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# THE IMPORTANCE OF GREEN INVESTMENTS IN IMPROVING THE COMPETITIVENESS OF MUNICIPALITIES IN POLAND

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Purpose: The aim of the article is to present the relationship between environmental (so-called "green") investments and the change in the level of competitiveness of municipalities in Poland. The significance of green investments in improving the competitiveness of local governments at the municipal level was determined based on the division of the studied units into four groups: urban municipalities, urban-rural municipalities, rural municipalities and cities with county rights. The study was designed to verify the hypothesis that there is a relationship between the change in the level of competitiveness and the scope of environmental investments in municipalities in Poland, with the highest relationship being noted in cities with county rights. Methodology: The study presents changes in the level of competitiveness of municipalities based on 21 indicators and the scope of green investments in municipalities based on 10 indicators constructed based on public statistical data from the Local Data Bank of the Central Statistical Office. The selection of indicators was made using the Z. Hellwig reduction method -i.e. by isolating diagnostic features that showed little correlation between each other. The level of competitiveness and environmental investments were presented based on a synthetic measure showing the taxonomic distance of a given municipality from the established development pattern. In turn, the relationships between the studied variables were established based on regression analysis.

**Findings:** As a result of the conducted research procedure, environmental investments and changes in the level of competitiveness of 2477 communes in Poland were presented, and the relationships between these variables were determined in the individual research groups. The most significant relationships were observed among cities with county rights and rural communes. In turn, the highest values of the synthetic index in the field of competitiveness were recorded in the case of urban-rural communes, and in the field of environmental investments - in the case of urban communes.

**Originality/value:** The article presents the results of extensive research conducted on a group of 2477 entities based on 31 indicators that uniquely present the competitiveness and environmental orientation of investments in municipalities in Poland. The obtained results of the study may be a source of inspiration for EU institutions in the field of formulating environmental strategies covering the entire area of the European Union.

**Keywords:** green investments, competitiveness, local governments, distance from the model. **Category of the paper:** Research paper.

## 1. Introduction

Determining the level of competitiveness of local government units is an extremely important research problem both in the theory of economic sciences and in economic practice. The level of competitiveness of a commune affects, for example, its investment attractiveness, the well-being and wealth of its residents, or the absorption capacity of EU funds (Soares, 2024; Zerbib, 2019; Caldecott, Rook, 2015). In addition, in the face of global climate change, various solutions are being developed to reverse the adverse effects of human interference in the natural environment. For example, within the framework of the European Union's climate policy, activities for sustainable development, decarbonization of the economy, or the principles of the so-called Green Deal are being promoted (Eckert, Kovalevska, 2021). Programmes and projects in the field of reducing emissions, disseminating renewable energy sources, greening public spaces and using environmentally friendly technologies are often implemented at the lowest levels of public management (Sikora, 2021). In connection with the above, the aim of this study is to present the relationship between environmental (so-called "green") investments and the change in the level of competitiveness of municipalities in Poland.

Research aimed at determining the factors influencing competitiveness is the subject of many scientific studies (Arfaoui et al., 2024; Vela Almeida et al., 2023; Kauffman et al., 1997; Porfir'ev, 2016; Siedschlag, Yan, 2021; Zhang et al., 2024). However, a research gap has been identified in the literature on the importance of environmental investments in local development. In order to fill this gap, the author of the study decided to analyze the relationship between green investments and the change in the level of competitiveness of municipalities in Poland. In other words, the article aims to analyse whether green investments are implemented primarily in communes that have recorded a significant improvement in their competitiveness level, or whether environmental investments contribute to improving the competitiveness of communes in Poland.

The aim of the article is to identify the relationship between environmental (so-called "green") investments and the change in the level of competitiveness of municipalities in Poland. The study will present changes in the level of competitiveness of all 1477 municipalities in Poland based on 31 indicators and the scope of environmental investments (so-called "green") based on 10 variables. Additionally, the research group will be divided into four types of municipalities: urban municipalities (236 units), urban-rural municipalities (662 local governments), rural municipalities (1513 local governments) and cities with county rights (66 cities). The basis used to calculate the indicators will be statistical data from the Local Data Bank of the Central Statistical Office (BDL GUS). The change in the level of competitiveness and the scope of environmental investments in individual communes will be presented based on a synthetic measure presenting the taxonomic distance of a given commune from the

established development pattern. In turn, the relationships between the variables studied will be established based on regression analysis.

The article will first review the literature on environmental investments and competitiveness. Then, the research methodology will be presented along with a description of the individual stages of the research procedure. The results of the study will be discussed in detail next. The final part of the study will provide conclusions and recommendations regarding the importance of green investments in the development of municipalities in Poland.

## 2. Environmental investments in subject literature

The issue of environmental investments appears more and more often in the literature on the subject. They play a key role in achieving sustainable development goals, constituting a response to contemporary challenges related to the degradation of ecosystems, climate change and limited natural resources (Gao, Zheng, 2017; Cheng, 2023). Environmental investments can be defined as financial, technological and organizational outlays undertaken to protect the natural environment, minimize the negative impact of human activity and effectively manage resources (Lee, 2020; Mu, 2024). In the literature, environmental investments are analyzed from various perspectives, from economic, through ecological, to social, which reflects their interdisciplinary nature (Tran et al., 2020; Murwaningsari, Rachmawati, 2023).

Environmental investments are activities that aim to reduce the negative impact of human activity on the environment through the use of technologies, processes and management strategies that contribute to the protection of natural resources, reduction of pollutant emissions and improvement of the quality of the environment (Shkuropat, Stepanov, 2019). In the literature, they are defined as both preventive and corrective actions, which may include direct investments in environmental protection technologies and infrastructure, as well as indirect actions, such as environmental education or changes in production processes leading to a reduction in the negative impact on the environment (D'Angelo, Cappa, Peruffo, 2024).

Environmental investments are becoming increasingly important in building the competitive advantage of enterprises, regions and countries (Seidl, Nunes, 2021; Bouchmel et al., 2024). According to the literature on the subject, investing in ecological technologies and strategies not only promotes environmental protection, but also brings economic benefits, improves operational efficiency and strengthens the reputation of the entity implementing such investments. (Nenavath, Mishra, 2023; Ganda, Ngwakwe, Ambe, 2015).

The literature on the subject highlights several mechanisms through which environmental investments can contribute to increased competitiveness (Li et al., 2022). Such investments can at least lead to reduced operating costs. In addition, environmental investments stimulate the development of technological innovations (Hu et al., 2024). Entities that have to adapt to increasingly stringent environmental standards are forced to develop new technologies and solutions, which helps increase their innovation (Siedschlag, Yan, 2021). The literature points to the so-called Porter hypothesis, according to which restrictive environmental regulations can encourage companies to develop innovative solutions that improve both ecological and economic performance (Kronenberg et al., 2021).

Not only individual entities, but also entire economies can benefit from environmental investments. Governments that promote green technologies and investments create favorable conditions for the development of innovations and increase the attractiveness of their market for foreign investors. Based on the literature on the subject, it is possible to indicate key mechanisms through which environmental investments contribute to the growth of countries' competitiveness (Martin, Moser, 2016; Li, Chang, Zunong, 2023; Chiţimiea et al., 2021; Ceccarelli, Ramelli, 2024). Investments in renewable energy, low-emission technologies and sustainable agriculture are creating new industries and economic sectors. In turn, economies that invest in resource-efficient technologies can reduce their dependence on raw material imports and improve their trade balance. In particular, investments in recycling and the circular economy contribute to reducing the use of primary raw materials, which in the long term lowers production costs and improves competitiveness (Kantorowicz et al., 2024).

Environmental investments in municipalities are a key element of local sustainable development policies. They aim to improve the quality of life of residents, protect natural resources and adapt to the challenges resulting from climate change and environmental degradation (Heijlen, Duhayon, 2024). Municipalities, as basic public administration units, play an important role in implementing environmental strategies, taking action in the field of water and air protection, waste management and sustainable urbanization (Du et al., 2024). Environmental investments in municipalities have a direct impact on the quality of life of local communities. They improve the health of residents, increase the attractiveness of municipalities for investors and tourists, and support the development of a local economy based on the sustainable use of natural resources (Khan et al., 2024). The key importance of such investments resources, inefficient waste management and excessive energy consumption (Mo, Ullah, Ozturk, 2023; Chi et al., 2024). In the long term, effective environmental investments contribute to reducing the costs associated with the negative effects of pollution and climate change (Saeed Meo, Karim, 2022).

Local government units, faced with global environmental challenges, growing competition for investors and residents, as well as regulatory requirements, increasingly perceive environmental investments as a key element in improving their competitiveness (Indriastuti, Chariri, 2021). These investments contribute to sustainable development, strengthen the attractiveness of the commune, improve the quality of life of residents and support the local economy (Kapeller, Leitch, Wildauer, 2023).

In summary, environmental investments are a key element of environmental protection policy and sustainable development strategies, especially local development. Their interdisciplinary nature and wide range of benefits – from protecting ecosystems, through reducing emissions, to increasing innovation – make them essential in striving to achieve a balance between social, economic and ecological needs. Scientific literature emphasizes the need for further development of these investments and integration of public policies with environmental protection activities at the local level, in order to ensure sustainable development for both current and future generations.

## 3. Stages of the research procedure – research methodology

The study was designed to verify the hypothesis that there is a relationship between the change in the level of competitiveness and the scope of environmental investments in municipalities in Poland, with the highest relationship being noted in cities with county rights. The study covered all municipalities in Poland – a total of 2477 units, divided into four groups: urban municipalities (236 units), urban-rural municipalities (662), rural municipalities (1513) and cities with county rights (66).

In order to examine the level of competitiveness and the scope of environmental investments of municipalities in Poland, a synthetic measure of distance from the model was used. The research procedure was carried out in two ways - the scope of green investments was determined based on the cumulative value of indicators in 2023 (in a static approach), while the competitiveness of individual municipalities was examined in a dynamic approach (based on the change in the value of indicators in a ten-year period, i.e. in the years 2014-2023). The research procedure consisted of five successive stages:

- 1. isolation of the so-called components i.e. indicators defining the level of competitiveness and the scope of green investments,
- 2. selection of variables construction of the geographic information matrix,
- 3. reduction of the multi-feature space,
- 4. determination of the results of green investments and the level of competitiveness of the units subject to the study,

- 5. ranking of the studied communes on the scale of the level of competitiveness and the scope of green investments based on a ranking created according to the decreasing value of the synthetic measure,
- 6. classification of local governments in four categories: urban communes, urban-rural communes, rural communes and cities with county rights,
- 7. determination of the relationship between the scope and scale of environmental investments and the change in the level of competitiveness of local government units at the commune level.

In the first stage, based on a review of the literature covering the theory of regional competitiveness, the most important components were identified, i.e. indicators determining the level of competitiveness and environmental investments (Chiţimiea et al., 2021; Wang, Wang, 2023; Zailani et al., 2019). The study used data from the Local Data Bank of the Central Statistical Office. The author of the study is aware of the imperfections and incompleteness of the construction of individual indicators characterizing the variables studied. Individual characteristics could be constructed more precisely, but all available public data that may determine the level of competitiveness and the scope of environmental investments were taken into account. However, it is worth considering in the future to complete a broader catalog of indicators, e.g. from other sources.

#### Table 1.

Indicators included in the analysis of competitiveness and green investments

Scope of the study	Indicators
Competitiveness (21 variables)	share of municipal investment expenditure in total expenditure; total budget revenue per capita; total capital expenditure per capita; amount of EU funds obtained by the municipality per capita; renovation of municipal apartments per 10,000 inhabitants; unemployment rate (destimulant); percentage of residential buildings connected to the water supply network; percentage of residential buildings connected to the sewage system; percentage of population using the water supply system; percentage of population using the sewage system; percentage of an apartment per 1 person; number of apartments per 1000 inhabitants; children in nurseries, wards and children's clubs per 1000 children up to 3 years of age; entities entered in the REGON register per 10,000 inhabitants; individuals conducting business activity per 10,000 inhabitants; foundations, associations and social organisations per 10,000 inhabitants; share of newly registered creative sector entities in the total number of newly registered entities; apartments put into use per 1000 inhabitants
Green investments (10 variables)	planting trees and shrubs per 1 km <sup>2</sup> of area; funds planned for revitalisation activities in the field of the environment per capita; percentage of the population using sewage treatment plants; treatment plants with increased removal of nutrients in % of the population; water consumption for industrial purposes per capita (destimulant); products containing asbestos remaining for disposal in relation to the inventoried total volume of products containing asbestos (destimulant); waste collected selectively in relation to total waste; share of parks, green areas and housing estate green areas in the total area; total area of green areas per capita; bicycle paths per 100 km <sup>2</sup>

Source: own research.

In the second stage of the conducted research procedure, a geographic information matrix was built based on 31 indicators (Table 1), which determined the scope of environmental investments as of 2023 and changes in the level of competitiveness in the years 2014-2023. Then, Pearson linear correlation coefficients were calculated between all the examined output indicators. It is extremely important that the indicators selected for the synthetic measure of distance from the standard are weakly correlated with each other. Thanks to this, the information capacity of these indicators is different.

The created matrices of Pearson linear correlation coefficients were the basis for reducing the output variables using the Z. Hellwig reduction method – i.e. extracting diagnostic features, i.e. those indicators that should be taken into account in the further research procedure (Mielke, Steudle, 2018). The Z. Hellwig reduction method uses correlation coefficients between variables for calculations. In the Z. Hellwig reduction method, the diagnostic feature is the indicator whose sum of absolute correlation coefficients with other features is the largest (it is then called the central feature). Then, the variables for which the value of the correlation coefficient with the diagnostic feature is higher than the critical value determined based on the following formula are eliminated (Inderst, Kaminker, Stewart, 2016):

$$r^* = \sqrt{\frac{(t^*)^2}{n-2+(t^*)^2}} \tag{1}$$

where:

 $r^*$  – critical value of Pearson's linear correlation coefficient,

 $t^*$  – value of Student's t-statistic (at significance level p = 0.05),

n – number of output indicators (variables).

As a result of the method, the variables that were statistically significantly correlated with the diagnostic feature (called satellite features) were eliminated. In each subsequent step, the correlation matrix was reduced by the central feature and satellite features. The Z. Hellwig method is repeated to obtain new reduced correlation matrices until the set of features is exhausted or isolated features are extracted.

In the next stage of the research procedure, the pattern and anti-pattern of the change in the level of competitiveness and the scope of environmental investments were determined. The pattern was considered to be the maximum standardized values of individual diagnostic features, while the anti-pattern was their minimum values (Spychała, 2023). In the next step, the taxonomic distance of each studied commune from the pattern of the scope of green investments and the change in the level of competitiveness was determined based on the following formula (Arvanitidis et al., 2009):

$$d_{i0} = \sqrt{\sum_{j=1}^{m} (z_{ij} - z_{0j})^2}$$
(2)

where:

 $d_{i0}$  – taxonomic distance of commune i from the adopted development pattern,

 $z_{ij}$  – standardized value of indicator (feature) j for commune i,

 $z_{0j}$  – standardized value of indicator (feature) j for the development pattern.

In the fifth stage of the research procedure, two synthetic measures were determined for each commune, which were an indicator of the change in the level of competitiveness of the commune and the scope of green investments. The synthetic measure was calculated based on the following formula:

$$v_i = 1 - \frac{d_{i0}}{d_0} \tag{3}$$

where:

 $v_i$  – synthetic measure of the level of development of commune *i*.

 $d_{i0}$  – taxonomic distance of commune i from the adopted development pattern,

 $d_0$  – taxonomic distance of the pattern from the anti-pattern of development.

#### Table 2.

<i>Municipalities</i>	with the highest	value of cha	ange in the	competitiveness	index in	2014-2023
1	0		0	1		

The highest values of the competitiveness index								
Place	Name of the commune	Value	Place	Name of the commune	Value			
	Urban communes							
1	HEL	0,319	6	ZAKOPANE	0,306			
2	WĘGRÓW	0,314	7	KARPACZ	0,305			
3	ŁEBA	0,312	8	LUBAWA	0,303			
4	SZKLARSKA PORĘBA	0,309	9	KOŁOBRZEG	0,295			
5	PŁOŃSK	0,308	10	ZŁOTORYJA	0,295			
	U	rban-rural n	nunicipaliti	ies				
1	MIELNO	0,560	6	BUDZYŃ	0,398			
2	WŁADYSŁAWOWO	0,469	7	LUTOMIERSK	0,397			
3	JASTARNIA	0,467	8	PIESZYCE	0,395			
4	OTYŃ	0,406	9	TUŁOWICE	0,391			
5	MORAWICA	0,404	10	OPATÓWEK	0,390			
		Rural con	nmunes					
1	USTRONIE MORSKIE	0,348	6	RASZYN	0,319			
2	SZTUTOWO	0,329	7	CISNA	0,318			
3	DOBROMIERZ	0,328	8	WIĄZOWNA	0,312			
4	KROTOSZYCE	0,324	9	STARE BOGACZOWICE	0,311			
5	ELBLĄG	0,322	10	CEDRY WIELKIE	0,310			
Cities with county rights								
1	CHORZÓW	0,304	6	M. ST. WARSZAWA	0,289			
2	ZABRZE	0,301	7	BIELSKO-BIAŁA	0,287			
3	ŚWINOUJŚCIE	0,297	8	LUBLIN	0,285			
4	SOPOT	0,293	9	WROCŁAW	0,284			
5	KATOWICE	0,291	10	GLIWICE	0,284			

Source: own research.

The synthetic indicator of the level of development takes values from 0 to 1, where the higher its value, the higher the level of development of the phenomenon studied. Based on the calculated synthetic indicators, a ranking of 2477 communes in Poland was established, and then detailed rankings were established, divided into four groups: urban communes, urban-rural communes, rural communes and cities with county rights.

#### Table 3.

The highest values of the environmental investment indicator								
Place	Name of the commune	Value	Place	Name of the commune	Value			
	Urban communes							
1	ŁĘKNICA	0,472	6	PRUSZKÓW	0,408			
2	SZCZAWNO-ZDRÓJ	0,438	7	GÓROWO IŁAWECKIE	0,406			
3	ZŁOTÓW	0,428	8	KOŁOBRZEG	0,397			
4	ZĄBKI	0,416	9	ŻYRARDÓW	0,395			
5	CZŁUCHÓW	0,411	10	LIDZBARK WARMIŃSKI	0,392			
	-	Urban-rural	municipal	ities				
1	PIWNICZNA-ZDRÓJ	0,400	6	GŁUSZYCA	0,359			
2	SZCZAWNICA	0,390	7	NAROL	0,356			
3	CIESZANÓW	0,381	8	PACANÓW	0,351			
4	LĄDEK-ZDRÓJ	0,363	9	CIĘŻKOWICE	0,340			
5	UNIEJÓW	0,362	10	WOŁOMIN	0,340			
		Rural c	ommunes					
1	BRODY	0,398	6	WIELKIE OCZY	0,380			
2	STARY DZIKÓW	0,397	7	HORYNIEC-ZDRÓJ	0,365			
3	KURYŁÓWKA	0,387	8	ADAMÓWKA	0,362			
4	KREMPNA	0,385	9	OLSZANICA	0,361			
5	JAŚLISKA	0,383	10	LEWIN KŁODZKI	0,359			
Cities with county rights								
1	CHORZÓW	0,425	6	M. ST. WARSZAWA	0,396			
2	ŁÓDŹ	0,409	7	RZESZÓW	0,395			
3	SOPOT	0,404	8	OLSZTYN	0,395			
4	BIAŁYSTOK	0,398	9	SIEMIANOWICE ŚLĄSKIE	0,393			
5	PŁOCK	0,396	10	TORUŃ	0,391			

Source: own research.



**Figure 1.** Diversification of competitiveness and environmental investments in municipalities. Source: own research.

Figure 1 and Tables 2 and 3 present the results of the conducted research procedure. Table 2 presents the communes with the highest values of the synthetic indicator regarding changes in the level of competitiveness in the years 2014-2023 within individual groups of units. In turn, Table 3 lists the communes with the highest values of the synthetic measure in the field of green investments as of 2023 calculated for each group of local government units. Figure 1 contains cartograms presenting the spatial differentiation of the values of the above synthetic indicators in Poland.

# 4. Results – conclusions based on the research conducted concerning the competitiveness and green investments

As a result of the conducted research procedure, the spatial differentiation of 1477 communes in Poland was presented due to the scope of environmental investments and changes in the level of competitiveness (figure 1). In the studied group of units, the value of the synthetic measure presenting changes in the level of competitiveness in the years 2014-2023 ranged from 0.1424 to 0.5597, with the lowest value recorded in the case of a unit classified as a rural commune, and the highest in the case of an urban-rural commune (Table 4). In turn, the value of this measure presenting the scope of environmental investments of the studied communes ranged from 0.0288 to 0.4718, with the lowest value of the indicator identified in the urban-rural commune, and the highest in the urban commune.

#### Table 4.

Type of communes	synthetic in	ndicator - comp	oetitiveness	synthetic indicator - investments			
	average value	minimum value	maximum value	average value	minimum value	maximum value	
Urban	0.2719	0.2437	0.3191	0.3353	0.2911	0.4718	
Urban-rural	0.2785	0.2412	0.5597	0.3046	0.0288	0.3996	
Rural	0.2687	0.1424	0.2700	0.3008	0.2824	0.3982	
Cities	0.2738	0.2370	0.3036	0.3517	0.3096	0.4252	
Total	0.2718	0.1424	0.5597	0.3065	0.0288	0.4718	

Average,	lowest and	highest values	s of synthetic	indicators

Source: own research.

Similar differentiation of the studied indicators was observed in the case of individual groups of local government units. It is also worth noting that the greatest differentiation of the change in competitiveness was noted in urban-rural communes, while the greatest similarity was observed in the case of cities with county rights. Similarly, the smallest differentiation of the scope of green investments was noted in cities with county rights, and the largest – again in urban-rural communes.

Taking into account the spatial differentiation of the indicators studied, it is worth noting that in the case of the scope of green investments, the highest values of the synthetic measure were observed in municipalities located in the southern and western part of Poland. In turn, the lowest values of the measure in the scope of environmental investments were recorded in municipalities in central and north-eastern Poland. However, in the case of the change in the level of competitiveness, the values of the synthetic indicator were evenly distributed in individual parts of Poland and - therefore - it is not possible to clearly indicate the regions in which the change in the level of competitiveness would be the largest or the smallest.

The leaders of changes in the level of competitiveness in individual types of communes were: Hel, Mielno, Ustronie Morskie and Chorzów. The high positions of the coastal communes in the ranking result, among others, from the largest number of business entities entered in the REGON system per 10,000 inhabitants and the percentage of inhabitants using the network infrastructure. In turn, the high position of Chorzów is the result of the high number of renovations of municipal apartments per 10,000 inhabitants, the availability of nurseries and kindergartens and the value of EU funds obtained per inhabitant. In turn, the leaders in the scope of environmental investments in the individual groups were: Łęknica, Piwniczna-Zdrój, Brody and – once again – Chorzów. The high position of the indicated communes is the result of, among others, the largest areas of green areas per 1 inhabitant, the smallest water consumption for industry per 1 inhabitant, or the share of sewage treatment plants with increased removal of biogenic substances. Moreover, in all the indicated communes, a number of environmental investmented, such as: expansion of water and sewage networks, construction of ecological waste incinerators, use of renewable energy sources, or investments in environmentally friendly transport.

# 5. Discussion – the importance of green investments in the competitiveness of regions

In the last stage of the research, the relationship between the change in the level of competitiveness and the scope of environmental investments in Polish municipalities was determined. The above relationships were examined separately for each type of municipality and for all municipal governments together. As part of the research procedure, simple linear regression models were built between the variables studied within the individual types of municipalities (Table 5). A positive relationship was observed in all types of municipalities, except for urban municipalities (Table 6).

#### Table 5.

3	
Research group	Regression model formula
All communes (2477)	y = 0.289 + 0.0652 * x
Urban communes (236)	y = 0.348 - 0.0465 * x
Urban-rural communes (662)	y = 0.302 + 0.0079 * x
Rural communes (1513)	y = 0.268 + 0.1224 * x
Cities with county rights (66)	y = 0.152 + 0.7307 * x

*Linear regression models between the studied variables* 

Source: own research.

Based on selected statistics of the obtained models, the explanatory power of the obtained regression functions was assessed as relatively low. The highest value of the determination coefficient R<sup>2</sup> was obtained in the case of the model defined for cities with county rights (8.16%). In the case of this type of communes, the variability of the dependent variable was therefore explained by the independent variable in 8.16%. It can therefore be assumed that in cities with county rights there is the strongest correlation between green investments and changes in the level of competitiveness. Therefore, the hypothesis formulated in the study was partially positively verified.

The highest quality of the regression model estimated for cities with county rights is also confirmed by the fact that in its case the standard error of the residuals was the lowest (1.04%). It can therefore be stated that in the case of cities with county rights the regression model determined a correct – positive relationship between the change in the level of competitiveness and the scope of environmental investments.

#### Table 6.

Parameters determining the quality of regression models in the system of individual research groups

Characteristics	All communes (2477)	Urban communes (236)	Urban- rural communes (662)	Rural communes (1513)	Cities with county rights (66)
Relationship: environmental investments and competitiveness	positive	negative	positive	positive	positive
Dependence coefficient R <sup>2</sup>	0.46%	0.04%	0.03%	2.33%	8.16%
P-value for F-test	0.08%	76.14%	68.08%	0.00%	2.01%
Standard error of residuals	2.01%	1.17%	3.16%	1.30%	1.04%
Sum of squared residuals	27.13%	849.14%	42.10%	104.83%	3943.70%
Coefficient of residual variation	13.51%	23.24%	8.79%	20.63%	26.29%
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Source: own research.

The synthetic measure of the dispersion of empirical values around theoretical values is the standard deviation of the residual component. It provides information about the average deviation of the empirical values of the explained variable from the theoretical values obtained from the regression function. As the value of the standard deviation of the residual component increases, the statistical "goodness" of the fit of a given regression function to the empirical data decreases (Arvanitidis et al., 2009). In the conducted study, positive and negative residuals were identified. Positive residuals show that the observed value of the explained variable is higher than the expected one, resulting from the model, while negative residuals indicate the opposite situation. The lowest value of the standard error of the residuals was noted in the case of the model estimated for cities with county rights. In turn, taking into account the residual variation coefficient, the model defined for urban-rural communes can be considered relatively well-fitted, because the value of this coefficient was 8.79% (this part of the average value of the explained variable constitutes its standard deviation of the residuals). The actual change in the level of competitiveness and the scope of green investments in urban-rural communes and in cities with county rights - apart from a few cases - differs relatively little from the value obtained from the regression model.

## 6. Conclusions

In conclusion of the research conducted in this article on the relationship between the improvement of competitiveness and the scope of green investments in municipalities in Poland, it can be noted that a positive relationship was identified in the case of urban-rural municipalities, rural municipalities, cities with county rights and municipalities in general. In the case of urban municipalities, a negative relationship was noted. Thus, the study identified both positive and negative relationships between environmental (so-called "green") investments and changes in the level of competitiveness of individual types of communes in Poland. It can therefore be noted that in most municipalities in Poland, the improvement of the competitiveness of a local government unit contributes to the implementation of environmental investments, and such green investments increase the level of competitiveness of the municipalities in Poland should therefore increase their interest in environmental investments, because they have a positive impact on the improvement of competitiveness. On the other hand, green investments are primarily decided by those municipalities that have achieved a satisfactory level of competitiveness.

Of all the estimated regression functions, the model built as part of the analysis of the group of cities with county rights should be considered the highest quality, explaining over 8% of the variability of the dependent variable, while the explanatory variable turned out to be significant at a significance level of 2%. Also, based on the analysis of residuals, the model built as part of the analysis of cities with county rights was considered to be the best match for reality. Therefore, to sum up the conducted research, it should be stated that the improvement of competitiveness had the greatest impact on the scope of environmental investments in the largest cities. This therefore confirms the hypothesis formulated in the study.

In relation to the above, it should be noted that in the context of the conducted research, it is not possible to clearly determine the relationship between the improvement of competitiveness and the scope of green investments, and the results of the conducted research procedure are based only on statistical dependence and their interpretation must be cautious. There is certainly no doubt that environmental investments have a positive impact on the improvement of the competitiveness of municipalities in Poland. However, it is very difficult to clearly determine the scale of this impact, because the level of competitiveness recorded in the studies resulted from the operation of a number of different types of stimuli. Moreover, it is worth noting that the results of green investments will be visible only in the longer term, so they were not included in the conducted study. Additionally, it is very difficult to measure the level of competitiveness or the scope of environmental investments, due to the lack of generally available objective indicators that would directly refer to the above-mentioned factors. Due to the specificity and extended time horizon of environmental investments, it would be worth considering extending the period studied in similar analyses in order to also take into account the long-term interactions between the variables studied.

The conducted research procedure is unique, because in the literature on the subject it is impossible to find another study in which the relationships between improving competitiveness and environmental investments were, firstly, conducted comprehensively for all territorial units of the lowest given country (the research group consisted of 1477 communes), and secondly – a synthetic measure created based on the Z. Hellwig feature reduction method would be used for this purpose. The above considerations, conducted research and obtained results may therefore constitute both an impulse to undertake more in-depth analyses in this direction, as well as inspiration for governments and European Union bodies in the scope of defining additional incentives to incur funds for the implementation of environmental investments. Green investments are not only a desirable action due to the implementation of the assumptions of the European Green Deal, but also – as the conducted research has shown – they increase the competitiveness of the region.

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