SMD increased by an average of 35.2% in Group A and as much as 145.6% in Group D. The difference between these two numbers is a cumulative effect of different annual average increases in poviats' SMDs, which were estimated at 3.35% in group A and 10.46% in Group B. Therefore, the pace of economic development appears to be strongly dependent on its level, which supports the convergence effect hypothesis.

Table 2. *Changes in poviats' SMDs between 2010 and 2019 (%).*

Poviat	SMD increase from 2010 to 2019	Annual average increase in SMD	Poviat	SMD increase from 2010 to 2019	Annual average increase in SMD
Radomski	171.7	11.8	Sochaczewski	58.3	5.2
Szydłowiecki	134.4	9.9	Płocki	56.3	5.1
Przysuski	129.8	9.7	Radom (town)	56.2	5.1
Siedlecki	120.7	9.2	Ostrołęka (town)	52.5	4.8
Żuromiński	112.6	8.7	Western Warsaw	51.4	4.7
Ostrowski	108.4	8.5	Miński	50.2	4.6
Węgrowski	106.5	8.4	Wołomiński	48.2	4.5
Makowski	103.8	8.2	Nowodworski	47.7	4.4
Siedlce (town)	103.7	8.2	Otwocki	46.7	4.4
Wyszkowski	100.0	8.0	Żyrardowski	45.0	4.2
Ostrołęcki	93.1	7.6	Białobrzegi	42.7	4.0
Sierpecki	82.2	6.9	Garwoliński	41.1	3.9
Lipski	81.2	6.8	Grodziski	38.2	3.7
Przasnyski	73.9	6.3	Warsaw	32.8	3.2
Płoński	72.5	6.2	Legionowski	30.8	3.0
Gostyniński	67.1	5.9	Pruszkowski	24.6	2.2
Grójcki	60.9	5.4	Piaseczyński	8.2	0.9

Source: *Calculated by the authors based on the Statistics Poland data, Local Data Bank, 2010-2019.*

Let us now consider gravitation effects (GRE) for four quartile groups of Mazowieckie poviats created based on the following formula:

- Group A: $GRE_i > \text{quartile 3 GRE}$
- Group B: $\text{quartile 3 GRE} > GRE_i > \text{median GRE}$
- Group C: $\text{median GRE} > GRE_i > \text{quartile 1 GRE}$
- Group D: $GRE_i < \text{quartile 1 GRE}$

Table 3 indicates that gravitation affects strongly differentiated Mazowieckie poviats in both 2010 and 2019. Interestingly, the composition of groups A and D little changed between the two years, pointing to the relative stability of differences in the impact of gravitation effects on poviats. Quartile Group A consists of poviats belonging to the Warsaw conurbation, and quartile group D of poviats most distant from the capital city.

Another interesting observation is that Groups A and D were created using gravitation effects and SMDs have similar compositions, which suggests strong gravitation effects on the economic development of poviats.

Table 3. Gravitation affects (GRE) by poviats in 2010 and 2019

2010		2019	
Powiat	GRE	Powiat	GRE
Group A			
Warsaw	5 163.01	Warsaw	10 100.95
Piaseczyński	4 466.84	Piaseczyński	7 506.46
Western Warsaw	1 642.67	Pruszkowski	4 062.09
Pruszkowski	1 579.39	Western Warsaw	3 252.11
Grójecki	1 103.30	Grójecki	2 467.94
Town of Ostrołęka	922.54	Nowodworski	2 287.97
Grodziski	766.89	Town of Ostrołęka	2 160.92
Otwocki	742.61	Otwocki	1 988.65
Group B			
Nowodworski	721.68	Legionowski	1 888.87
Wołomiński	565.27	Grodziski	1 534.15
Legionowski	551.43	Wyszowski	1 220.79
Wyszowski	548.13	Wołomiński	1 092.80
City of Radom	421.98	Sochaczewski	938.63
Sochaczewski	418.26	City of Radom	780.29
Miński	401.61	Miński	778.28
Garwoliński	325.07	Garwoliński	719.58
City of Siedlce	320.33	Town of Siedlce	711.63
Group C			
Przasnyski	270.87	Ostrowski	700.72
Ostrowski	256.73	Płoński	465.45
Płoński	214.66	Przasnyski	387.80
Białobrzegi	180.24	Węgrowski	370.29
Żyrardowski	161.97	Żyrardowski	362.84
Płocki	144.70	Sierpecki	314.73
Makowski	134.22	Płocki	288.51
Przysuski	130.40	Białobrzegi	272.28
Group D			
Węgrowski	125.27	Makowski	271.15
Gostyniński	117.81	Ostrołęcki	232.59
Sierpecki	96.97	Radomski	214.13
Radomski	83.27	Gostyniński	205.04
Ostrołęcki	81.58	Szydłowiecki	176.60
Szydłowiecki	68.94	Siedlecki	149.00
Siedlecki	66.86	Przysuski	141.50
Lipski	59.12	Lipski	140.84
Żuromiński	41.54	Żuromiński	88.62

Source: Calculated by the authors based on the Statistics Poland data, Local Data Bank, 2010-2019.

The above analysis shows that the Mazowieckie poviats differed significantly in the level and dynamic of economic development and the impact of gravitation effects in the years under study. The greatest SMDs and gravitation effects were obtained for

poviats making up the Warsaw conurbation or contiguous to it (Group A) and the smallest for some of the Group D poviats, namely Szydłowiecki, Radomski, Przysuski, Żuromiński, Lipski, and Gostyniński.

Poviats in Group A feature well-developed economies with high rates and a modern employment structure dominated by the services sector, with a relatively large share of the industry. They lay astride two national roads – Warsaw-Poznań and Warsaw-Gdańsk – and the Moscow-Berlin rail line, along which manufacturing, trading, and service firms operate, as well as a considerable number of providers of transportation, forwarding, and customs services. All Group A poviats have vast economic potential and prospects of continued development.

As for poviats in Group D are typically agricultural units, with services accounting for a low share of employment. They mostly host small and medium-sized enterprises based in the food industry (sausage makers, bakeries, Etc.) and wood, construction, and footwear industries, which primarily produce for local markets. Critical business activity for both local and national markets is the farming of vegetables, mainly pepper, which has earned the municipality of Przytyk contributing around 80% of the domestic production of pepper, the name of a pepper field. Even if the rates of unemployment in these poviats are now markedly above the average for the voivodeship, the growth potential of their agriculture and food processing industry is substantial. The fact that all SMDs analysed Group D's SMD grew the fastest between 2010 and 2019 seems to promise a brighter future for these poviats.

4.2 The Determinants of Economic Development – An Econometric Analysis

In order to determine the significance and strength of the impact of the analysed factors (explanatory variables) on SMDs' values, an econometric model was constructed.

In assessing the statistical usefulness of explanatory variables to be analysed, one should bear in mind that their coefficients of variation should not exceed 30%. In this study, an analysis of Pearson's linear correlation coefficients found relatively statistical solid associations between some of the explanatory variables (the strongest one occurred between "the number of sole entrepreneurs per 1000 of the working age population" and gravitation effects, $r = 0.82$). Even so, they were included in the model because they had a slightly different effect on the dependent variable. Based on the statistically significant estimates of the model parameters with absolute values of Student's t-test exceeding 2.3, the following relationships were identified, *ceteris paribus* (Table 4).

Table 4. *SMD regressions for Mazowieckie poviats*

Variables	Parameter estimates	t-stud
INW	0.23	5,66
OS FIZ	0.11	2,57
SB	-0.32	-8,61
GRE	0.34	6,21
Free term	-3.25	-10,59
N = 340 Corrected R ² = 0.814	Kolmogorov- Smirnov test: d=0.04558, p>0.20	

Source: Calculated by the authors in the Statistica package.

The analysis of variables showed that per capita investments of enterprises significantly contributed to the economic development of poviats. A 1% increase in their volume caused a per capita SMD to grow by 0.23%. This finding is consistent with economic theory, according to which investments are a vehicle that expands economies' capacity to produce and stimulates economic development.

Also consistent with economic theory is the confirmed significance of the number of sole entrepreneurs in a poviat for its economic development, reflecting the entrepreneurial spirit of the local population and influencing the values of many other macro variables, including more substantial job creation and thereby a lower rate of unemployment and economic development of the poviat. In this study, a 1% increase in the number of sole entrepreneurs per 1000 working-age population (OS FIZ) resulted in a 0.11% increase in a per capita SMD.

The estimate of the parameter representing the unemployment rate's effect on per capita SMDs in the poviats was also aligned with theoretical predictions. An increase in unemployment by 1% was associated with a 0.32% reduction in the per capita SMD. It must be noted that the unemployment rate is a measure of the underutilisation of the labour supply; therefore, its high value implies a limited possibility of expanding production in the long term.

The analysis found a positive relationship between gravitation effects and poviats' economic development. It demonstrated that a 1% increase in the cumulative gravitation effect in a poviat contributed to a 0.43% increase in its SMD. This association, too, is consistent with economic theory.

To determine the goodness-of-fit between the model and empirical data, the corrected coefficient of determination (R²) was applied. Its value was relatively high and indicated that the model explained 81% of the variance of the dependent variable. The distribution of residuals was tested for normality using the Kolmogorov-Smirnov test. The test's value was 0.04558 at p>0.20, confirming that residuals had a normal distribution and that the function form of the model was correct.

5. Conclusions

The above analysis influencing the economic development of poviats in the Polish Mazowieckie voivodeship was carried out in the economic growth and development theory framework. Its findings show that the development of research in this area drove the evolution of views about which factors play a pivotal role in economic development, from traditional ones such as the availability of labor and the degree of its utilisation, to the stock of real capital. Its increase results from investment activity and the primacy of qualitative factors such as labour productivity, human capital, innovations, and gravitation effects.

Unfortunately, in this study, the analysis of economic development factors other than traditional was prevented by the paucity of statistical data on the poviats. The SMDs of Mazowieckie poviats showed marked differences in the level and dynamic of their economic development during the 2010-2019 period.

Both at the beginning and at the end of that period, the highest levels of economic development characterised poviats lying within the limits of Warsaw and adjacent to it (Group A: Piaseczyński, Pruszkowski, Nowodworski, Grodziski, Western Warsaw, Otwocki, Sochaczewski, and Warsaw) and the lowest ones more distant poviats (Group D: Szydłowiecki, Przysuski, Radomski, and Żuromiński).

However, different annual average growth rates of SMDs, the highest in the Radomski, Szydłowiecki, and Przysuski poviats and the lowest in the poviats in the Warsaw conurbation, reduced the spread between the poviats' minimum and maximum SMDs in 2010 and 2019.

The contribution of gravitation effects to poviats' economic development also proved significantly different. Their role proved the most prominent in poviats belonging to the Warsaw conurbation and those adjacent to them and the least obvious in the outlying poviats. The rankings of poviats created using the criteria of gravitation effects and the values of the SMDs were significantly similar.

As well as indicating which factors significantly contributed to the economic development of poviats in the Mazowieckie voivodeship, the analysis of the outcomes of econometric modeling enabled the formulation of economic policy recommendations. These are:

- Because of investment outlays' ability to spur economic development, poviats, especially the less developed ones, should make wider use of investment incentives.
- Economic development largely depends on local entrepreneurial activity; the poviat authorities should therefore consider measures to increase the number of natural persons engaging in business activity.

- The relatively high unemployment rates in the less developed poviats require that they make more effort to develop job creation programs and encourage the unemployed to be more active in finding a job, primarily through the provision of skill improvement training or retraining courses.
- As gravitation effects are significant to economic development, the national government should initiate and support broader economic cooperation between poviats at different levels of economic development to reduce disparities between them.

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