

## ECONOMIC CONDITIONS FOR THE DEVELOPMENT OF SMART CITIES IN POLAND IN A REGIONAL PERSPECTIVE

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**Purpose:** The main purpose of the article is to identify the economic conditions for the development of smart cities in Poland and their changes over time.

**Design/methodology/approach:** To achieve this goal, the first part of the article presents the distinguishing features of a smart city. Then, in national and international terms, the regions in which such units develop most dynamically and most often are indicated. In the second part of the article, the analysis of economic conditions is limited to Poland in the Voivodeship system. In the course of the study, budget data of Polish communes from 2003-2017 are used. The study covers the level of income per capita, as well as property and investment expenses, while looking for regularities and features that predispose a given region for creating smart cities. At the end, tips are formulated with the orientation both at supporting the idea of developing smart cities in Poland and preventing economic exclusion of those regions that are currently not actively participating in their creation.

**Findings:** The incomes of communes in Poland in all researched Voivodeships in the years 2003-2017 systematically increased. The overall increase in the value of income per capita over the fifteen year research period ranged from 78% to almost 120%. However, the fastest income growth rate concerned Voivodeships with the largest number of smart cities (already existing and listed in international rankings and classifications) and the highest absolute income per capita. These were the Masovian and Pomeranian Voivodeships, which, in connection with the above, can be considered the most entitled to create smart cities in Poland.

**Originality/value:** The research on financial aspects of smart cities development is rarely analyzed in literature and practice, therefore the results and conclusions fill the existing gap and contribute to municipal economics and management, especially in Poland.

**Keywords:** smart city, municipal economics and management; smart cities in Poland.

**Category of the paper:** research paper.

## 1. Introduction

A smart city is a response to the growing needs of residents of large cities. Most of them expect higher and higher quality of urban services (Osika, 2018; Rożałowska, 2018; Matussek, and Wolny, 2018; Wolniak, 2017), primarily including:

- trouble-free operation of urban technical and infrastructure systems (Karwot et al., 2016; Kaźmierczak et al., 2018; Ober et al., 2018),
- fast, secure and effective access to information, including the Internet (Sojda et al., 2018),
- flexible and diverse public transport (Dohn et al., 2019; Kożuch et al., 2018),
- minimizing pollution and greening life in the city (Ignac-Nowicka, 2018),
- green relaxation and recreation space,
- rich cultural, entertainment and tourist offer.

Meeting the above mentioned expectations is a real challenge for cities, due to two key circumstances. Some of them are contradictory to one another, for example the intensive development of city public transport may increase the level of environmental pollution. In addition, most of them are extremely costly, which is why smart cities most often arise and develop in regions with the highest level of economic and civilization development. A review of literature, rankings and statistics on smart cities indicates that their largest concentrations are in Europe and the United States of America. In Africa, apart from the sometimes mentioned Cairo, smart cities do not occur at all.

In light of the above, it can be concluded, that the potential opportunities for creating smart cities are closely correlated with their income and rich sources of funding. Although, you can also find unique and benchmarking examples of cooperation between the public and private sphere supporting the implementation of urban solutions in smaller and less prosperous urban units. The strong economization and technologization of smart cities, however, is not conducive to their widespread emergence and may also increase interregional distance in international, national and local perspectives, favor regional pauperization and pose a serious civilization threat.

In international rankings, units such as Warsaw and Wrocław appear most frequently on the list of smart cities located in Poland. In addition, some rankings include: Kraków, Gdynia, Gdańsk, Sopot, Opole, Katowice, Poznań, Łódź, Olsztyn, Lublin and Rzeszów (<https://www.forbes.com/sites/iese/2018/07/13/the-smartest-cities-in-the-world-in-2018>; IESE, 2019; Sikora-Fernandez, 2018). These are universally recognizable cities, very often being the capitals of Voivodeships. Their development is definitely faster than in other cities of the region, which is why they attract both the population and representatives of the business world, which allows them to gain additional developmental strength. Given the above circumstances, the main purpose of the article is to identify the economic conditions for the development of

smart cities in Poland and their changes over time in the long-term research perspective, covering 15 years of the functioning of Polish communes, i.e. the period of 2003-2017.

## **2. Methodology**

To achieve the above mentioned objective, the article uses budget data of Polish communes regarding income and expenditure of property and investment per capita. In the course of the analysis, an attempt was made to answer the following research questions:

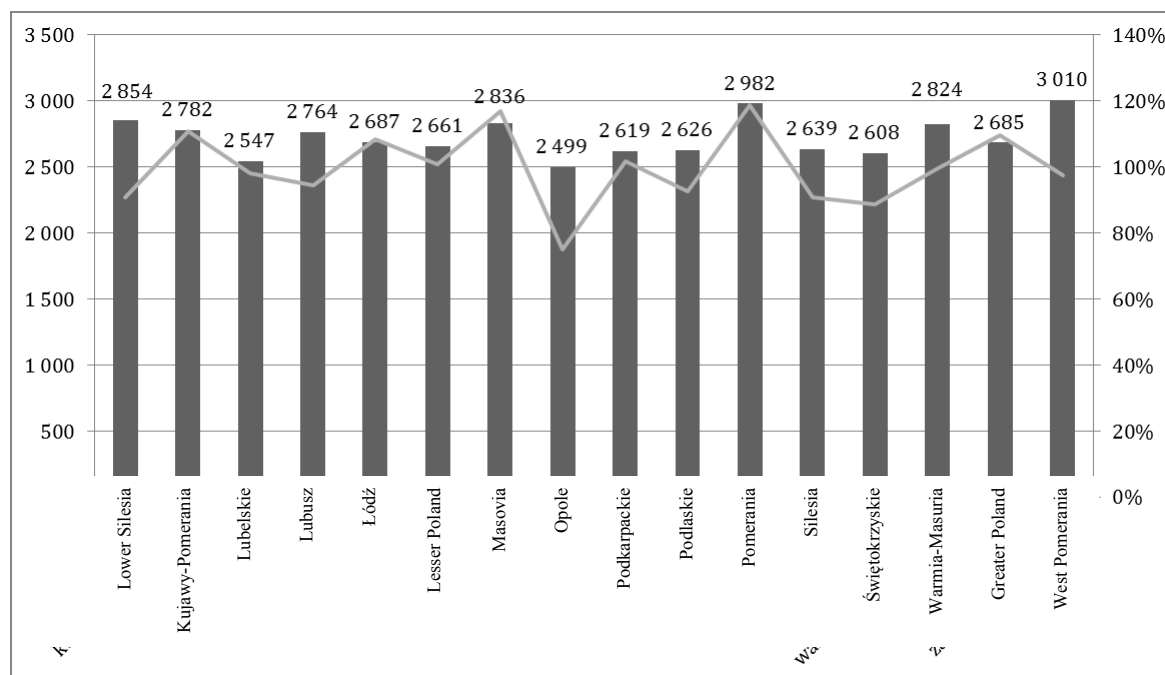
- How did the income of communes change in individual Voivodeships and how did it affect the possibilities of creating smart cities in them?
- What income do communes generate in Voivodeships in which smart cities are located? And what difference separates them in this respect from other communes in regional terms?
- How did the property and investment expenditure of communes in particular Voivodeships change over time, and what was the relative and absolute differentiation of these expenses in individual Voivodeships?
- Whether, and in what manner, the intensive development of communes, including creating the potential to implement smart solutions in individual Voivodeships, affect the debt of these units?

In answering the above research questions, dynamics indicators, standard deviation and coefficient of variation were used to determine the variability of the analyzed parameters over time. In addition, structure indicators and the arithmetic mean were used to determine the average of the variables researched horizontally. The research also indicates the minimum and maximum values and their range to illustrate the differentiation of individual parameters in the researched Voivodeships.

## **3. Analysis of communes' income by Voivodeships in the context of the possibility of creating smart cities in Poland**

The analysis of economic conditions for the development of smart cities in the Voivodeship system started from the income per capita. The average level of these incomes for communes located in individual Voivodeships in the years 2003-2017 is presented in Figure 1, together with the total value of its changes during the fifteen year research period.

Figure 1 shows that the average income of communes per capita in almost all Voivodeships exceeded PLN 2,500. The exception in this case is only the Opole Voivodeship, where the average is PLN 2,499. Four of the sixteen researched Voivodeships have an income exceeding PLN 2,800, and these are the following Voivodeships: Lower Silesia, Masovia, Pomerania and West Pomerania. In this list, only the West Pomeranian Voivodeship does not have a smart city, mentioned in the introduction to this article. Warsaw is in the Masovian Voivodeship, Wrocław is in the Lower Silesian Voivodeship, and as many as three smart urban units are located in Pomerania: Gdynia, Gdańsk and Sopot. It should be added, however, that smart cities such as: Opole, Kraków, Katowice, Lublin and Rzeszów were created in Voivodeships with lower profitability, and therefore the implementation of city solutions is also possible in less prosperous regions. Regions in which, according to international rankings, there are no smart cities, and which also have a low level of income (up to PLN 2,650) per capita are the following Voivodeships: Podkarpackie, Podlaskie and Świętokrzyskie, which can be considered as having the lowest development potential in this respect.



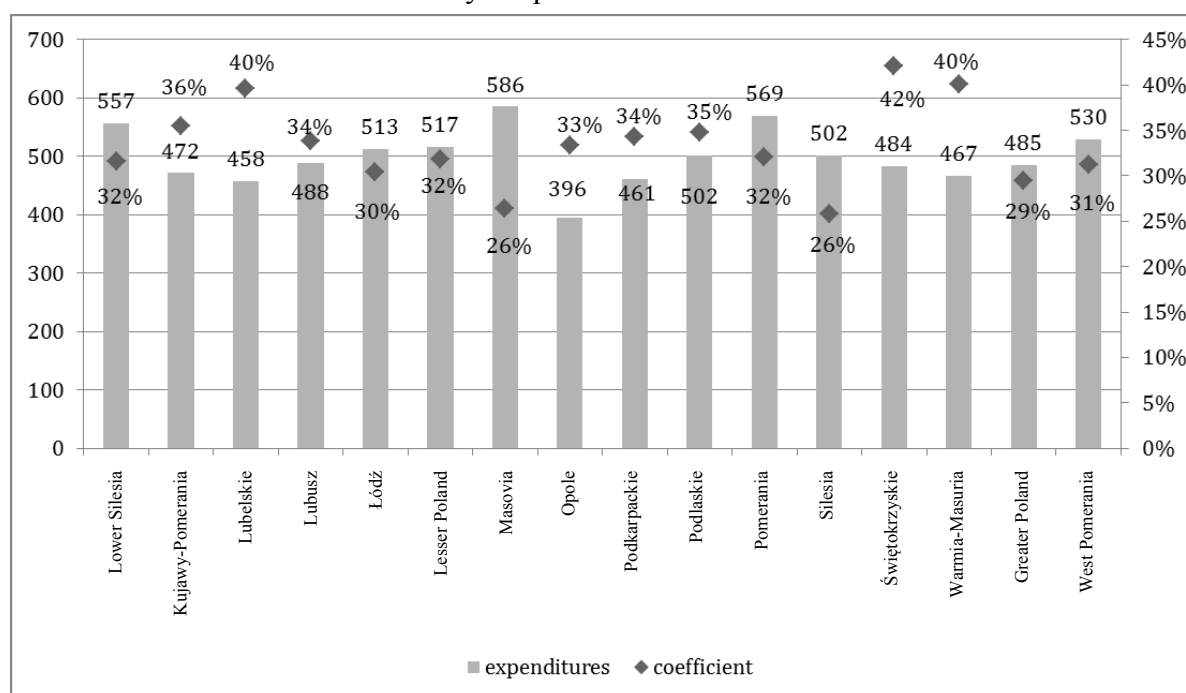
**Figure 1.** Average income per capita [in PLN] in Polish communes by Voivodeship and increase in income per capita in the years 2003-2017. Source: own compilation on the basis of data from the Ministry of Finance.

The level of income per capita in all analyzed communes systematically increased over time. Nevertheless, the level of this increase was very diverse and ranged from 78% (min.) in the Opole Voivodeship to almost 120% (max.) in the Masovian and Pomeranian Voivodeships. And it is these last two Voivodeships that can be considered the fastest developing. On the other hand, Podkarpackie and Świętokrzyskie Voivodeships were characterized by low dynamics of per capita income growth, which seems to confirm their above-mentioned lower possibilities in the creation of smart cities. It is also worth paying

attention to the relatively low income growth in the Opole and Silesian Voivodeships, which may signal some pauperization of these regions and a decrease in their ability to implement intelligent urban solutions.

#### 4. Analysis of property and investment expenditure of communes by Voivodeship in the context of the possibility of creating smart cities in Poland

An important economic parameter affecting the development of smart cities is the level of property expenditure, because, as already mentioned, the creation of these units requires significant outlays on technical and IT infrastructure. Figure 2 shows the average property expenditure of Polish communes per capita by Voivodeship in the years 2003-2017. In addition to that, it contains the value of the coefficient of variation for these expenses, which reflects the level of their fluctuations in the analyzed period.



**Figure 2.** Average property expenditure per capita [in PLN] in Polish communes by Voivodeship and the coefficient of variability of property expenditure in the years 2003-2017. Source: own compilation on the basis of data from the Ministry of Finance.

According to the data presented in Figure 2, the highest average level of property expenditure per capita was recorded in those Voivodeships, in which the level of expenditure per capita was also the highest. These Voivodeships are: Masovia, Pomerania, West Pomerania and Lower Silesia. At the same time, the differentiation of these expenses expressed by the PLN 190 range is quite significant, as it constitutes over 30% of the maximum value (PLN 586 for the Masovian Voivodeship).

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In the group of Voivodeships with significantly lower property expenditure per capita (below PLN 500), there were the Voivodeships: Opole, Lubelskie, Podkarpackie, Lubusz, Kujawy-Pomerania, Świętokrzyskie, Warmia-Masuria and Greater Poland. With a few exceptions (Opole or Greater Poland), these are less industrialized regions, in which urban-rural and rural communes dominate, and thus, by nature, less predisposed to being smart cities. In the aforementioned Voivodeships, property expenditure was also characterized by a significant level of differentiation, often exceeding 40%, which proves the difficulties in stabilizing property expenditure and creating a stable development policy, which is primarily due to lower and less stable income levels in these regions.

At a later stage of the analysis of economic conditions, reference was made to the share of investment expenditure, i.e. closely related to the new development potential, in total commune expenditure. The results of this analysis, broken down into Voivodeship in the years 2003-2017, together with their average value, are presented in Table 1.

**Table 1.**

*Share of investment expenditure in total expenditure in Polish communes by Voivodeship in years 2003-2017 [in %]*

Voivodeship	Years							
	2003	2004	2005	2006	2007	2008	2009	2010
Lower Silesia	14.86%	17.04%	16.42%	21.18%	19.71%	21.09%	21.36%	25.12%
Kujawy-Pomerania	15.30%	13.96%	14.57%	18.13%	14.26%	16.51%	20.91%	24.06%
Lubelskie	16.12%	17.46%	15.58%	17.18%	15.49%	15.82%	19.91%	26.34%
Lubusz	17.50%	16.79%	20.29%	21.40%	17.61%	16.62%	22.78%	27.02%
Łódź	17.61%	18.84%	19.35%	20.56%	19.63%	22.73%	24.63%	25.74%
Lesser Poland	18.44%	18.10%	18.45%	19.79%	18.88%	20.45%	23.19%	23.67%
Masovia	17.46%	21.04%	21.97%	23.96%	24.08%	26.57%	26.25%	24.09%
Opole	12.11%	15.15%	15.85%	18.47%	16.53%	15.45%	19.56%	22.03%
Podkarpackie	19.09%	18.43%	16.04%	17.55%	15.91%	16.84%	21.54%	24.66%
Podlaskie	20.60%	19.34%	19.82%	20.53%	16.30%	16.86%	25.20%	27.66%
Pomerania	16.70%	17.74%	17.03%	20.97%	18.47%	21.47%	21.61%	25.87%
Silesia	17.68%	19.75%	19.17%	21.81%	21.08%	20.24%	23.14%	23.59%
Świętokrzyskie	18.95%	20.94%	17.37%	20.20%	15.24%	16.73%	24.87%	28.18%
Warmia-Masuria	15.35%	14.62%	14.90%	16.50%	15.48%	16.34%	19.18%	26.38%
Greater Poland	16.51%	17.48%	18.47%	18.46%	17.82%	19.75%	21.15%	22.27%
West Pomerania	14.57%	17.57%	16.80%	20.57%	17.05%	19.46%	21.63%	23.13%

Cont table 1.

Voivodeship	Years							
	2011	2012	2013	2014	2015	2016	2017	average
Lower Silesia	22.46%	18.30%	17.39%	18.89%	16.30%	11.91%	16.66%	<b>19.60%</b>
Kujawy-Pomerania	21.06%	17.07%	14.93%	18.37%	17.54%	10.16%	12.99%	<b>17.21%</b>
Lubelskie	24.70%	18.83%	15.93%	18.64%	19.05%	9.89%	13.17%	<b>17.99%</b>
Lubusz	19.52%	12.76%	12.99%	16.89%	14.33%	9.88%	13.91%	<b>20.00%</b>
Łódź	21.46%	18.04%	17.27%	17.86%	16.36%	10.73%	15.01%	<b>21.14%</b>
Lesser Poland	25.68%	20.55%	17.70%	18.73%	19.28%	10.91%	12.57%	<b>20.12%</b>
Masovia	21.89%	18.23%	17.64%	18.75%	18.28%	13.18%	15.81%	<b>23.18%</b>
Opole	18.72%	14.28%	12.40%	14.33%	12.41%	8.40%	11.40%	<b>16.89%</b>
Podkarpackie	21.29%	15.84%	16.62%	17.74%	14.02%	10.51%	15.61%	<b>18.76%</b>
Podlaskie	23.32%	16.07%	17.34%	19.49%	19.12%	10.38%	15.06%	<b>20.79%</b>
Pomerania	23.99%	18.04%	16.29%	18.26%	17.28%	11.19%	14.54%	<b>19.98%</b>
Silesia	22.66%	17.88%	17.58%	18.66%	17.34%	10.53%	13.44%	<b>20.81%</b>
Świętokrzyskie	24.24%	18.02%	15.85%	17.14%	15.59%	8.02%	11.73%	<b>20.31%</b>
Warmia-Masuria	22.59%	16.74%	12.54%	14.84%	13.29%	8.92%	13.41%	<b>17.34%</b>
Greater Poland	21.13%	17.00%	14.17%	16.48%	14.38%	11.91%	15.90%	<b>18.99%</b>
West Pomerania	22.39%	17.87%	16.60%	16.19%	14.82%	9.32%	12.21%	<b>18.85%</b>

Source: own compilation on the basis of data from the Ministry of Finance.

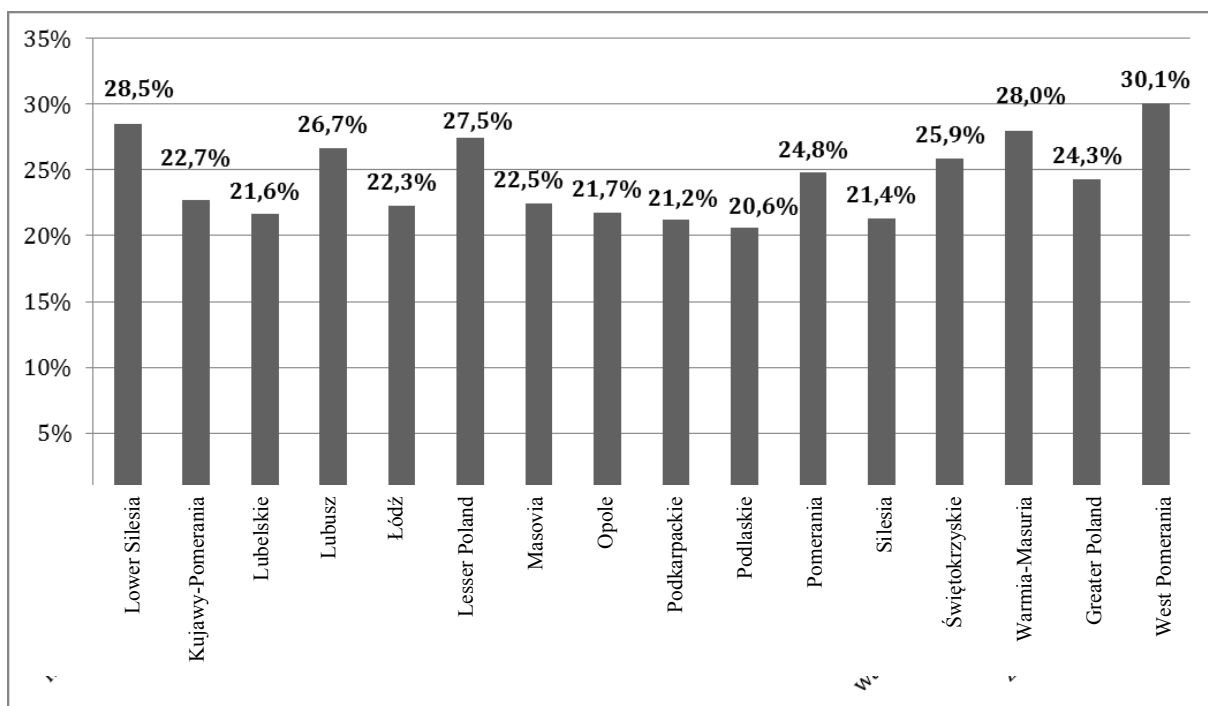
The development of all analyzed Voivodeships is positively demonstrated by the systematic increase in the share of investment expenditure in total expenditure, particularly intensive in the years 2003-2011, which is associated with the dynamic use of EU funds for the development and creation of new technical and IT infrastructure. In the years 2012-2016, the share of investment expenditure in total expenditure decreases, but already in 2017 the expenditure on this type of activity of communes is growing again. Voivodeships, in which the percentage of property expenditure was the highest – over 1/5 of total expenditure – are: Masovian, Łódź, Lubusz, Podlaskie, Lesser Poland, Silesian and Świętokrzyskie Voivodeship. In this case, attention should be paid to those Voivodeships, in which considerable investment expenditure was incurred, despite low income per capita. These include the Podlaskie and Świętokrzyskie Voivodeships, which means that they are trying to increase their development potential and may also be able to participate more intensively in the creation of smart cities in Poland.

## 5. The development of smart cities and the level of debt of communes in individual Voivodeships in the years 2003-2017

In the last part of the analysis of the economic conditions for the development of smart cities, it is worth answering the question about the sources of financing for this development, and specifically to what extent does this development occur at the expense of increasing the debt of communes in individual regions? In connection with the above, Figure 3 presents the average share of liabilities of Polish communes in total revenues generated by Voivodeships in the years 2003-2017. The data presented on it shows that the share of this debt in total revenues in all Voivodeships in the analyzed period was on average over 20%, which means that its

repayment with the involvement of 2% of achieved revenues would last a minimum of 10 years. At the same time, it is worth emphasizing, that the majority of communes in Poland have a deficit budget balance, and the level of rare financial surpluses does not exceed 3%, which means that the real time of repayment of this debt extends to a dozen or even several dozen years in the case of communes with the highest level debt.

Voivodeships in which the average debt was the highest (over 25%) are: West Pomerania, Lower Silesia, Warmia-Masuria, Lesser Poland, Świętokrzyskie and Lubusz. These include two Voivodeships with the highest level of profitability and a significant potential for creating smart cities, i.e. the West Pomeranian and Lower Silesian Voivodeships, which proves that the intensive development of these regions was largely at the expense of increasing debt, and thus the cost of growth financing risk. The most indebted group also includes the Świętokrzyskie Voivodeship, characterized by one of the lowest profitability levels, but with high investment parameters. In this case, financing development needs by returnable foreign sources is subject to an even higher level of risk than in the case of the two above-mentioned Voivodeships, due to considerably smaller possibilities of obtaining income per capita.

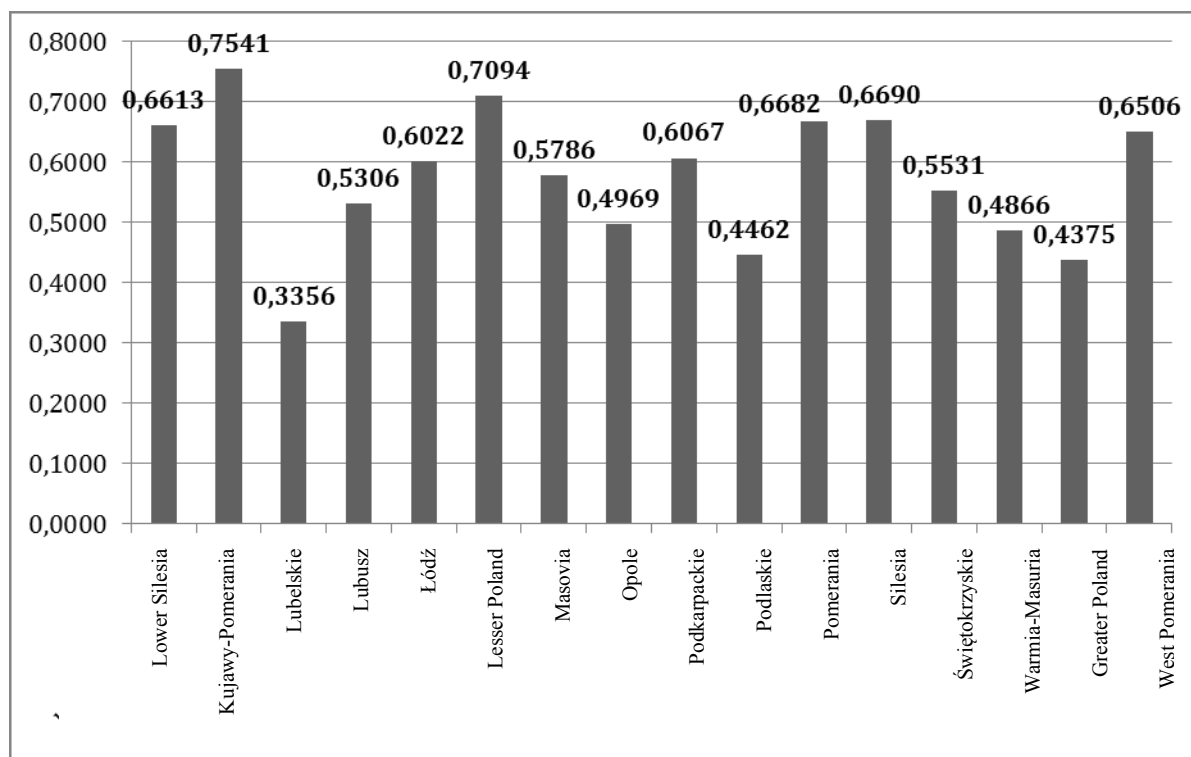


**Figure 3.** The average share of liabilities of Polish communes in total revenues generated by Voivodeships in the years 2003-2017. Source: own compilation on the basis of data from the Ministry of Finance.

The above conclusions are also confirmed by the analysis of the dependencies between the level of commune debt in the researched Voivodeships and the amount of property expenditure in these communes. The results of this analysis in the form of Pearson's linear correlation coefficients for the significance level  $p = 0.1$  are presented in Figure 4. The strongest correlations relate to the Kujawy-Pomerania and Lesser Poland Voivodeships, which also noted as one of the higher levels of investment expenditure (average share in total expenditure over



20%). Important correlations between the indicated variables are also characterized by such Voivodeships as: Lower Silesia, Łódź, Podkarpackie, Pomerania, Silesia and West Pomerania. Three among those mentioned (Lower Silesia, Pomerania and West Pomerania) are in the group of Voivodeships identified in the introduction as predisposed to creating smart cities in Poland.



**Figure 4.** Pearson's linear correlation coefficients between the average share of liabilities of Polish communes in total revenues generated and the level of property expenditure per capita by Voivodeship in the years 2003-2017. Source: own compilation on the basis of data from the Ministry of Finance.

## 6. Summary

In this article, three key research questions are posed in the methodological subsection. Synthetic answers to these questions, which are the result of analyses and assessments, are presented below. The incomes of communes in Poland in all researched Voivodeships in the years 2003-2017 systematically increased. The overall increase in the value of income per capita over the fifteen year research period ranged from 78% to almost 120%. However, the fastest income growth rate concerned Voivodeships with the largest number of smart cities (already existing and listed in international rankings and classifications) and the highest absolute income per capita. These were the Masovian and Pomeranian Voivodeships, which, in connection with the above, can be considered the most entitled to create smart cities in Poland.

Communes located in Voivodeships with the highest level of income per capita had an average income above PLN 2,900 (PLN 3,010 in the Masovian Voivodeship and PLN 2,982 in the Pomeranian Voivodeship). The amount of PLN 400-500 separated them from communes located in Voivodeships with the lowest income level, which constituted about 13-16% of the maximum value. This is quite a significant differentiation that may hinder the development of smart cities in regions with lower industrialization and population.

The tendency conducive to the implementation of intelligent solutions – apart from the overall increase in commune incomes – was also an increase in property expenditure over time. Nevertheless, the differentiation of individual regions deepened in this respect, which in the case of this parameter was over 30%, which proves the increasingly clear dominance of the wealthiest Voivodeships, which once again turned out to be: Masovian, Lower Silesian, Pomeranian and West Pomeranian Voivodeship.

The share of investment expenditure in individual Voivodeships in the years 2003-2011 increased quite dynamically, due to the development of infrastructure financed from EU funds. From 2011 this tendency clearly weakened until 2017, when again all Voivodeships increased the level of investment financing. This time, the group of the most intensively investing Voivodeships also includes those with lower income and property expenditure per capita, such as the Voivodeships: Łódź, Lubusz, Podlaskie, Lesser Poland, Silesia and Świętokrzyskie.

Nevertheless, in some of the above-mentioned Voivodeships, the development took place at the expense of an increase in debt, in particular in the Świętokrzyskie, Lubusz and Sielsian Voivodeships. The group of the most seriously indebted includes also the two most prosperous Voivodeships, namely: Lower Silesia and West Pomerania.

The analysis shows that both the increase in income and the accompanying increase in property expenditure in the years 2003-2017 favored the development of smart cities in Poland. Nevertheless – due to the considerable differences in income and expenditure – this development was most certainly uneven. West Pomeranian and Pomeranian Voivodeships were developing the fastest, i.e. the north-west region of Poland, as well as the Masovian and Lower Silesian Voivodeships, located in the central and south-western regions respectively. Other regions in the analyzed categories were far behind the leaders, where this difference may increase over time and promote pauperization of less prosperous, less industrialized regions, and thus less predisposed to creating smart cities in Poland. This is one of the most serious threats associated with the uprising and development of smart cities, not only in Poland, but also in the world.

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