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Statistical and Forecasting Analysis of the Development of Technical Infrastructure in the Vicinity of Airports in Poland

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Abstract: Research in the field of infrastructural development has attracted quite a lot of interest. A significant part of them concerns the regions of the European Union. However, in the European literature definitely lacks positions in which technical infrastructure is analyzed in catchment areas of airports in Poland. The lack of literature items concerning the infrastructural development of districts located in the overlapping areas of influence of at least two ports is particularly noticeable. The author decided to fill this gap by conducting research, a fragment of which is presented in the text. However, bearing in mind the fact that the development of airports and their accompanying infrastructure causes gradual transformations in the degree of spatial development. Undertaking research on the proposed topic seems particularly important. The main objective was to carry out a prognostic and statistical comparative analysis of the degree of infrastructural development of districts located in the areas of airports in Poland for years 2002-2021. Due to the limited framework of the study, the presented results are only selected. They will apply only to districts located in the catchment areas of the three ports. The medium-term rate of change method was chosen as a forecasting tool.

Keywords: labor market; areas of impact air transport; quantitative methods; air transport; airport; technical infrastructure

JEL Classification: R11; O11

1. Introduction

Many authors undertake research in the field of infrastructural development (Kołodziejczyk, 2017), (Pomianek, 2020), (Surówka, 2009), (Chwastek et al., 2021). Several specific goals were set in the research undertaken by the author. One of them is an attempt to determine whether the processes of economic development in some regions have been and still are conducive to increasing the competitiveness of weaker areas or deepening disproportions. One of the factors affecting the competitiveness of regions is the technical infrastructure, which has become a source of interest in the publication. As some authors rightly point out, the level of infrastructural development can determine the attractiveness of a spatial unit, and therefore constitute an important element of regional or local competitiveness, as well as determine opportunities or threats for further development (Polna, 2017). In the opinion of other authors, it is the technical infrastructure that plays an important role in stimulating social and economic development at the voivodeship, district

and commune level (Chwastek et al., 2021). Broadly understood infrastructure is one of the factors traditionally indicated in theories of development or competitiveness (Pomianek, 2020). There are many definitions of this term in the literature (Surówka, 2007b). Most often, it is understood as the basic devices and institutions providing services necessary for the proper functioning of the economy and the life of society (Lijewski, 1994). One of the definitions defines it as a set of selected devices, building networks and systems directly related to the production of material goods, but necessary for the production process itself. Sometimes it is also identified as a factor expanding or even developing the demand for goods and services. In addition to the diversity of infrastructure concepts, there is also a lack of a uniform classification of this concept. Most often, infrastructure is divided into technical and social. The first one consists of transport, water and sanitary, energy and communication networks, which include, among others, roads, water supply, sewage and gas networks. On the other hand, institutions in the field of education and upbringing, dissemination of culture, health care, social care or housing construction, serving to raise the general standard of living of residents, are referred to as social infrastructure (Kroszel, 1990). Technical infrastructure is quite often defined as a complex of public utility devices necessary primarily to ensure the proper functioning of the national economy and the proper integration of individual systems of socio-economic space. By some authors it is also called economic, technical and economic, production or economic. There are also positions that technical and economic infrastructure is a concept broader than technical. The literature quite often emphasizes the fact that in the case of technical infrastructure there is agreement as to the area of this concept, while in the case of social infrastructure there is no unanimity. An overview of the definition of technical infrastructure can be found in the works of some authors (Surówka, 2007a). It must be stated with all firmness that infrastructure is more and more often associated as a source of competitive advantage. Without an increase in the level of infrastructural development, an appropriate level of development cannot be achieved. Therefore, according to some authors (Sztando, 2004) the development of infrastructure should extend the development of entrepreneurship. It should be based on forecasts and strategic economic plans, because otherwise the infrastructure, instead of being a factor of economic development, may become a brake or even a barrier. The main purpose of the work is to identify the degree of diversification of infrastructural development of districts located in the zones of influence of selected airports in Poland. Weak interest of researchers in the discussed issues was the main premise for undertaking the research.

2. Forecasting as a Research Tool – Research Methodology

Forecasting is the prediction of future phenomena and processes based on scientific foundations. According to another definition, it is a rational, scientific prediction of future events, that is, inferring about unknown events on the basis of known events. In the opinion of another author, it is a scientifically based prediction of the course and state of probable future events (things, facts, phenomenon). Forecasting (prediction) is a scientific way of predicting how future processes and events will develop. Most often they are used to minimize the uncertainty of future events that will arise in the future. Such action provides

information on the subject of interest to us, prompts us to make decisions related to the implementation of the prepared forecast and prepares the occurrence of other actions. The diversity of definitions is justified by the variety of prognostic situations, goals and research methods. The forecasting process must be carefully planned and carefully carried out. Apart from the analyst, the recipient of the forecast should participate in it, who does not need to know the forecasting methods, it is enough that the requirements as to the shape and result are clearly formulated. Forecasting supports decision-making processes and prepares other activities. Many methods are used to make forecasts. In the practical part, the medium-term rate of change method was used (Surówka, 2009). The effectiveness of this deliberation is based on the fact that the dynamics of changes in the examined features is taken into account to forecast the future development of a given phenomenon. As is commonly known, the medium-term rate of changes is used to determine the average rate of changes occurring in a specific time period. With its help, you can make a forecast that will take into account changes over time and in the case of fluctuations in the value of the tested feature, it will indicate the most realistic predicted value. To calculate it, use a specific formula:

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

where:

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

Thus, it is a geometric mean calculated using individual string indices. Assuming that the value of the medium-term rate of changes will show a similar tendency, the average rate of changes in the value of the phenomenon from year to year, expressed as a percentage, was determined. Then the forecast values were 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.

In scientific research, many methods are used for forecasting, which are based on the current development trend of the phenomenon. The method proposed above can be considered more effective, as it takes into account the dynamics of changes in the studied phenomenon.

3. Forecasting and Statistical Analysis of the Diversification of Infrastructural Development of Districts Located in the Zones of Influence of Katowice Pyrzowice, Kraków Balice and Rzeszów Jasionka Airports

The areas of influence of airports in Poland are defined and named in various ways. According to one definition, it is an area extending within a radius of 100 kilometers from the port. The author took this criterion into account in her research. The names of districts located

in the areas of influence of the three surveyed airports in Poland (Katowice-Pyrzowice Airports, Kraków Balice and Rzeszów Jasionka) were identified on the basis of the methodology described in the literature (Surówka, 2022), and on the basis of already available published information on this subject (Kujawiak, 2016). The results are summarized in Table 1. The name of the city in which the airport is located is given in parentheses.

Table 1. Cities and cities with districts rights belonging to the protection of 100 km of airports in Poland

Katowice – Pyrzowice Airport
Areas: bieruńsko-lędziński (Kraków), chrzanowski, myślenicki (Kraków), oświęcimski (Kraków), bocheński (Rzeszów, Kraków), kluczborski (Wrocław), Jastrzębie-Zdrój (Kraków), wodzisławski, wielicki, krapkowicki, Sosnowiec (Kraków), gliwicki, pajęczański, będziński, Gliwice, Jaworzno (Kraków), Częstochowa, cieszyński, rybnicki (Kraków), nyski (Wrocław), suski (Kraków), Bytom (Kraków), Rybnik (Kraków), wadowicki (Kraków), mikołowski (Kraków), wieluński, opolski (Wrocław), Siemianowice śląskie, Świętochłowice (Kraków), Mysłowice (Kraków), Ruda Śląska, kłobucki, Piekary Śląskie (Kraków), Żory (Kraków), Zabrze, pszczyński (Kraków), kędzierzyńsko - kozielski, Opole (Wrocław), strzelecki, głubczycki, Katowice, radomszczański, zawierciański, krakowski, myszkowski, namysłowski (Wrocław), włoszczowski, miechowski, raciborski, pińczowski (Rzeszów), żywiecki (Kraków), tarnogórski (Kraków), lubliniecki (Kraków), piotrkowski, bełchatowski, Dąbrowa Górnicza (Kraków), łaski, proszowicki (Rzeszów, Kraków), olkuski (Kraków), Bielsko-Biała (Kraków), Tychy (Kraków), prudnicki (Wrocław), oleski, częstochowski, jędrzejowski (Kraków), konecki, brzeski (Wrocław, Rzeszów, Kraków), Chorzów (Kraków), kielecki (Rzeszów), kazimierski (Rzeszów, Kraków), wieruszowski (Wrocław), bielski, (Kraków)
Kraków Balice Airport
Areas: bocheński (Rzeszów, Katowice), brzeski (Rzeszów, Katowice, Wrocław), chrzanowski, dąbrowski, krakowski, limanowski, miechowski, myślenicki (Katowice), nowosądecki (Katowice, Rzeszów), nowotarski, olkuski (Katowice), oświęcimski (Katowice), proszowicki (Rzeszów, Katowice), suski (Katowice), tarnowski (Rzeszów), tatrzański, wadowicki (Katowice), wielicki, Kraków, Nowy Sącz, Tarnów (Rzeszów), będziński, bielski, cieszyński, częstochowski, gliwicki, lubliniecki (Katowice), mikołowski (Katowice), myszkowski, pszczyński (Katowice), rybnicki (Katowice), tarnogórski (Katowice), bieruńsko-lędziński (Katowice), wodzisławski, zawierciański, żywiecki (Katowice), Bielsko-Biała (Katowice), Bytom (Katowice), Chorzów (Katowice), Częstochowa, Dąbrowa Górnicza (Katowice), Gliwice, Jastrzębie-Zdrój (Katowice), Jaworzno (Katowice), Katowice, Mysłowice (Katowice), Piekary Śląskie (Katowice), Ruda Śląska, Rybnik (Katowice), Siemianowice Śląskie, Sosnowiec (Katowice), Świętochłowice (Katowice), Tychy (Katowice), Zabrze, Żory (Katowice), buski (Rzeszów), jędrzejowski (Katowice), kazimierski (Katowice, Rzeszów), pińczowski (Rzeszów, Katowice), włoszczowski
Rzeszów – Jasionka Airport
Areas: biłgorajski, janowski, krasnostawski, kraśnicki, lubelski, tomaszowski (Warszawa), zamojski, bocheński (Katowice, Kraków), brzeski (Katowice, Kraków, Wrocław), dąbrowski, gorlicki, nowosądecki (Katowice, Kraków), proszowicki (Kraków) tarnowski (Kraków), Tarnów (Kraków), lipski, bieszczadzki, brzozowski, dębicki, jarosławski, jasielski, kolbuszowski, krośnieński, leżajski, lubaczowski, łańcucki, mielecki, niżański, przemyski, przeworski, ropczycko-sędziszowski, rzeszowski, sanocki, stalowowolski, strzyżowski, tarnobrzeski, leski, Krosno, Przemyśl, Rzeszów, miasto Tarnobrzeg, buski (Kraków), kazimierski (Kraków, Katowice), kielecki (Katowice), opatowski, ostrowiecki, pińczowski (Kraków, Katowice), sandomierski, staszowski

At the beginning, for the units located in the area of influence of the three surveyed ports, statistical material was collected for the characteristics that are most often used to define the technical infrastructure. Finally, the examined category was determined by means of nine measures. In the publication, the results refer only to the three that are most often used to measure infrastructure development. The choice of these measures was dictated by the

possibility of obtaining relevant statistical information and based on previous research experience (Kołodziejczyk, 2017), (Klepacka-Dunajko et al., 2017), (Chwastek et al., 2021), (Polna, 2017). Finally, the following indicators were proposed:

1. X_1 – length of the sewage network in km per 100 km^2 of area,
2. X_2 – length of the water supply network in km per 100 km^2 of area,
3. X_3 – length of the gas network in km per 100 km^2 of area,
4. X_4 – percentage of all dwellings connected to the water supply system,
5. X_5 – percentage of all dwellings connected to the sewage system,
6. X_6 – length of public commune district hard surface roads in km per 100 km2 of surface,
7. X_7 – length of public commune district roads with unsurfaced surface in km per 100 km2 of area,
8. X_8 – length of municipal and district public roads with improved hard surface (in km),
9. X_9 – population using sewage treatment plants as a percentage of the total population (%).

Statistical data for the features selected for the study in the cross-section of districts for the research period 2000-2018 were obtained from the Local Data Bank. The collected material was statistically processed. Basic statistical measures were determined, and the results are summarized in Table 2.

Table 2. Selected descriptive measures of infrastructural development of districts located in the zones of influence of airports in Krakow, Rzeszów and Katowice

	X_{mean}	Min	Max	Me	Q1	Q3	V_s	X_{mean}	Min	Max	Me	Q1	Q3	V_s
	AREA OF IMPACT OF RZESZOW-JASIONKA AIRPORT							AREA OF IMPACT OF KATOWICE – PYRZOWICE AIRPOT						
X_1	116.39	4.8	651.8	84.7	42	123.2	109.71	171.68	20.6		706.3	43.75	129.10	94.26
X_2	138.11	8.2	539.3	112.5	64	153.2	81.97	227.38	54.6	676.2	153.25	103.75	334.80	72.1
X_3	136.89	0.20	712.8	103	47.7	155,9	11.53	187.80	0.4	685.5	136.5	18.25	302.75	98.89
X_4	77.38	17.8	100	84	71.7	90.4	25.28	90.24	36.5	100	93.85	87.65	97.35	12.55
X_5	51.94	15.1	96.8	54.4	33.2	67.5	21.81	55.67	15.7	100	50.00	39.85	73.60	39.43
X_6	124.75	21.7	377.7	103	83.5	146.9	57.69	176.16	59.0	502.6	154.25	93.95	245.35	56.19
X_7	26.22	0	67.1	23.3	13.2	31.5	62.82	23.90	2.20	150.7	18.90	10.9	28.90	94.92
X_8	340.12	43.6	904.4	314.1	234.8	406.6	53.06	253.21	23.4	904.4	246.8	103.55	328.80	66.13
X_9	63.6	18.5	100	64.3	48.2	79.2	32.6	70.01	34.6	99.9	67.95	56.55	86.05	26.54
AREA OF IMPACT OF KRAKÓW BALICE AIRPORT														
X_1	219.96	20.6	706.3	145.85	78.95	373.3	79.02							
X_2	269.43	27.5	676.2	220.65	125.1	416.7	63.51							
X_3	257.04	0.4	685.5	231.2	86.75	427.4	74.4							
X_4	89.91	40.6	100	97.35	86.55	99.40	15.97							
X_5	69.01	29.7	100	67.8	52.8	88.65	29.72							
X_6	212.67	75.9	502.6	189.35	122.8	268	45.30							
X_7	26.07	0	150.7	19.70	10.9	31.5	94.63							
X_8	231.37	23.4	672.9	221.7	93.25	314.3	71.45							
X_9	72.07	34.6	100	69.80	55.25	90.65	27.31							

Due to the assumed purpose of the study, the conducted analysis focused only on units located in the catchment area of three selected ports. And the results of the analysis were narrowed down to three variables. By analyzing the table above, we can see that the highest average value of the X1 (length of the sewage network in km per 100 km2 of area), X2 (length of the water supply network in km per 100 km2 of area) oraz X3 (length of the gas network in

Table 3. Forecast of the length of the distribution network in districts located in the zone of impact of Rzeszów-Jasionka Airport (2021-2022)

	2021	2022	2023		2021	2022	2023		2020	2022	2023	
Districts name	Variable X_1			R	Variable X_2			R	Variable X_3			R
Biłgorajski	40.3	44.31	46.46	38	61.7	62.63	63.09	39	27.5	28.16	28.50	42
Janowski	8.4	8.99	9.29	48	53.1	54.06	54.54	45	19.2	21.08	22.09	44
Krasnostawski	25.5	27.76	28.96	43	87.9	88.44	88.71	35	39.4	40.45	40.99	38
Kraśnicki	26.6	29.91	31.71	42	94.4	96.48	97.53	34	65.8	67.41	68.24	33
Lubelski	29.8	34.92	37.80	40	137.2	140.42	142.06	18	110.2	115.82	118.74	23
Tomaszowski	18.7	19.33	19.66	45	64.0	64.71	65.07	37	24.9	27.21	28.45	43
Zamojski	14.7	16.31	17.19	46	59.7	60.95	61.58	41	50.5	52.78	53.96	36
Bocheński	106.3	116.02	121.21	18	156.6	163.69	167.36	10	198.7	206.50	210.51	7
Brzeski	90.4	100.67	106.24	23	153.3	160.84	164.75	12	193.8	199.34	202.17	10
Dąbrowski	73.0	76.11	77.72	30	193.3	194.68	195.38	7	155.9	156.96	157.50	15
Gorlicki	112.3	126.25	133.87	15	50.4	58.69	63.33	38	129.0	133.70	136.12	16
Nowosądecki	89.9	95.75	98.82	26	117.2	126.23	131.01	20	119.7	128.75	133.52	20
Proszowicki	62.5	64.68	65.79	33	187.6	187.30	187.15	8	69.1	73.55	75.88	29
Tarnowski	125.5	132.02	135.41	13	136.0	142.63	146.07	17	197.8	203.66	206.66	8
Tarnów	517.1	526.10	530.67	2	459.7	469.65	474.70	3	564.7	584.09	594.04	3
Lipski	9.7	10.64	11.14	47	94.7	98.1f0	99.85	33	0.2	0.2	0.2	49
Bieszczadzki	4.8	5.09	5.24	49	8.2	8.36	8.45	49	0.4	0.31	0.28	48
Brzozowski	135.9	147.19	153.18	10	31.0	37.23	40.80	47	134.2	134.38	134.47	17
Dębicki	123.2	133.07	138.30	11	139.9	145.10	147.78	16	188.0	195.57	199.47	11
Jarosławski	122.7	126.73	128.79	17	106.6	108.29	109.15	29	102.5	105.56	107.12	25
Jasielski	112.4	117.46	120.07	19	52.7	55.69	57.25	42	154.5	159.70	162.37	13
Kolbuszowski	104.6	109.45	111.96	20	102.0	103.62	104.45	31	102.2	104.07	105.01	26
Krośnieński	133.0	135.65	137.00	12	58.3	60.65	61.86	40	130.2	133.00	134.43	18
Leżajski	115.7	125.41	130.57	16	112.5	116.29	118.24	25	103.0	104.29	104.94	27
Lubaczowski	51.8	55.79	57.90	35	48.2	49.80	50.62	46	34.5	36.02	36.81	39
Łańcucki	255.9	264.67	269.17	5	184.1	196.28	202.66	6	219.4	229.27	234.36	6
Mielecki	100.9	107.18	110.46	21	159.7	162.84	164.43	13	127.0	131.47	133.76	19
Niżański	97.3	105.47	109.80	22	103.4	104.66	105.30	30	73.0	74.43	75.15	31
Przemyski	65.8	69.19	70.94	32	51.2	54.03	55.50	43	58.4	59.38	59.87	35
Przeworski	154.9	160.18	162.89	8	115.8	118.12	119.30	23.5	116.3	118.23	119.21	22
Ropczycko-sedz.	130.1	151.02	162.72	9	115.8	118.12	119.30	23.5	152.3	158.57	161.81	14
Rzeszowski	173.5	181.68	185.92	7	151.2	161.76	167.31	11	191.5	200.46	205.09	9
Sanocki	74.9	82.76	87.00	28	45.8	51.72	54.96	44	66.5	69.37	70.84	32
Stalowowolski	71.1	76.65	79.58	29	96.6	99.20	100.53	32	83.7	86.98	88.67	28
Strzyżowski	77.8	90.55	97.69	27	80.0	79.65	79.47	36	170.1	172.36	173.50	12
Tarnobrzeski	121.4	130.50	135.30	14	108.8	110.28	111.02	28	114.4	116.48	117.53	24
Leski	31.4	33.78	35.04	41	26.6	27.53	28.00	48	19.5	20.08	20.37	45
Krosno	386.2	399.91	406.94	4	526.6	554.75	569.38	2	662.9	698.49	716.99	2
Przemyśl	400.9	409.62	414.05	3	358.0	366.89	371.41	4	430.3	468.66	489.11	4
Rzeszów	651.8	691.63	712.45	1	539.3	560.33	571.16	1	712.8	764.58	791.86	1
Tarnobrzeg	220.3	233.58	240.51	6	239.3	248.43	253.12	5	230.1	240.75	246.26	5
Buski	64.8	69.11	71.37	31	122.3	123.09	123.49	22	63.2	65.50	66.69	34
Kazimierski	32.9	36.55	38.52	39	153.2	158.09	160.59	14	0.4	0.4	0.4	47
Kielecki	84.7	95.27	101.04	24	129.8	133.62	135.58	19	20.8	25.94	28.97	41
Opatowski	24.5	26.71	27.89	44	127.0	128.07	128.61	21	47.7	49.83	50.92	37
Ostrowiecki	83.0	93.36	99.01	25	148.9	149.73	150.15	15	69.3	73.34	75.45	30
Pińczowski	42.0	45.43	47.25	37	112.2	114.13	115.11	26	10.8	13.79	15.58	46
Sandomierski	45.2	49.15	51.25	36	181.3	184.69	186.41	9	118.8	124.05	126.76	21
Staszowski	56.9	59.31	60.56	34	110.9	111.88	112.87	27	32.3	34.07	34.99	40

km per 100 km2 of area) is characteristic for the catchment area of the Kraków-Balice Airport, and the lowest is for Rzeszow-Jasionka. The examined features are characterized by statistically significant differentiation. The highest value of the coefficient of variation has features X1 (area of influence of Rzeszów-Jasionka and Katowice-Pyrzowice Airports) and X7 (area of influence of Kraków-Balice Airport). The percentage of all dwellings connected to the water supply system was also examined. The highest average level of this feature is characteristic for the Katowice-Pyrzowice catchment area, and the lowest for Rzeszów-Jasionka. In the next stage, the prediction of the studied features was made. The medium-term rate of change method was chosen as the research tool. The prognosis period was 2022-2023. The results for the first three indicators are presented in Tables 3-5. Districts located in the zones of influence of at least two airports are bolded in italics.

Analyzing the information in Table 3 above, we notice that the length of the distribution network in the districts located in the zone of influence of the Rzeszów-Jasionka Airport varies. Rzeszów, the districts in which the airport is located, can be considered a leader in terms of this feature. The highest positions are occupied by district cities. Tomaszowski district is also located within the area of influence of the Warsaw Airport. It occupies distant positions in the ranking due to the studied features. The Bieszczady and Lipski districts are definitely the worst. Districts located in the area of influence of more than one airport occupy distant positions in terms of infrastructural development. Similar forecasts were made for the area of influence of Kraków-Balice Airport. The results are summarized in Table 4. Analyzing the information contained therein, we can see that there are more units located in the zone of more than one airport compared to the area of influence of the Rzeszów-Jasionka Airport.

Analyzing the information contained in Table 4, we can notice a very large differentiation of the positions occupied in the rankings in terms of the examined features. The highest position in the ranking for the forecast of the length of the distribution network in districts

Table 4. Forecast of the length of the distribution network in districts located in the zone of impact of Kraków-Balice Airport (2021-2022) – Part 1

	2021	2022	2023		2021	2022	2023		2021	2022	2023	
Districts name	Variable X_1			R	Variable X_2			R	Variable X_3			R
Bocheński	106.3	116.02	121.21	38	156.6	163.69	167.36	38	198.7	206.50	210.51	33
Brzeski	90.4	100.67	106.24	39	153.3	160.84	164.75	39	193.8	199.34	202.17	35
Chrzanowski	126.9	128.37	129.11	37	209.0	211.53	212.80	31	243.1	262.90	273.40	26
Dąbrowski	73.0	75.61	76.95	46	193.3	194.96	195.80	35	155.9	157.22	157.89	39
Krakowski	182.3	195.81	202.94	25	237.6	245.69	249.83	27	262.3	275.57	282.46	25
Limanowski	84.9	93.29	97.78	43	86.7	90.55	92.54	54	153.0	162.37	167.28	38
Miechowski	20.6	20.80	20.91	60	139.7	140.20	140.46	42	32.0	36.31	38.68	53
Myślenicki	150.2	152.89	154.26	31	131.0	133.42	134.65	43	165.2	171.87	175.31	37
Nowosądecki	89.9	95.75	98.82	42	117.2	126.23	131.01	46	119.7	128.75	133.52	44
Nowotarski	90.1	94.06	96.10	44	27.5	27.84	28.01	60	39.1	42.38	44.13	52
Olkuski	46.7	48.46	49.36	53	123.7	125.45	126.33	47	135.8	140.36	142.69	42
Oświęcimski	187.7	201.68	209.06	24	250.3	253.37	254.93	26	275.4	285.42	290.57	23
Proszowicki	62.5	64.68	65.79	51	187.6	187.30	187.15	37	69.1	73.55	75.88	47
Suski	70.0	79.55	84.80	45	54.6	55.78	56.38	59	17.7	19.00	19.69	56
Tarnowski	125.5	132.02	135.41	35	136.0	142.63	146.07	41	197.8	203.66	206.66	34
Tatrzański	94.6	98.15	99.98	41	62.2	63.45	64.08	58	27.1	33.08	36.55	54

Table 4. Forecast of the length of the distribution network in districts located in the zone of impact of Kraków-Balice Airport (2021-2022) – Part 2

	2021	2022	2023		2021	2022	2023		2021	2022	2023	
Districts name	Variable X_1			R	Variable X_2			R	Variable X_3			R
Wadowicki	135.1	146.20	152.09	32	194.2	199.70	202.50	33	251.2	253.89	255.25	29
Wielicki	125.4	134.78	139.73	34	332.8	347.39	354.93	19	346.9	361.32	368.75	19
Kraków	485.3	504.22	513.95	6	473.7	489.80	198.06	34	587.6	609.35	620.52	5
Nowy sącz	586.0	602.71	611.24	2	500.2	522.64	534.23	7	683.9	794.16	784.08	1
Tarnów	517.1	526.10	530.67	5	459.7	469.65	474.70	11	564.7	584.09	594.04	6
Będziński	133.7	151.22	160.83	29	227.3	234.99	238.94	28	249.4	261.85	268.30	27
Bielski	173.9	182.04	186.25	26	285.6	290.96	293.68	23	342.4	350.25	354.24	20
Cieszyński	149.5	158.65	163.43	28	184.4	188.33	190.32	36	250.6	261.68	267.40	28
Częstochowski	46.2	49.84	51.77	52	99.5	101.88	103.08	51	54.3	60.33	63.58	49
Gliwicki	63.9	66.65	68.08	48	114.7	116.92	118.04	49	74.3	86.99	94.12	46
Lubliniecki	63.5	65.08	65.88	50	98.2	97.03	96.45	53	23.0	25.64	27.07	55
Mikołowski	227.0	228.42	229.13	23	302.7	308.99	312.18	21	219.3	237.48	147.12	41
Myszkowski	40.3	42.86	44.20	55	130.5	132.28	133.18	44	99.2	109.18	114.55	45
Pszczyński	153.9	156.77	158.23	30	201.2	205.80	208.14	32	205.9	214.58	219.06	32
Rybnicki	121.6	127.37	130.36	36	222.1	225.71	227.54	29	114.3	129.39	137.66	43
Tarnogórski	96.6	99.69	101.27	40	126.5	130.28	132.22	45	137.2	149.24	155.65	40
Bieruńsko-lędziński	372.3	375.18	376.62	18	253.8	260.21	263.48	25	251.7	285.54	304.13	22
Wodzisławski	326.8	355.63	370.98	19	284.5	291.46	295.00	22	214.9	226.68	232.81	31
Zawierciański	34.1	36.12	37.17	58	100.2	101.22	101.73	52	53.1	54.43	55.11	50
Żywiecki	163.1	175.91	182.69	27	82.2	87.06	89.59	55	44.0	44.41	44.61	51
Bielsko-biała	706.3	724.24	733.38	1	561.2	570.61	575.37	4	509.9	524.87	532.52	8
Bytom	402.1	409.57	413.36	13	488.5	491.09	492.40	9	454.6	479.41	492.33	14
Chorzów	142.0	85.65	66.52	49	571.3	571.20	571.15	6	615.4	653.89	674.03	3
Częstochowa	373.0	376.81	378.73	16	403.4	409.44	412.50	16	435.3	482.47	507.94	11
Dąbrowa górnicza	180.7	212.19	229.94	22	219.2	221.48	222.63	30	254.2	275.54	286.87	24
Gliwice	341.1	359.65	369.30	20	336.8	347.48	352.94	20	430.9	462.14	478.59	15
Jastrzębie-zdrój	373.6	394.09	404.75	14	448.4	444.50	442.57	13	327.6	342.93	350.86	21
Jaworzno	265.4	287.35	299.00	21	261.4	274.76	281.69	24	165.2	174.86	179.90	36
Katowice	398.9	410.62	416.61	12	434.5	443.31	447.79	12	450.9	474.63	496.96	13
Mysłowice	418.8	418.8	418.8	11	497.7	495.98	495.12	8	423.9	438.52	446.02	17
Piekary śląskie	392.9	396.64	398.52	15	344.2	364.05	374.41	18	395.8	421.77	435.38	18
Ruda śląska	359.2	371.73	378.15	17	390.6	395.45	397.90	17	417.4	456.20	476.93	16
Rybnik	433.2	434.95	435.82	10	413.8	421.73	425.75	15	265.3	254.48	249.24	30
Siemianowice śląskie	515.7	556.40	577.94	3	636.9	660.05	671.94	2	564.7	612.24	637.49	4
Sosnowiec	476.6	518.47	540.77	4	558.8	567.57	572.00	5	488.6	515.31	529.20	9
Świętochłowice	252.4	178.17	149.70	33	676.2	716.37	737.35	1	685.5	719.68	737.40	2
Tychy	454.3	457.41	458.97	8	569.6	580.94	586.69	3	445.8	486.60	508.38	10
Zabrze	470.9	481.38	486.71	7	419.5	429.49	434.58	14	514.1	541.97	556.47	7
Żory	425.4	444.93	455.03	9	444.8	469.76	482.76	10	436.6	478.00	500.15	12
Buski	64.8	69.11	71.37	47	122.3	123.09	123.49	48	63.2	65.50	66.69	48
Jędrzejowski	22.2	22.58	22.77	59	80.0	82.48	83.75	56	8.1	11.99	14.58	58
Kazimierski	32.9	36.55	38.52	57	153.2	158.09	160.59	40	0.4	0.4	0.4	60
Pińczowski	42.0	45.43	47.25	54	112.2	114.13	115.11	50	10.8	13.79	15.58	57
Włoszczowski	36.5	38.02	38.80	56	81.1	82.55	83.29	57	5.0	8.28	10.66	59

Table 5. Forecast of the length of the distribution network in districts located in the zone of impact of Katowice-Pyrzowice Airport (2021-2022) – Part 1

	2021	2022	2023		2021	2022	2023		2021	2022	2023	
Districts name	Variable X_1			R	Variable X_2			R	Variable X_3			R
Bełchatowski	45.5	48.77	50.49	53	135.6	138.25	139.59	40	18.8	20.10	20.79	54
Łaski	27.6	29.21	30.04	69	125.7	127.57	128.52	46	11.0	14.68	16.96	59
Pajęczański	27.2	29.63	30.93	67	107.9	109.40	110.16	52	9.6	10.30	10.67	68
Piotrkowski	27.8	29.88	30.97	66	108.3	108.46	180.53	35	10.6	13.83	15.80	60
Radomszczański	32.1	34.57	35.87	63	101.7	103.06	103.75	55	12.1	13.27	13.89	67
Wieluński	40.1	44.74	47.26	56	114.3	115.54	116.16	49	13.8	15.85	16.99	58
Wieruszowski	50.8	52.77	53.79	51	108.3	110.21	111.18	51	6.1	7.14	7.73	70
Bocheński	106.3	116.02	121.21	35	156.6	163.69	167.36	36	198.7	206.50	210.51	31
Brzeski	90.4	100.67	106.24	36	153.3	160.84	164.75	37	193.8	199.34	202.17	32
Chrzanowski	126.9	128.27	128.97	34	209.0	210.68	211.53	30	243.1	256.73	263.82	26
Krakowski	182.3	207.73	221.74	22	237.6	246.33	250.81	26	262.3	276.17	283.38	22
Miechowski	20.6	21.17	21.47	72	139.7	140.26	140.54	39	32.0	35.60	37.55	47
Myślenicki	150.2	152.89	154.26	28	131.0	133.42	134.65	42	165.2	171.87	175.31	34
Olkuski	46.7	48.46	49.36	55	123.7	125.45	126.33	47	135.8	140.36	142.69	37
Oświęcimski	187.7	201.68	209.06	23	250.3	253.37	254.93	25	275.4	285.42	290.57	20
Proszowicki	62.5	64.68	65.79	47	187.6	187.30	187.15	34	69.1	73.55	75.88	41
Suski	70.0	79.55	84.80	43	54.6	55.78	56.38	72	17.7	19.00	19.69	56
Wadowicki	135.1	146.20	152.09	30	194.2	199.70	202.50	32	251.2	253.89	255.25	27
Wielicki	125.4	134.11	138.69	32	332.8	347.02	354.35	18	346.9	361.41	368.88	16
Głubczycki	31.5	34.04	35.34	64	56.4	56.74	56.91	71	14.2	14.77	15.06	64
Kędzierzyńsko-k	89.7	95.21	98.09	40	105.8	107.42	108.24	54	34.1	36.01	37.00	48
Kluczborski	28.6	31.51	33.07	65	64.4	64.92	65.19	70	17.0	18.76	19.71	55
Krapkowicki	89.4	99.19	104.49	37	91.6	92.40	92.80	60	43.6	46.83	48.54	45
Namysłowski	29.3	35.34	38.82	60	64.6	66.06	66.81	68	12.8	14.50	15.43	62.5
Nyski	48.4	52.84	55.21	50	81.5	85.73	87.93	63	29.8	32.21	33.49	50
Oleski	20.9	21.71	22.13	71	88.1	89.47	90.16	61	12.8	14.50	15.43	62.5
Opolski	80.1	87.73	91.81	41	87.4	87.56	87.63	64	26.1	32.83	36.82	49
Prudnicki	27.8	29.37	30.19	68	64.1	64.90	65.31	69	14.0	14.41	14.62	65
Strzelecki	68.9	75.78	79.47	44	70.5	71.11	71.42	67	23.2	27.33	29.66	51
Opole	376.7	397.79	408.78	11	348.7	361.39	367.90	17	277.9	277.04	276.61	23
Będziński	133.7	146.50	153.35	29	227.3	232.83	235.64	27	249.4	260.31	265.94	24
Bielski	173.9	182.04	186.25	24	285.6	290.96	293.68	22	342.4	350.25	354.24	17
Cieszyński	149.5	162.37	169.21	26	184.4	189.60	192.26	33	250.6	260.56	265.68	25
Częstochowski	46.2	50.78	53.23	52	99.5	101.77	102.92	56	54.3	59.10	61.65	43
Gliwicki	63.9	78.93	87.72	42	114.7	117.50	118.93	48	74.3	83.99	89.30	40
Kłobucki	50.4	55.87	58.82	49	107.2	108.37	108.96	53	5.4	6.47	7.08	71
Lubliniecki	63.5	65.08	65.88	46	98.2	97.03	96.45	59	23.0	25.64	27.07	53
Mikołowski	227.0	228.42	229.13	21	302.7	308.99	312.18	20	219.3	237.48	147.12	36
Myszkowski	40.3	42.10	43.03	58	130.5	132.44	133.43	43	99.2	106.39	110.18	39
Pszczyński	153.9	156.77	158.23	27	201.2	205.80	208.14	31	205.9	214.58	219.06	30
Raciborski	56.9	61.57	64.05	48	127.1	128.26	128.85	45	61.4	62.52	63.09	42
Rybnicki	121.6	127.37	130.36	33	222.1	225.71	227.54	28	114.3	129.39	137.66	38
Tarnogórski	96.6	99.69	101.27	38	126.5	130.28	132.22	44	137.2	149.24	155.65	35
Bieruńsko-lędziński	372.3	375.18	376.62	17	253.8	260.21	263.48	24	251.7	285.54	304.13	19
Wodzisławski	326.8	369.70	393.22	14	284.5	290.72	293.89	21	214.9	224.57	229.56	29
Zawierciański	34.1	35.57	36.33	62	100.2	101.28	101.82	57	53.1	54.33	54.96	44
Żywiecki	163.1	175.91	182.69	25	82.2	87.06	89.59	62	44.0	44.41	44.61	46
Bielsko-biała	706.3	724.24	733.38	1	561.2	570.61	575.37	4	509.9	524.87	532.52	5
Bytom	402.1	409.57	413.36	10	488.5	491.09	492.40	8	454.6	479.41	492.33	10
Chorzów	142.0	85.65	66.52	45	571.3	571.20	571.15	6	615.4	653.89	674.03	2
Częstochowa	373.0	379.60	382.94	15	403.4	411.89	416.21	14	435.3	477.74	500.49	8
Dąbrowa górnicza	180.7	212.19	229.94	20	219.2	221.48	222.63	29	254.2	275.54	286.87	21
Gliwice	341.1	361.57	372.27	18	336.8	345.42	349.81	19	430.9	453.63	465.45	13
Jastrzębie-zdrój	373.6	394.09	404.75	12	448.4	444.50	442.57	11	327.6	342.93	350.86	18
Jaworzno	265.4	287.35	299.00	19	261.4	274.76	281.69	23	165.2	174.86	179.90	33
Katowice	398.9	426.53	441.06	7	434.5	440.00	442.77	10	450.9	471.01	481.41	11
Mysłowice	418.8	418.8	418.8	9	497.7	495.98	495.12	7	423.9	438.52	446.02	14

Table 5. Forecast of the length of the distribution network in districts located in the zone of impact of Katowice-Pyrzowice Airport (2021-2022) – Part 2

	2021	2022	2023		2021	2022	2023		2021	2022	2023	
Districts name	Variable X_1			R	Variable X_2			R	Variable X_3			R
Piekary śląskie	392.9	396.64	398.52	13	344.2	364.05	374.41	16	395.8	421.77	435.38	15
Ruda śląska	359.2	371.39	377.64	16	390.6	395.21	397.54	15	417.4	448.99	465.67	12
Rybnik	433.2	434.95	435.82	8	413.8	421.73	425.75	13	265.3	254.48	249.24	28
Siemianowice śląskie	515.7	543.32	557.67	2	636.9	701.86	736.78	2	564.7	609.17	632.70	3
Sosnowiec	476.6	518.47	540.77	3	558.8	567.57	572.00	5	488.6	515.31	529.20	6
Świętochłowice	252.4	178.17	149.70	31	676.2	716.37	737.35	1	685.5	719.68	737.40	1
Tychy	454.3	457.41	458.97	5	569.6	580.94	586.69	3	445.8	486.60	508.38	7
Zabrze	470.9	481.38	486.71	4	419.5	429.49	434.58	12	514.1	541.97	556.47	4
Żory	425.4	444.93	455.03	6	444.8	469.76	482.76	9	436.6	478.00	500.15	9
Jędrzejowski	22.2	22.58	22.77	70	80.0	82.48	83.75	65	8.1	11.99	14.58	66
Kazimierski	32.9	36.55	38.52	61	153.2	158.09	160.59	38	0.4	0.4	0.4	72
Kielecki	84.7	95.27	101.04	39	129.8	133.62	135.58	41	20.8	25.94	28.97	52
Konecki	39.9	46.16	49.66	54	94.9	96.02	96.59	58	16.0	17.42	18.18	57
Pińczowski	42.0	45.43	47.25	57	112.2	114.13	115.11	50	10.8	13.79	15.58	61
Włoszczowski	36.5	38.93	40.21	59	81.1	82.84	83.73	66	5.0	8.28	10.66	69

located in the zone of impact of Kraków-Balice Airport is held by Bielsko-Biała, and the lowest by the Miechów district. Similar forecasts of the distribution network were prepared for districts located in the zone of influence of the Katowice-Pyrzowice Airport. The results are presented in Table 5.

4. Discussion and Conclusion

The subject of the work were issues related to the development of technical infrastructure in catchment areas of airports in Poland. The aim was to identify differences in the development of selected elements of the technical infrastructure of the counties located in the zones of influence of the surveyed units. In the course of the study, a statistical assessment of the level of infrastructural development of units located in the impact zones of three selected airports was made. In the next stage of the study, the values of the measures characterizing the length of the distribution network for the years 2022-2023 were predicted. Thanks to this, it was possible to assess the rate of change of the examined features. The need for forecasting is most often due to the desire to know the future. Statistical studies conducted so far in the field of the analyzed issues have contributed to obtaining, among others, the following results: for the majority of the surveyed districts, the length of the distribution network is increasing, the decrease applies only to a few. The results of the forecasts obtained allow us to claim that nothing will change in this respect. Similar trends in their research were also noticed by other authors (see Błachut et al. (2018) or Kałuża-Jurczyńska et al. (2021)). We also observe a similar rate of development of the distribution network for all the surveyed units. In the course of the analysis, it was also observed that the examined units are characterized by statistically significant differences. Similar results can also be found in the works of other authors (see Bożek and Szewczyk (2014) or Kołodziejczyk (2017)). The values of variables characterizing the distribution network are higher than the average in the catchment area of the Rzeszów-Jasionka Airport in cities with district rights and provincial capital (Tarnów, Krosno, Przemyśl, Rzeszów, Tarnobrzeg). As noted by other researchers, these are districts

with the best conditions for social and economic development (Gawroński et al., 2014). These are units with very high positions in the rankings. The values of the feature length of the sewage network in km per 100 km2 are higher than the average in the area of influence of this port, apart from district cities, also for the following districts: tarnowski, brzozowski, dębicki, jarosławski krośnieński, łańcucki, przeworski, ropczycko – sędziszowski, rzeszowski, tarnobrzeski. In the case of the X2 feature, these are, as for the X1 feature, cities with district rights and districts: bocheński, brzeski, dąbrowski, proszowicki, dębicki, łańcucki, mielecki, rzeszowski, kazimierski, ostrowiecki, sandomierski). It is worth noting that the Bochnia and brzeski districts are located in the zones of influence of all three airports surveyed. In the Bochnia district, large investments in the sewage system have been carried out recently and over the eight compared years, the percentage of people using the sewage system increased from 44.7 percent in 2010 to 57.4 percent. Along with a slight increase in the number of people using the sewage system, the percentage of people using sewage treatment plants increased from 50.2 to 60.3 percent (Strategia rozwoju powiatu bocheńskiego na lata 2021-2023). These results are similar to the results obtained as a result of own research. The variable X3 was also examined (length of the gas network in km per 100 km2 of area). Higher than average values for this feature were also recorded by cities with district rights, provincial capital and district units: bocheński, brzeski, dąbrowski, tarnowski, dębicki, jasielski, łańcucki, ropczycko – sędziszowski, rzeszowski, strzyżowski. For feature X4, these were districts: biłgorajski, janowski, krasnostawski, karśnicki, lubelski, dąbrowski, proszowicki, lipski, jarosławski, kolbuszowski, leżajski, lubaczowski, łańcucki, mielecki, niżański, przeworski, ropczycko-sędziszowski, rzeszowski, stalowowolski, tarnobrzeski, buski, kazimierski, kielecki, opatowski, ostrowiecki, pińczowski, sandomierski, staszowski. Percentage of all dwellings connected to the sewage system districts have a higher than average percentage of dwellings connected to the sewage system: biłgorajski, bocheński, gorlicki, brzozowski, dębicki, jarosławski, jasielski, kolbuszowski, krośnieński, leżajski, lubaczowski, łańcucki, mielecki, niżański, przemyski, przeworski, ropczycko-sędziszowski, rzeszowski, sanocki, tarnobrzeski, kielecki, ostrowiecki. When analyzing the catchment area of the Katowice-Pyrzowice Airport, in the case of the X1 feature, higher than average values were recorded mainly by districts located in the area of influence of more than one airport (oświęcimski, bielski, mikołowski, bieruńko-lędzieński, Bielsko-Biała, Bytom, Dąbrowa Górnicza, Jastrzębie Zdrój, Jaworzno, Mysłowice, Piekary Śląskie, Rybnik, Sosnowiec, Świętochłowice, Tychy Zabrze, Żory). This group includes the oświęcimski district, which occupies the highest position in the ranking in the field of infrastructural development of districts in the Śląskie Voivodeship (Polna, 2017). Apart from them, there were districts and cities with district rights: krakowski, Opole, wodzisławski, Częstochowa, Gliwice, Katowice, Ruda Śląska, Siemianowice Śląskie. In the case of the X2 feature, these were also cities with district rights (Opole, Bielsko-Biała, Bytom, Chorzów, Częstochowa, Gliwice, Jastrzębie Zdrój, Jaworzno, Katowice, Mysłowice, Piekary Śląskie, Ruda Śląska, Rybnik, Siemianowice Śląskie, Sosnowiec, Świętochłowice, Tychy, Zabrze, Żory). In addition to the districts: krakowski, oświęcimski, wielicki, bielski, mikołowski, bieruńsko-lędziński, wodzisławski. Świętochłowice is district also located in the zone of influence of the Katowice-Pyrzowice

Airport. It occupies the high position in terms of forecast of the length of the distribution network in the zone of influence of the Kraków-Balice and Katowice-Pyrzowice Airports. It also occupies a high or very high position in the rankings of infrastructure development prepared by other authors (Polna, 2017). In the area of influence of the Katowice-Pyrzowice Airport, higher values for the X3 feature are found in cities with district rights, provincial capital and districts: bocheński, brzeski, chrzanowski, krakowski, oświęcimski, wadowicki, wielicki, będziński, bielski, cieszyński, mikołowski, pszczyński, bieruński-lędziński, wodzisławski. Districts located in the zone of influence of Kraków-Balice Airport were also assessed against the average. Values higher than the average for the X1 variable were recorded similarly to the previous areas of influence for cities with district rights and provincial capital (Kraków, Nowy Sącz, Tarnów, Bielsko-Biała, Bytom, Częstochowa, Gliwice, Jastrzębie – Zdrój, Jaworzno, Katowice, Mysłowice, Piekary Śląskie, Ruda Śląska, Rybnik, Siemianowice Śląskie, Sosnowiec, Świętochłowice, Tychy Zabrze, Żory) and for district units: mikołowski, bieruńsko-lędziński oraz wodzisławski. Mikołowski and bierńsko-lędzieński districts are also located in the zone of influence of the Katowice-Pyrzowice Airport. They occupy similar positions in the rankings of the values of the projected features characterizing the distribution network in both areas of airports' influence. In the case of the X3 feature, apart from cities with district rights and provincial capital, these were units: krakowski, oświęcimski, wielicki, bielski. To sum up, it can be stated that most of the districts located only within the catchment area of the Rzeszów-Jasionka Airport are favorable in terms of infrastructural development. A different situation applies to units located in the zones of influence of the other two catchment areas. In addition, they are characterized by the volatility of positions occupied in the constructed rankings. We do not find publications in which technical infrastructure is analyzed in districts located in the zones of influence of airports in Poland. this makes it impossible to compare the obtained results with other studies. With the above in mind, it was only possible to make a local comparison.

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