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# A Quantitative Picture of the Diversity of Technical Infrastructure in the Catchment Areas of Airports in Poland

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Abstract: Recent years have brought a very extensive discussion on the definition of regional competitiveness and factors influencing the improvement of the competitive position. The problem of competitiveness is being discussed more and more widely in research on the regional and local economy. Its main factors include technical infrastructure. The aim of the analysis was to verify the differences in its level in districts located in the area of influence of airports in Bydgoszcz, Poznań and Wrocław in the future. Recently, many publications have been published in which researchers make an effort to identify the differences in infrastructure in the regions of the European Union. In the European literature, the lack of articles examining it in the areas of overlapping airport isochrones is particularly acute. The author decided to fill this gap by conducting research, a fragment of which is included in the text, and which is a continuation of previously published research. The research and forecasting tool was the medium-term rate of change method. The forecasts were prepared for the years 2022-2023. The results obtained from the analysis allowed to draw detailed conclusions.

Keywords: regional development management; spatial management; forecasting; sustainable development; air transport; airport isochrones

JEL Classification: R11; O11

## 1. Introduction

The literature presents various definitions and concepts (see Surówka (2007) or Surówka (2009) or Polna (2017) or Maciulyte-Sniukiene et al. (2022) or Fourie (2006) or Klepacka – Dunajko (2017) or Kroszel (1997)). One of them defines it as a complex of public utility facilities necessary to ensure the proper functioning of the national economy and the life of the population, appropriately distributed in space, along with historically shaped internal and at the same time characteristic relations between the individual elements (Kupiec et al., 2005). According to another author, it is a set of devices, networks of buildings and systems that do not directly relate to the production of material goods, but are necessary for the implementation of the production process itself. It is undeniable that broadly understood infrastructure is one of the factors traditionally indicated in both development and competitiveness theories (Pomianek, 2020). Among a wide range of development factors, great importance is attached to infrastructural equipment, especially in territorial units characterized by a low level of socio-economic development. Infrastructure investments are

of fundamental importance for stimulating the economic strength of the region, as they constitute the basis for supporting various activities that will result in economic growth (Miłek, 2022). As some authors rightly point out, the level of infrastructure development may determine the attractiveness of a spatial unit, and thus constitute an important element of regional or local competitiveness, as well as determine opportunities or threats for further development. Investment in infrastructure is key to stimulating economic dynamics as it forms the basis for supporting various measures aimed at economic growth (Miłek, 2022). In their research, some authors analyze the relationship between infrastructure and entrepreneurship (see Audretsch et al., 2015). Technical infrastructure plays an important role in stimulating social and economic development (Chwastek et al., 2021). As mentioned, the literature on the subject provides many definitions of this concept. It is a popular statement that it should be understood as basic devices and institutions providing services necessary for the proper functioning of the economy and the life of society (Wawrzyniak, 2015). In one of the works, a very synthetic and general definition was given, according to which it is a set of technical devices for public use that are the product of people, appropriately organized into systems, the functional effects of which are important for the functioning of the economy and people's existence (Surówka, 2007). In addition to the diversity of infrastructure concepts, there is also a lack of uniform classification of this concept. It is most often divided into technical and social. The first of them are devices, industrial networks and related facilities that provide necessary and basic services for a specific spatial and economic entity in the field of energy, heat and water supply, sewage and waste disposal, transport, telecommunications, etc. (Surówka, 2007). On the other hand, institutions in the field of education and upbringing, dissemination of culture, health care, social welfare and housing, which serve to improve the general standard of living of residents, are called social infrastructure. The author defines this issue similarly, according to whom it should be understood as a set of public utility devices necessary primarily to ensure the proper functioning of the national economy and proper integration of individual systems of the socio-economic space. By some authors it is also called economic, technical-economic, production or economic (Surówka, 2007). The literature also quite often emphasizes the fact that while in the case of technical infrastructure there is agreement as to the scope of this concept, in the case of social infrastructure there is no unanimity. It must be stated with certainty that infrastructure is increasingly often associated as a source of competitive advantage. Without increasing the level of infrastructure development, it is impossible to achieve the appropriate level of development. Therefore, according to some authors (Sztando, 2004), infrastructure development should support the development of entrepreneurship.

In the own research presented in the practical part, several specific goals were set. One of them is an attempt to determine whether economic development processes in some regions have been and still are conducive to increasing the competitiveness of weaker areas or widening disproportions. During the research procedure, the following hypotheses were also formulated: Hypothesis 1:. Districts located in the areas of influence of the studied airports are characterized by dynamic changes in the diversification of infrastructure development, which translates into significant variability of positions in the rankings for selected features

characterizing them. Moreover, counties located in the areas of influence of overlapping isochrones occupy distant places in the rankings. Hypothesis 2: The values of features characterizing infrastructure are not subject to dynamic changes, which means that preparing forecasts of this phenomenon should be considered important. During the research, both hypotheses were verified and the goal was achieved.

## 2. Forecasting as a Research Tool

Forecasting is the rational and scientific prediction of the future. According to another definition, it is a rational, scientific prediction of future events, the result of which is a forecast. The forecasting process must be carefully planned and carefully carried out. In addition to the analyst, the recipient of the forecast should also participate in it. The recipient does not need to know forecasting methods; it is enough that the requirements regarding the shape and result are clearly formulated. The forecasting process consists of the following elements:

- Formulation of the forecasting task
- Formulation of prognostic premises
- Choosing a forecasting method
- Forecast construction
- Forecast verification

Forecasting uses information about these factors and their impact on the phenomenon under study. Forecasting examines the relationship between these factors and the phenomenon under study, as well as the formation in the past in order to draw conclusions about the future. Statistical and mathematical sciences are used for forecasting. The diversity of definitions is justified by the diversity of forecasting situations, goals and research methods. Forecasting supports decision-making processes and prepares other activities, this is the basic function – preparatory. The activating function of the forecast consists in stimulating actions conducive to the implementation of the forecast. The information function prepares people for upcoming changes and reduces fear of them. Many methods are used for forecasting. In the practical part, the medium-term rate of change method was used (Surówka, 2023). Forecasts using this method are made using the following formulas:

$$\overline{\mathrm{T_n}} = (\overline{i_g} - 1) \cdot 100\% \tag{1}$$

where:

$$\overline{i_g} = \sqrt[n-1]{i_{n/n-1} \cdot i_{n-1/n-2} \cdot \ldots \cdot i_{2/1}} \tag{2}$$

Then, the forecast values are determined according to the formula:

$$K_n = K_0 (1+r)^n \tag{3}$$

$K_n$ – forecast of the value of the feature in the period n

$K_0$ – value of the variable from the last research period

r – medium-term pace of change

n – number of periods

## 3. Dynamic and Prognostic Analysis of the Diversity of Technical Infrastructure in the Areas Affected by Airports in Poznań, Wrocław and Bydgoszcz

There are various criteria for separating the area of influence of air transport in the literature. One of them is the area of a circle with a radius of about 100 km in the center of which there is an airport. This method is quite often called isochronous and it was used in our own research.

In our own research, at the beginning, based on the literature, the names of districts located in the impact zones of the Bydgoszcz Szwederowo, Poznań - Ławica and Wrocław - Strachowice Airports were defined. The obtained results are presented in table 1.

Then, statistical material was collected for the features most often used to define technical infrastructure. Due to the fact that it should be considered from a multi-level and multi-aspect perspective. Moreover, as some authors rightly point out, infrastructure is most often presented as a set of devices and facilities that perform ancillary functions in relation to other spatial systems. Taking into account one element of infrastructure, it is not possible to assess the infrastructure due to significant differences in the spatial distribution of indicators (Kołodziejczyk, 2017). Taking the above into account, it was finally decided to define the examined category using nine measures that could, at least approximately, define the examined phenomenon. The choice of these measures was dictated by the availability of research material and based on previous research experience (Salamon et al., 2018), (Surówka, 2022). Ultimately, the examined category was defined using the following indicators:

$X_9$ - population using sewage treatment plants as a percentage of the total population (%)

$X_8$ - length of municipal and district public roads with paved surfaces (in km)

$X_7$ – length of public municipal and district roads with unpaved surfaces in km per 100 square kilometers of surface

$X_6$ – length of public municipal and district roads with hard surfaces in km per 100 square kilometers of area

$X_5$ - percentage of all apartments connected to the sewage system

$X_4$ – percentage of all apartments connected to the water supply network

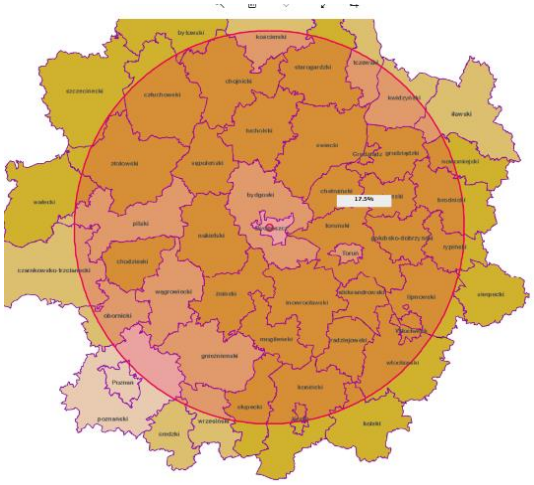
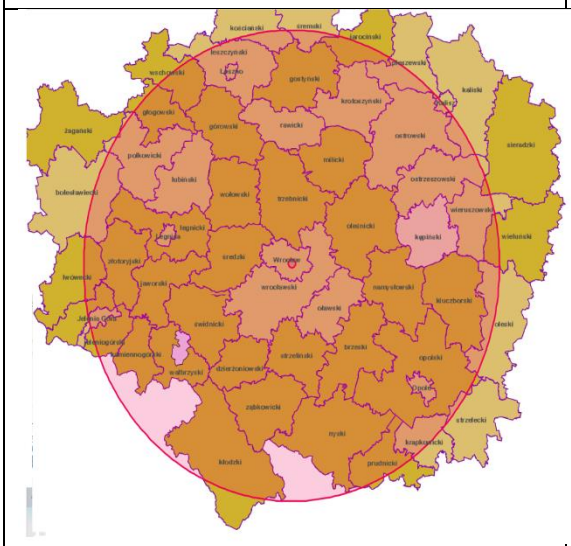
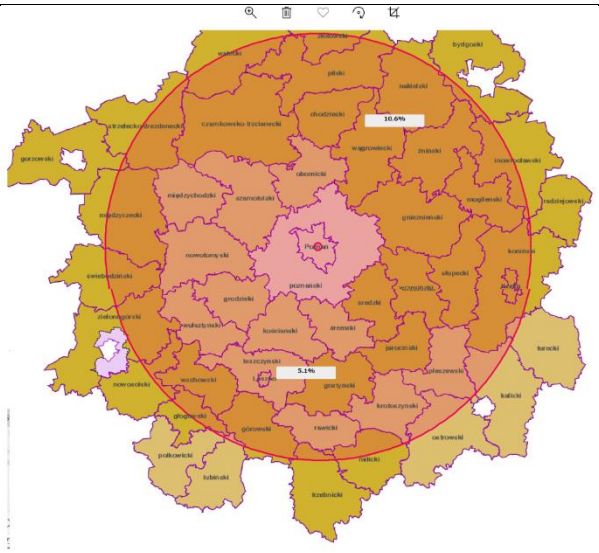
$X_3$ - length of the gas distribution network in km per 100 square kilometers of area

$X_2$ - length of the water distribution network in km per 100 square kilometers of area

$X_1$ - length of the sewage distribution network in km per 100 square kilometers of area

The next step to achieve the research goals was a detailed quantitative analysis of the obtained statistical information. Then forecasts were made. The medium-term rate of change method was chosen as the research tool. The forecast period covered the years 2022-2023. Forecasting is the prediction of phenomena and processes in the future based on scientific foundations. The author defines this issue similarly, according to whom forecasting is a scientific method of predicting how processes or events will develop in the future. They are most often used to minimize uncertainty about future events that will occur in the future. Such action provides information on the topic we are interested in, prompts us to make decisions related to the implementation of the prepared forecast and prepares us to take other

Table 1. Districts and cities with districts rights located within the area of influence of airports in Wrocław, Bydgoszcz and Poznań

| | |
|---|---|
| Bydgoszcz Szweredowo Airport<br>  | Bydgoszcz Szweredowo Airport (districts and cities with district rights): bydgoski, toruński, Bydgoszcz, Toruń, brodnicki, chełmiński, golubsko-dobrzyński, grudziądzki, rypiński, wąbrzeski, Grudziądz (Gdańsk), aleksandrowski, lipnowski, radziejowski, włocławski, Włocławek, inowrocławski, mogileński (Poznań), nakielski (Poznań), żniński (Poznań), sępoleński, świecki, tucholski |
| Wrocław - Strachowice Airport<br>  | Poznań Ławica Airport<br>  |
| Wrocław – Strachowice Airport (districts and cities with district rights): wrocławski, Wrocław, Opole (Katowice), Leszno (Poznań), lubiński, leszczyński (Poznań), Legnica, jeleniogórski, śremski (Poznań), średzki (Poznań), oławski, ostrowski, trzebnicki, kościański (Poznań), ostrzeszowski, Jelenia Góra, świdnicki, kępiński, bolesławiecki, gostyński (Poznań), pleszewski (Poznań), oleśnicki, brzeski (Kraków, Rzeszów, Katowice) głogowski, milicki, polkowicki, namysłowski (Katowice), złotoryjski, wschowski (Poznań), jarociński (Poznań), ząbkowicki, legnicki, opolski (Rzeszów, Katowice), kluczborski (Katowice), rawicki (Poznań), krotoszyński (Poznań), krapkowicki, wołowski, dzierżoniowski, nyski (Katowice), wieruszowski (Katowice), strzeliński, jaworski, wałbrzyski, kłodzki, lwówecki, kamiennogórski, prudnicki (Katowice), górowski (Poznań) | |
| Poznań Ławica Airport (districts and cities with district rights): górowski (Wrocław), mogileński (Bydgoszcz), nakielski (Bydgoszcz) , żniński (Bydgoszcz), międzyrzecki, sulęciński, wschowski (Wrocław), Zielona Góra, chodzieski, czarnkowsko-trzcianecki (Szczecin), gnieźnieński, gostyński (Wrocław), grodziski (Warszawa), jarociński (Wrocław), koniński, kościański (Wrocław), krotoszyński (Wrocław), leszczyński (Wrocław), międzychodzki, nowotomyski, obornicki, pilski, pleszewski (Wrocław), poznański, rawicki (Wrocław), słupecki, szamotulski, średzki (Wrocław), śremski (Wrocław), wągrowiecki, wolsztyński, wrzesiński, Konin, Leszno (Wrocław), Poznań, choszczeński (Szczecin) | |

actions. The main goal of the presented part of the study is to identify the degree of diversification of infrastructural development of counties located in the zones of influence of selected airports in Poland in the forecast period. The main reason for undertaking the research was the poor interest of researchers in the discussed issues. The results from the second stage (forecast values) for the first three indicators are presented in tables 2-4. In Table 2, information for four counties located in the catchment areas of at least two airports is bold. The tables also contain information about the positions occupied in the rankings by the surveyed units in 2023.

Table 2. Forecast of the length of the distribution network in counties located in the impact areas of the Bydgoszcz Szweredowo Airport (2021-2022)

| | 2021 | 2022 | 2023 | | 2021 | 2022 | 2023 | | 2021 | 2022 | 2023 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Variable $X_1$ | | | R | Variable $X_2$ | | | R | Variable $X_3$ | | | R |
| Aleksandrowski | 59.9 | 61.99 | 64.15 | 6 | 189.8 | 190.61 | 191.41 | 5 | 21.2 | 22.54 | 23.97 | 9 |
| Brodnicki | 48.0 | 48.68 | 49.37 | 11 | 145.0 | 145.94 | 146.89 | 13 | 13.1 | 15.43 | 18.18 | 13 |
| Bydgoski | 50.0 | 51.92 | 53.92 | 7 | 125.2 | 127.12 | 129.06 | 16 | 45.8 | 51.37 | 57.62 | 5 |
| Chełmski | 48.1 | 49.01 | 49.95 | 8 | 147.1 | 147.72 | 148.35 | 11 | 21.3 | 23.72 | 26.41 | 8 |
| Golubsko-dobrzyński | 30.7 | 31.10 | 31.51 | 19 | 178.7 | 179.09 | 179.49 | 6 | 6.0 | 6.67 | 7.42 | 21 |
| Grudziącki | 32.2 | 33.41 | 34.67 | 15 | 158.8 | 160.38 | 161.97 | 9 | 16.6 | 18.62 | 20.89 | 11 |
| Inowrocławski | 48.5 | 49.14 | 49.79 | 9 | 126.5 | 127.69 | 128.89 | 17 | 27.8 | 29.44 | 31.18 | 6 |
| Lipnowski | 15.3 | 15.95 | 16.64 | 23 | 148.5 | 148.93 | 149.36 | 10 | 0.8 | 0.86 | 0.93 | 23 |
| Radziejowski | 21.6 | 22.11 | 22.63 | 22 | 169.1 | 170.02 | 170.95 | 7 | 4.8 | 5.55 | 6.42 | 22 |
| Rypiński | 34.5 | 35.82 | 37.19 | 14 | 146.2 | 146.87 | 147.54 | 12 | 7.6 | 9.16 | 11.05 | 19 |
| Sępoleński | 29.7 | 30.87 | 32.08 | 18 | 87.0 | 87.68 | 88.37 | 22 | 9.4 | 9.98 | 10.59 | 20 |
| Świecki | 47.6 | 48.49 | 49.39 | 10 | 107.6 | 108.36 | 109.12 | 19 | 12.9 | 14.07 | 15.35 | 16 |
| Toruński | 61.1 | 63.42 | 65.82 | 5 | 138.3 | 139.95 | 141.62 | 15 | 23.2 | 25.77 | 28.63 | 7 |
| Tucholski | 44.5 | 45.21 | 45.93 | 13 | 80.6 | 80.78 | 80.96 | 23 | 14.4 | 15.65 | 17.01 | 14 |
| Wąbrzeski | 45.2 | 45.58 | 45.97 | 12 | 162.0 | 162.72 | 163.43 | 8 | 15.9 | 17.62 | 19.53 | 12 |
| Włocławski | 27.6 | 29.13 | 30.74 | 20 | 144.1 | 145.33 | 146.57 | 14 | 10.9 | 11.27 | 11.64 | 18 |
| Bydgoszcz | 408.5 | 411.82 | 415.17 | 2 | 365.7 | 367.99 | 370.30 | 2 | 400.2 | 406.74 | 413.38 | 1 |
| Toruń | 596.3 | 622.75 | 650.37 | 1 | 352.9 | 358.77 | 364.74 | 3 | 379.5 | 383.00 | 386.53 | 3 |
| Włocławek | 307.8 | 317.14 | 326.76 | 4 | 252.1 | 248.57 | 245.09 | 4 | 254.9 | 256.83 | 258.77 | 4 |
| Mogieliński | 33.6 | 33.91 | 34.23 | **16** | 106.7 | 107.03 | 107.36 | **20** | 13.1 | 13.82 | 14.58 | 17 |
| Nakielski | 25.0 | 25.63 | 26.27 | **21** | 86.6 | 88.01 | 89.44 | **21** | 17.5 | 19.26 | 21.19 | 10 |
| Żniński | 32.7 | 32.92 | 33.14 | **17** | 108.0 | 109.01 | 110.03 | **18** | 13.8 | 14.95 | 16.20 | 15 |
| Grudziądz | 361.1 | 366.27 | 371.52 | **3** | 379.3 | 385.55 | 391.91 | **1** | 385.0 | 392.24 | 399.61 | 2 |

Analyzing the information contained in Table 2, we notice that the length of the distribution network in the counties located in the catchment area of the Bydgoszcz Szweredowo Airport varies. The analyzed set of variables is characterized by varying variability. The clear leader in terms of the length of the sewage distribution network is Toruń, the water distribution network is Grudziądz and the gas distribution network is Bydgoszcz. This allows us to claim that the highest places in the ranking are occupied by district cities. The catchment area of the Bydgoszcz airport also includes the mogieliński and żniński districts, which are also located in the isochrone area of the second Poznań Ławica Airport covered by the study. In terms of the second and third features, żniński districts is more distant in the area of influence of this port. The situation is definitely the worst (in the

Table 3. Forecast of the length of the distribution network in counties located in the impact area of the Wrocław - Strachowice Airport (2021-2023)

| | 2021 | 2022 | 2023 | | 2021 | 2022 | 2023 | | 2021 | 2022 | 2023 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Variable $X_1$ | | | R | Variable $X_2$ | | | R | Variable $X_3$ | | | R |
| Bolesławiecki | 71.0 | 73.61 | 76.32 | 17 | 59.1 | 60.01 | 60.94 | 40 | 21.2 | 22.05 | 22.93 | 33 |
| Dzierżoniowski | 58.0 | 58.49 | 58.98 | 23 | 75.5 | 76.33 | 77.18 | 31 | 62.7 | 63.91 | 65.14 | 10 |
| Głogowski | 88.6 | 91.62 | 94.75 | 13 | 99.9 | 100.99 | 102.09 | 17 | 58.3 | 61.66 | 65.22 | 9 |
| Górowski | 11.1 | 11.45 | 11.81 | 47 | 60.2 | 61.10 | 62.01 | 39 | 12.4 | 12.54 | 12.68 | 45 |
| Jaworski | 59.9 | 61.67 | 63.49 | 21 | 61.7 | 62.54 | 63.40 | 38 | 19.3 | 19.51 | 19.72 | 35 |
| Kamiennogórski | 47.3 | 48.10 | 48.91 | 27 | 76.0 | 76.98 | 77.98 | 30 | 33.8 | 36.75 | 39.97 | 23 |
| Kłodzki | 36.9 | 38.17 | 39.49 | 35 | 54.2 | 55.28 | 56.38 | 42 | 32.0 | 33.50 | 35.07 | 28 |
| Legnicki | 83.4 | 86.22 | 89.14 | 14 | 77.6 | 77.92 | 78.24 | 29 | 38.9 | 41.44 | 44.15 | 21 |
| Lubiński | 98.1 | 100.57 | 103.11 | 10 | 77.8 | 79.04 | 80.29 | 28 | 62.5 | 63.75 | 65.02 | 11 |
| Lwówecki | 33.5 | 34.17 | 34.86 | 39 | 50.2 | 50.76 | 51.33 | 46 | 9.5 | 9.72 | 9.95 | 46 |
| Milicki | 41.8 | 43.81 | 45.91 | 31 | 55.2 | 55.75 | 56.30 | 43 | 15.8 | 16.25 | 16.70 | 41 |
| Oleśnicki | 35.8 | 36.88 | 37.99 | 36 | 89.6 | 90.77 | 91.96 | 21 | 34.7 | 36.02 | 37.39 | 25 |
| Oławski | 101.2 | 108.36 | 116.03 | 6 | 104.4 | 109.88 | 115.64 | 11 | 52.8 | 57.53 | 62.68 | 13 |
| Polkowicki | 63.2 | 64.75 | 66.34 | 19 | 70.3 | 71.34 | 72.39 | 33 | 42.8 | 44.11 | 45.47 | 20 |
| Strzeliński | 35.7 | 37.75 | 39.92 | 34 | 58.4 | 58.67 | 58.95 | 41 | 12.3 | 13.23 | 14.22 | 44 |
| Świdnicki | 92.9 | 100.62 | 108.98 | 7 | 107.7 | 108.62 | 109.54 | 14 | 50.1 | 51.37 | 52.67 | 15 |
| Trzebnicki | 26.0 | 27.46 | 29.00 | 45 | 81.4 | 82.67 | 83.96 | 25 | 34.4 | 35.85 | 37.37 | 26 |
| Wałbrzyski | 48.3 | 47.53 | 46.78 | 29 | 69.7 | 67.01 | 64.43 | 37 | 44.8 | 42.09 | 39.55 | 24 |
| Wołowski | 39.9 | 40.88 | 41.88 | 33 | 49.8 | 50.41 | 51.04 | 47 | 17.2 | 18.37 | 19.63 | 36 |
| Wrocławski | 98.3 | 102.49 | 106.86 | 8 | 144.5 | 148.69 | 153.01 | 7 | 81.7 | 89.03 | 97.02 | 7 |
| Ząbkowicki | 28.1 | 29.04 | 30.01 | 43 | 66.7 | 69.49 | 72.41 | 32 | 17.0 | 17.99 | 19.04 | 37 |
| Złotoryjski | 43.5 | 44.01 | 44.52 | 32 | 54.8 | 55.50 | 56.20 | 44 | 16.7 | 17.44 | 18.21 | 39 |
| Jelenia Góra | 265.2 | 271.84 | 278.64 | 5 | 337.4 | 341.57 | 345.79 | 5 | 276.1 | 285.87 | 295.99 | 4 |
| Legnica | 379.1 | 382.67 | 386.28 | 4 | 366.7 | 370.07 | 373.48 | 3 | 390.4 | 398.58 | 406.94 | 3 |
| Wrocław | 436.0 | 454.24 | 473.25 | 2 | 463.9 | 466.34 | 468.79 | 2 | 491.9 | 493.42 | 494.95 | 2 |
| Wschowski | 31.7 | 33.01 | 34.38 | 41 | 53.6 | 54.34 | 55.08 | 45 | 15.3 | 16.33 | 17.43 | 40 |
| Wieruszowski | 50.8 | 51.78 | 52.77 | 26 | 108.3 | 109.25 | 110.21 | 13 | 6.1 | 6.60 | 7.14 | 47 |
| Brzeski | 90.4 | 95.40 | 100.67 | 11 | 153.3 | 157.03 | 160.84 | 6 | 193.8 | 196.55 | 199.34 | 6 |
| Ostrowski | 19.6 | 20.55 | 21.55 | 46 | 86.7 | 87.51 | 88.34 | 22 | 18.3 | 19.61 | 21.02 | 34 |
| Kluczborski | 28.6 | 30.02 | 31.51 | 42 | 64.4 | 64.66 | 64.92 | 35 | 17.0 | 17.86 | 18.76 | 38 |
| Krapkowicki | 89.4 | 94.17 | 99.19 | 12 | 91.6 | 92.00 | 92.40 | 20 | 43.6 | 45.19 | 46.83 | 19 |
| Namysłowski | 29.3 | 32.18 | 35.34 | 38 | 64.6 | 65.33 | 66.06 | 34 | 12.8 | 13.62 | 14.50 | 42 |
| Nyski | 48.4 | 50.57 | 52.84 | 25 | 81.5 | 83.59 | 85.73 | 24 | 29.8 | 30.98 | 32.21 | 30 |
| Opolski | 80.1 | 83.83 | 87.73 | 15 | 87.4 | 87.48 | 87.56 | 23 | 26.1 | 29.27 | 32.83 | 29 |
| Prudnicki | 27.8 | 28.58 | 29.37 | 44 | 64.1 | 64.50 | 64.90 | 36 | 14.0 | 14.20 | 14.41 | 43 |
| Opole | 376.7 | 387.10 | 397.79 | 3 | 348.7 | 354.99 | 361.39 | 4 | 277.9 | 277.47 | 277.04 | 5 |
| Gostyński | 45.8 | 47.31 | 48.87 | 28 | 95.8 | 96.44 | 97.09 | 19 | 63.8 | 64.04 | 64.28 | 12 |
| Jarociński | 98.8 | 101.23 | 103.72 | 9 | 116.9 | 117.55 | 118.21 | 10 | 66.9 | 68.05 | 69.22 | 8 |
| Kępiński | 71.2 | 75.30 | 79.64 | 16 | 106.0 | 106.84 | 107.69 | 15 | 21.1 | 22.87 | 24.80 | 32 |
| Kościański | 62.8 | 65.76 | 68.86 | 18 | 99.9 | 100.50 | 101.09 | 18 | 57.2 | 58.94 | 60.73 | 14 |
| Krotoszyński | 34.6 | 35.55 | 36.53 | 37 | 114.3 | 114.38 | 114.46 | 12 | 44.6 | 45.97 | 47.37 | 18 |
| Leszczyński | 46.0 | 49.83 | 53.98 | 24 | 79.8 | 81.20 | 82.63 | 26 | 42.3 | 45.53 | 49.01 | 16 |
| Ostrzeszowski | 33.3 | 34.04 | 34.80 | 40 | 130.8 | 131.25 | 131.71 | 8 | 34.3 | 34.91 | 35.52 | 27 |
| Pleszewski | 40.0 | 42.95 | 46.11 | 30 | 118.6 | 120.19 | 121.80 | 9 | 26.7 | 27.63 | 28.60 | 31 |
| Rawicki | 60.3 | 62.13 | 64.01 | 20 | 81.7 | 82.09 | 82.48 | 27 | 47.1 | 47.88 | 48.68 | 17 |
| Śremski | 55.7 | 57.32 | 59.00 | 22 | 101.0 | 102.05 | 103.12 | 16 | 40.2 | 40.68 | 41.17 | 22 |
| Leszno | 660.4 | 666.35 | 672.35 | 1 | 500.0 | 504.64 | 509.33 | 1 | 679.1 | 683.64 | 688.20 | 1 |

area of influence of the Bydgoszcz Szwederowo Airport) in the following districts: lipnowski and tucholski. The development strategy of the lipnowski district contains information that the availability of network devices and universal access to the infrastructure of the area has a huge impact on decisions made regarding the location of both residential construction and projects related to the construction/expansion of industrial investments (Strategia Obszaru Rozwoju Społeczno – Gospodarczego Powiatu Lipnowskiego). Similar forecasts were made for the catchment area of Wrocław Strachowice Airport. The results are summarized in Table 3. Analyzing the information contained therein, we notice that most districts are characterized by an increase in the distribution network, the decline only concerns the wałbrzyski districts. In the catchment area of Wrocław Starachowice Airport, Leszno is the clear leader. Wrocław is next in the ranking. The area of influence of this airport includes górowski and wschowski districts, which is also within the catchment area of Poznań Ławica Airport. In terms of the examined features, they occupy very distant positions. In terms of features X1 and X2 wieruszowski districts (also located in the catchment area of the Katowice Pyrzowice Airport) occupies much higher positions in the rankings in the catchment area of the examined ports. Kluczborski districts is also within the catchment area of the Katowice Pyrzowice Airport. Analyzing it against the background of other counties, it should be stated that it occupies higher positions in the ranking presented in Table 3. The district that compares most favorably to this area of influence is Opole. Analyzing the information contained in Table 3, it can also be concluded that there are more units in the zone of more than one airport compared to the area of influence of the Bydgoszcz-Szweredowo Airport. Moreover, districts located in the catchment area of more than one airport occupy distant positions (more than half) in the infrastructure development rankings.

Similar forecasts were prepared for districts located in the catchment area of Poznań Ławica Airport. The results are presented in Table 4. Analyzing the information contained in this table, one can notice a very large diversity of positions in the rankings in terms of the examined features. The highest position in the distribution network length forecast ranking is occupied by Leszno in the districts located in the influence zone of the Poznań Ławica Airport, and the lowest by the following districts: trzebnicki (variable X1), wschowski (variable X2) and górowski (variable X3). The best infrastructure development in terms of the examined features in the studied area is characterized by district cities (Leszno, Wrocław and Opole). Pleszewski districts is also a unit located in the catchment area of the Wroclaw Starachowice Airport. In terms of the examined features, the results are different in both studied areas.

## 4. Discussion and Conclusion

The topic of the work was issues related to the development of technical infrastructure in the catchment areas of airports in Poland. The aim was to identify spatial inequalities in infrastructure development in counties located in the impact zones of airports in Bydgoszcz, Wrocław and Poznań. During the research, a statistical assessment was made of the level of infrastructure development in counties located in the three studied isochrones. In the last

Table 4. Forecast of the length of the distribution network in counties located in the influence areas of the Poznań-Ławica Airport (2021-2023)

| | 2021 | 2022 | 2023 | | 2021 | 2022 | 2023 | | 2021 | 2022 | 2023 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Variable $X_1$ | | | R | Variable $X_2$ | | | R | Variable $X_3$ | | | R |
| Górowski | 11.1 | 11.45 | 11.81 | 35 | 60.2 | 61.10 | 62.01 | 31 | 12.4 | 12.54 | 12.68 | 34 |
| Średzki | 55.1 | 57.82 | 60.68 | 11 | 72.0 | 72.99 | 73.99 | 28 | 26.8 | 28.76 | 30.86 | 21 |
| Mogileński | 33.6 | 33.91 | 34.23 | 27 | 106.7 | 107.03 | 107.36 | 14 | 13.1 | 13.82 | 14.58 | 32 |
| Nakielski | 25.0 | 25.63 | 26.27 | 30 | 86.6 | 88.01 | 89.44 | 23 | 17.5 | 19.26 | 21.19 | 24 |
| Żniński | 32.7 | 32.92 | 33.14 | 28 | 108.0 | 109.01 | 110.03 | 13 | 13.8 | 14.95 | 16.20 | 29 |
| Międzyrzecki | 26.3 | 27.38 | 28.51 | 29 | 27.1 | 27.33 | 27.57 | 35 | 14.0 | 14.05 | 14.09 | 33 |
| Sulęciński | 15.8 | 16.11 | 16.42 | 34 | 30.5 | 30.69 | 30.89 | 33 | 14.8 | 15.05 | 15.31 | 31 |
| Wschowski | 31.7 | 33.01 | 34.38 | 25 | 53.6 | 54.34 | 55.08 | 32 | 15.3 | 16.33 | 17.43 | 28 |
| Zielona Góra | 153.6 | 136.44 | 121.20 | 5 | 161.1 | 145.94 | 132.20 | 6 | 177.9 | 164.07 | 151.32 | 5 |
| Grodziski | 132.1 | 135.50 | 138.99 | 3 | 293.5 | 298.43 | 303.45 | 2 | 192.4 | 196.53 | 200.76 | 3 |
| Chodzieski | 57.3 | 58.62 | 59.96 | 12 | 88.5 | 89.16 | 89.82 | 22 | 34.3 | 35.12 | 35.97 | 20 |
| Czarnkowsko – trzecianecki | 19.3 | 19.80 | 20.32 | 33 | 63.0 | 64.09 | 65.20 | 29 | 7.2 | 7.51 | 7.84 | 35 |
| Gnieźnieński | 67.4 | 70.41 | 73.55 | 8 | 124.1 | 126.60 | 129.15 | 7 | 70.7 | 74.43 | 78.36 | 6 |
| Gostyński | 45.8 | 47.31 | 48.87 | 17 | 95.8 | 96.44 | 97.09 | 20 | 63.8 | 64.04 | 64.28 | 8 |
| Jarociński | 98.8 | 101.23 | 103.72 | 6 | 116.9 | 117.55 | 118.21 | 10 | 66.9 | 68.05 | 69.22 | 7 |
| Koniński | 43.9 | 46.34 | 48.91 | 16 | 155.0 | 155.89 | 156.79 | 5 | 13.3 | 14.45 | 15.70 | 30 |
| Kościański | 62.8 | 65.76 | 68.86 | 9 | 99.9 | 100.50 | 101.09 | 16 | 57.2 | 58.94 | 60.73 | 10 |
| Krotoszyński | 34.6 | 35.55 | 36.53 | 24 | 114.3 | 114.38 | 114.46 | 11 | 44.6 | 45.97 | 47.37 | 14 |
| Leszczyński | 46.0 | 49.83 | 53.98 | 14 | 79.8 | 81.20 | 82.63 | 25 | 42.3 | 45.53 | 49.01 | 12 |
| Międzychodzki | 24.9 | 25.32 | 25.75 | 31 | 60.1 | 61.25 | 62.42 | 30 | 17.3 | 18.35 | 19.46 | 26 |
| Nowotomyski | 33.1 | 35.12 | 37.27 | 22 | 91.5 | 92.80 | 94.12 | 21 | 50.8 | 53.10 | 55.51 | 11 |
| Obornicki | 44.6 | 46.18 | 47.82 | 18 | 98.0 | 99.12 | 100.25 | 18 | 34.9 | 35.78 | 36.68 | 19 |
| Pilski | 48.6 | 49.77 | 50.98 | 15 | 84.3 | 85.08 | 85.87 | 24 | 43.4 | 44.83 | 46.31 | 15 |
| Pleszewski | 40.0 | 42.95 | 46.11 | 20 | 118.6 | 120.19 | 121.80 | 9 | 26.7 | 27.63 | 28.60 | 22 |
| Poznański | 121.2 | 129.52 | 138.40 | 4 | 161.7 | 166.44 | 171.31 | 4 | 152.2 | 156.23 | 160.37 | 4 |
| Rawicki | 60.3 | 62.13 | 64.01 | 10 | 81.7 | 82.09 | 82.48 | 26 | 47.1 | 47.88 | 48.68 | 13 |
| Słupecki | 31.8 | 33.01 | 34.27 | 26 | 112.9 | 113.41 | 113.93 | 12 | 15.1 | 18.90 | 23.66 | 23 |
| Szamotulski | 45.0 | 46.16 | 47.35 | 19 | 96.8 | 97.50 | 98.21 | 19 | 42.3 | 43.72 | 45.20 | 16 |
| Śremski | 55.7 | 57.32 | 59.00 | 13 | 101.0 | 102.05 | 103.12 | 15 | 40.2 | 40.68 | 41.17 | 17 |
| Wągrowiecki | 35.1 | 36.09 | 37.12 | 23 | 99.6 | 100.18 | 100.77 | 17 | 18.6 | 19.23 | 19.88 | 25 |
| Wolsztyński | 67.4 | 71.96 | 76.82 | 7 | 76.9 | 78.68 | 80.50 | 27 | 57.3 | 60.14 | 63.11 | 9 |
| Wrzesiński | 38.3 | 39.87 | 41.50 | 21 | 119.8 | 121.24 | 122.69 | 8 | 34.7 | 36.36 | 38.09 | 18 |
| Konin | 278.5 | 286.08 | 293.87 | 2 | 245.7 | 247.80 | 249.91 | 3 | 210.2 | 214.00 | 217.87 | 2 |
| Leszno | 660.4 | 666.35 | 672.35 | 1 | 500.0 | 504.64 | 509.33 | 1 | 679.1 | 683.64 | 688.20 | 1 |
| Choszczeński | 23.9 | 24.12 | 24.34 | 32 | 29.5 | 29.77 | 30.04 | 34 | 18.6 | 18.77 | 18.95 | 27 |

stage of the research, forecasts of the values of measures characterizing the length of the distribution network were prepared. The time range of the forecasts was 2022-2023. Thanks to this research procedure, it was possible to assess the rate of change of the examined features. The need for forecasting most often results from the desire to know the future. So far, statistical research on the analyzed issues has allowed us to obtain, among others: the following results: for most of the surveyed districts, the length of the distribution network is increasing, while the decrease concerns only a few. Moreover, they are characterized by a similar growth rate. Moreover, they are characterized by a similar pace of development in all surveyed units. Other authors have also noticed similar trends in their research (see Błachut

et al. (2018) or Surówka (2023) or Kałuża-Jurczyńska et al. (2021)). During the analysis of the isochrones covered by the study, it was observed, among other things, that the studied units are characterized by statistically significant differences. Similar results can also be found in the works of other authors (Bożek & Szewczyk, 2014), (Kołodziejczyk, 2017). The values of variables (2021) characterizing the distribution network (sewage distribution network) are higher than the average in the area of influence of the Poznań-Ławica Airport in cities with county rights and the following counties: Zielona Góra, Konin, Leszno, grodziski, Gniezno, jarociński, Konin, pleszewski, Poznań and wrzesiński. As other researchers note, these are districts with good and very good conditions for socio-economic development. Moreover, they occupy very high places in the rankings. In the case of the X2 variable, the tested variable is characterized by high variability, similarly to the previous feature. Of these, only two are located in the zone of influence of another port (czarnkowsko – trzecianecki and choszczeński). It is worth emphasizing that, as other authors note, the wrzesiński district has a poorly developed gas distribution network. The variable X3 (length of the gas network in km per 100 km2 of area) was also examined. Only a few counties recorded higher than average values of this districts: gostyński, kościański, nowotomyski, jarociński, choszczeński and wrzesiński. Analyzing the catchment area of the Wrocław-Starachowice Airport, in the case of feature X1, higher than average values were recorded by districts: lubiński, oławski, wrocławski, Jelenia Góra, Legnica, Wrocław, Opole, jarociński and Leszno. This group includes Leszno, a city that occupies the highest position in the ranking in terms of the infrastructure development of counties in the Greater Poland Voivodeship. In the case of variable X2, these were cities with county rights (Jelenia Góra, Legnica, Wrocław, Opole, Leszno). In addition, districts: wrocławski, brzeski and ostrzeszowski. The length of the distribution water supply network in brzeski districts at the end of 2010 was 647.4 km and increased compared to 2004 by 183.7 km, i.e. by 39.6%. During the period under study, the number of active water supply connections leading to residential buildings and collective accommodation also increased significantly. Compared to the end of 2010, it amounted to 13.5 thousand. During the period under study, the sewerage network was also expanded in brzeski dstricts. In the area of influence of the Wrocław-Strachowice Airport, X3 features higher than the average value occur in the following units: wieruszowski, ostrowski, kluczborski, krapkowicki, opolski, pleszewski and Leszno. Districts located in the impact zone of the Bydgoszcz Szweredowo Airport were also assessed against the average. Values higher than average for the X1 variable were recorded similarly to the previous impact areas for cities with county rights and the capital of the voivodeship (Bydgoszcz, Grudziądz, Toruń and Włocławek). There are also districts in the Bydgoszcz Szweredowo Airport's impact zone: mogieliński, nakielski and żniński also located in the influence zone of Poznań Ławica Airport. They occupy similar positions in the rankings of the values of forecasted features characterizing the distribution network in both airport impact areas. In the case of the X3 variable, these are only cities with rights (Bydgoszcz, Grudziądz, Toruń and Włocławek). To sum up, it can be stated that each of the studied areas of impact of airports is characterized by different specificity and that objects located in the influence zones of at least two isochrones in the studied areas perform similarly. Additionally, they are characterized by

variability in their positions in the constructed rankings. Moreover, a two-part hypothesis was positively verified: districts located in the areas of influence of the studied airports are characterized by dynamic changes in the diversification of infrastructure development, which translates into significant variability of positions in the rankings for selected features characterizing them. The values of features characterizing infrastructure are not subject to dynamic changes, therefore the preparation of forecasts of this phenomenon should be considered reliable. The lack of publications that analyze the technical infrastructure in counties located in the impact areas of airports in Poland makes it impossible to compare the results obtained with other studies. Taking the above into account, it was only possible to refer to research conducted locally. As mentioned earlier, the presented analyzes constitute a continuation and deepening of the issues undertaken in the author's previous research.

The construction of infrastructure by public authorities is considered their obligation resulting from the need to provide residents with adequate access to public goods and services (Cilak et al., 2015). It is also worth noting that, unlike a commune, which is subject to the presumption of jurisdiction, in the case of a district, the scope of its jurisdiction has been specified enumeratively. The district's tasks can be divided into five groups: tasks in the field of technical infrastructure, tasks in the field of social infrastructure, tasks in the field of public safety and order, tasks in the field of spatial and ecological order, and tasks in the field of districts promotion and cooperation with non-governmental organizations (Sthral & Jaworska-Dębska, 2010). A very similar classification is proposed by Jan Zimmermann. According to him, the tasks of the district can be divided into: matters of technical infrastructure, matters of spatial and ecological order, matters of social infrastructure, matters of public security and defence, and matters of external representation of the districts (Zimmermann, 2018). In this context, the research carried out is of great practical importance and can constitute an important source of information for local government administration bodies, for example on the directions of development of the analyzed statistical units in terms of infrastructure development. All the more so because the infrastructure developed by local government units is an important factor in regional and local development.

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