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INVESTMENT ATTRACTIVENESS OF POLISH VOIVODESHIP IN THE CONTEXT OF LABOUR RESOURCES – DYNAMIC APPROACH

Małgorzata JAWOREK[1*], Magdalena KUCZMARSKA[2], Włodzimierz KARASZEWSKI[3]

[1] Departament of Investment and Real Estate, Faculty of Economic Sciences and Management, Nicolaus Copernicus University in Toruń; mjaworek@umk.pl, ORCID: 0000-0003-1448-1127
[2] Departament of Investment and Real Estate, Faculty of Economic Sciences and Management, Nicolaus Copernicus University in Toruń; mkuczmarska@umk.pl, ORCID: 0000-0002-7587-5122
[2] Departament of Investment and Real Estate, Faculty of Economic Sciences and Management, Nicolaus Copernicus University in Toruń; wkaras@umk.pl, ORCID: 0000-0002-8351-4589
* Correspondence author

Purpose: The purpose of the article is to identify the potential investment attractiveness of Poland's voivodeships in the context of the labour resources, and identifying changes over time.
Design/methodology/approach: The measurement of the potential investment attractiveness of Poland's voivodeships was made on the basis of secondary data derived from the Central Statistical Office. The identification of investment attractiveness in the context of the labour resources was made on the basis of the synthetic index constructed from five standardized variables. Thus, three classes of voivodeships (A, B, C) were distinguished.
Findings: At the beginning of analysis – in 2014 – the highest level of potential investment attractiveness in the labour resources (class A) had six voivodeships: Warmińsko-Mazurskie, Świętokrzyskie, Lubuskie, Dolnośląskie, Kujawsko-Pomorskie and Zachodniopomorskie. In 2023 this included only four units: Świętokrzyskie, Podkarpackie, Opolskie and Warmińsko-Mazurskie. Investment attractiveness, measured by individual variables within the labour resources pillar, varies significantly in Polish voivodeships. The voivodeships with the lowest labour costs, i.e. the most attractive for efficiency-seeking investors, were Warmińsko-Mazurskie, Podkarpackie, Świętokrzyskie i Kujawsko-Pomorskie. The highest value of labour productivity was observed in Mazowieckie and Dolnośląskie. Particularly important in the context of investment attractiveness is the availability of labour resources, which can be measured by the unemployment rate. The most attractive in this variable were: Warmińsko-Mazurskie and Kujawsko-Pomorskie. The labour market is especially in demand for people with vocational and technical skills. In this area, the most attractive voivodeships were: Opolskie, Kujawsko-Pomorskie, Wielkopolskie, and Warmińsko-Mazurskie Voivodeship. An important indicator of the quality of labour resources is the percentage of graduates in the fields of biological and technical sciences. Among the regions with the highest values of this indicator were Dolnośląskie, Świętokrzyskie and Małopolskie.
Research limitations/implications: Due to the variability over time of the determinants of business location choice, studies to identify them should be conducted successively. It should also be noted that due to the changes of assessments of investment attractiveness determined by the specifics of businesses, it is reasonable to take into account its types in future studies.

A serious problem is the limitations in access to data, as well as the growing reluctance of entrepreneurs to participate in surveys.
Practical implications: The results of the study have practical applications in decision-making processes regarding the choice of business location. They can also be used by institutions working for the socio-economic development of regions to encourage investors to choose their areas as places to locate capital.
Originality/value: Although the topic of investment attractiveness has been addressed frequently in the available literature, there are no studies devoted specifically to the context of labour resources in Poland.
Keywords: investment attractiveness, Polish voivodeships, labour resources.
Category of the paper: Research paper.

1. Introduction

The investment attractiveness of a region is a set of factors considered in its selection as a place to make an investment. The primary considerations for investors' decisions are the assessments of location benefits. The investment attractiveness of a region can be assessed as 1) potential and 2) real. The former is the result of an assessment of the factors that could potentially be considered in the choice of an area as an investment location and the importance of a particular factor for investors, while the latter is the result of a retrospective assessment of their decision to choose a region as a business location (Jaworek et al., 2022, p. 12). The measurement of investment attractiveness can be carried out at different levels of aggregation of the analysed spatial division units: at the national level, at the regional level (e.g. voivodeships) or subregional level. It should be emphasised that the assessment of investment attractiveness is always individual. Investors tend to consider the configuration of location factors, but also the occurrence of a specific factor (e.g. availability of highly qualified employees), when guided by the expected benefits. These factors can be grouped into relatively uniform attractiveness pillars, an example of which is provided in the diagram below (Figure 1).

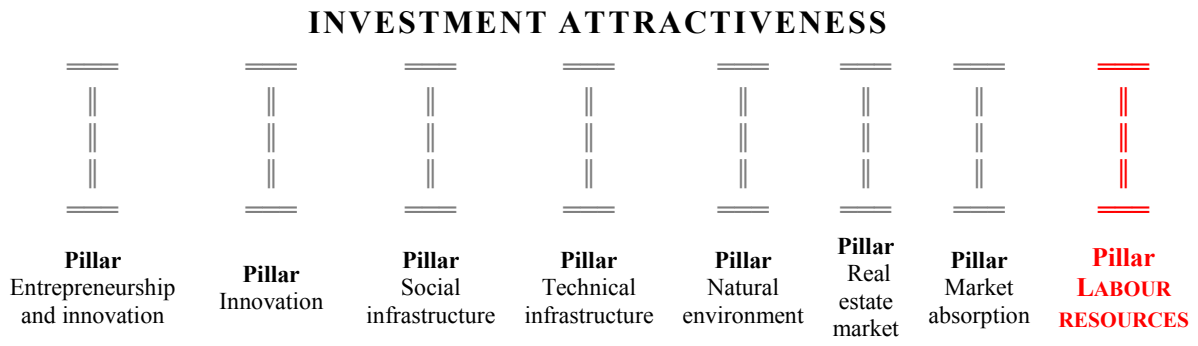


Figure 1. Investment attractiveness pillars.

Source: own elaboration.

Despite the presence of a wide range of locational attractiveness factors, a pillar related to labour resources is currently gaining particular importance. Labour resources, their condition, quality characteristics, and price, are undoubtedly among the basic factors considered in assessing the investment attractiveness of a region. The ability to employ workers with the right qualifications, professional skills, and experience is a prerequisite for doing business in a given area. Of course, the needs in this regard vary depending on the type of activity. The conduct of manufacturing activities is conditioned to a greater extent by the ability to employ workers with professional education than service activities, where there is a greater need for highly qualified workers in various fields of education. One of the parameters that indicates the availability of labour resources is the unemployment rate. Its high level means that the labour market is characterised by a large scale of supply, followed by competitive prices. However, in numerous cases, high unemployment does not indicate the ability to meet the needs of hiring workers with certain skills (especially high skills). Thus, the assessment of labour resources is multifaceted.

Although the topic of investment attractiveness is often discussed in the literature, identifying potential attractiveness, labour resources as a pillar, being a configuration of many factors of attractiveness, has not been comprehensively considered. The scope of the analysis, the results of which are presented in this study, fills this gap.

Therefore, the purpose of the article is to identify the potential investment attractiveness of Polish voivodeships in the context of the labour resources.

The rest of this paper is organised as follows. The following section provides a brief general overview of the literature related to investment attractiveness. The methodology used in the research is presented next. Then, the research findings are discussed. Finally, the general conclusions are stated.

2. Literature review

Potential investment attractiveness is often identified through the prism of foreign direct investment, i.e. from the perspective of a foreign investor deciding to locate capital in a particular place. The Polish literature is significant in this area (i.e. Dworzecki, 1995; Janton-Drozdowska et al., 2002; Kociszewska, Kamińska, 2008; Stawicka, 2008; Kućmierczyk, 2009; Nizielska, 2010; Orchwa-Malizewska et al., 2010; Krawczyk, Figna, 2011; Lizińska, 2012; Jedliński, 2013; Pakulska, Poniatowska-Jaksch, 2013; Owczarczuk, 2014; Pilarska, 2017; Sporek, 2017; Kisiel, Graszkiewicz, 2018; Szypuła, Leszczyńska, 2021). The focus of many scientists has also been on measuring the potential investment attractiveness of individual regions, subregions, cities, or rural areas of Poland. Using secondary data, researchers have identified the investment attractiveness of various areas or pillars (i.e. Gawlikowska-Hueckel, 1997; Swianiewicz, Dziemianowski, 1999; Tarkowski et al., 2015; Hildebrandt et al., 2005,

2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013; Godlewska-Majkowska et al., 2007, 2008, 2009, 2013; Banak et al., 2008; Godlewska-Majkowska, 2008, 2011; Guzik, 2008; Wierzbińska, Surówka, 2008; Lizińska, 2010; Pawlas, 2011; Raszkowski, 2011; Zarębski, 2012; Zarębski, Godlewska-Majkowska, 2013; Makowiecka, 2019; Godlewska-Majkowska, Komor, 2021). In these studies, factors related to labour resources appeared. However, these surveys did not analyse labour resources as a comprehensive pillar consisting of a wide variety of quantitative and qualitative diagnostic variables.

Labour market-related variables also appeared in studies on the identification of the determinants of foreign investment in host countries. In particular, they concerned labour cost (Schneider, Frey, 1985; Wheeler, Mody, 1992; Hennart, Park, 1994; Buckley, Casson, 1998; Tatoglu, Glaister, 1998; Globerman, Shapiro, 1999; Cheng, Kwan, 2000; Tahir, Larimo, 2004; Vijayakumar et al., 2010). Currently, labour resource determinants are not only concerned with the search for low-cost labour but also highly skilled workers (Peluffo, 2015; Mayeko, 2024). Studies also indicate that the lack of skilled labour has a limiting effect on foreign investment inflows (Kinda, 2010).

Factors related to labour resources were also important for investors undertaking foreign direct investments in Poland. In the first decade of the 21st century, investors indicated mainly low labour costs among the most important determinants (Pissulla, 1997; PAIZ/PAIiIZ, 2000, 2003, 2005; Jaworek, 1999; Witkowska, 1998; Housh, 1997; Karaszewski, 2001; Prices Waterhouse Coopers, 2002, Stawicka, 2007; Jaworek, 2006; Jaworek, Karaszewski, 2008; Różański, 2010). Over the last 15 years, investors have indicated the level of skills, competences and qualifications of employees, and work efficiency as the most important determinants (Polsko-Niemiecka Izba Przemysłowo-Handlowa, 2012, 2013, 2015, 2016, 2017; PAIiH, 2016, 2017; EY, 2017).

3. Methods

The assessment of potential investment attractiveness in the context of the labour resources was carried out by collecting and compiling information and data presented in the Local Data Bank of the Statistics Poland. Research was conducted at the turn of September and October 2024. The indicators characterising the attractiveness within the pillar "Labour resources" were calculated as arithmetic means of the standardised factors. Each of the diagnostic variables was standardised based on the following formulae:

$$F'_{ij} = \frac{F_{ij} - F_{minj}}{F_{maxj} - F_{minj}} \cdot 100 \tag{1}$$

for a stimulant, and

$$F'_{ij} = \frac{F_{maxj} - F_{ij}}{F_{maxj} - F_{minj}} \cdot 100 \quad (2)$$

for a destimulant.

The division of statistical units into investment attractiveness classes (A, B, C, D) was based on the natural division according to the Jenks optimisation method. The set of location factors related to the labour resources used in this study is presented in Table 1.

Table 1.
Investment Attractiveness Factors in the Context of the Labour Resources

Pos.	Factor Group/Factor Type	Designation	Character
Efficiency determinants ($F_{eff.}$)			
1	Gross value added per 1 employed person (PLN)	$F_{eff.}1$	Stimulant
2	Average monthly gross wages and salary in relation to the average domestic (Poland = 100%)	$F_{eff.}2$	Destimulant
Resource factor ($F_{res.}$)			
3	Registered unemployment rate (%)	$F_{res.}1$	Stimulant
4	Percentage of graduates of stage I sectoral vocational schools and technical secondary schools in total number of graduates upper secondary and post-primary schools (%)	$F_{res.2}$	Stimulant
5	Percentage of graduates in the fields of biological sciences, environment, health, physical sciences, mathematics and statistics, information and communication, engineering and engineering trades, architecture and building (%)	$F_{res.}3$	Stimulant

Source: own study.

4. Discussion and Results

Among the efficiency factors in the area analysed, the labour productivity appears to be especially important for foreign investors. We measure it with the gross value added per 1 employed person ($F_{eff.}1$). In 2014, at the beginning of the analysis period, this value for Poland reached PLN 108.5 thousand, while in 2021 (the last year for which data were available) it was already 155.1. The highest value of this factor (class A) was observed in Mazowieckie (PLN 142.3 thousend/employed person in 2014 *versus* 193.3 in 2022) and Dolnośląskie (123.8 *versus* 170.9). In 2014 many voivodeships located in western Poland registered the gross value added per 1 employed person exceeded PLN 100 thousend (Śląskie, Pomorskie, Zachodniopomorskie, Wielkopolskie, Lubuskie, Opolskie) or was very close to this level (Łódzkie), which placed them in a high class B in terms of labour productivity. In 2022, only three voivodeships remained in this class, where the value of the described indicator exceeded PLN 150 thousand (Śląskie, Pomorskie i Zachodniopomorskie). In 2014, Lubelskie, Podkarpackie and Świętokrzyskie were among the voivodeships with the lowest labour productivity (class D), while in 2022 it also included the first two and the Podlaskie Voivodeship (Figure 2, Table 2).

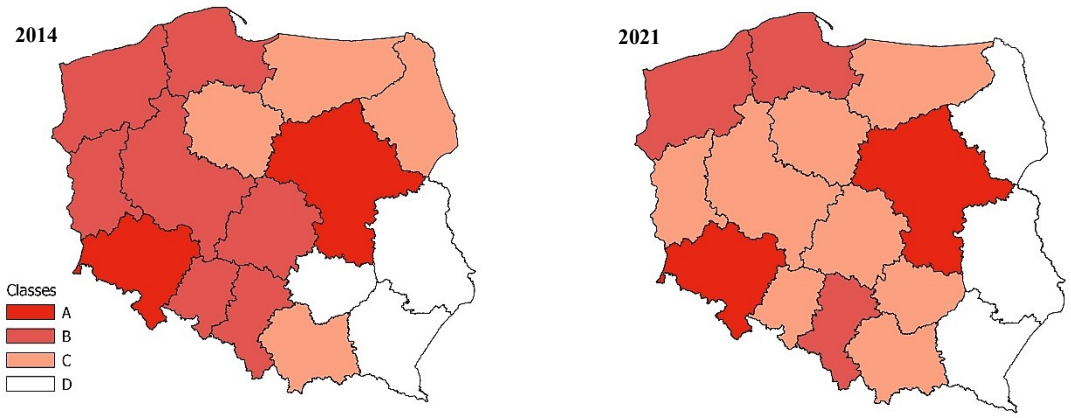


Figure 2. Classes of Polish voivodeships in terms of "gross value added per 1 employed person" factor in years 2014 and 2021.

Source: own study based on (Local Data Bank of the Statistics Poland, 2024).

As indicated in the literature review, labour costs were an important factor in the location of FDI in Poland. But over time, its importance began to decline in favour of qualitative factors such as the qualifications and skills of the workforce (Jaworek, Karaszewski, 2018). From a regional perspective, the highest labour costs are observed in the Mazowieckie Voivodeship (in 2014 it amounted to 123.1% average monthly gross wages and salary in relation to the average for Poland ($F_{eff}2$), in 2023 – 117.6%). Other voivodeships with high labour costs were Dolnośląskie, Śląskie and, in 2023, Małopolskie, but it should be noted that in the analysed period, the average monthly gross wages and salary in these units was similar to the average for the whole country (the exception was the Małopolskie Voivodeship, in which in 2014 the described labour costs indicator amounted to 92.4% of domestic avarage). On the other hand, the voivodeships with the lowest labour costs, i.e. the most attractive for efficiency-seeking investors, were Warmińsko-Mazurskie, Podkarpackie, Świętokrzyskie i Kujawsko-Pomorskie, where the average monthly gross wages and salary did not exceed 90% of the average for Poland, both in 2014 and 2023. The importance of this factor for investment attractiveness was confirmed by the results of studies conducted in the Warmińsko-Mazurskie and Kujawsko-Pomorskie provinces. Foreign investors ranked the unemployment rate in 2nd and 7th place, respectively, among the determinants of choosing this voivodeship (Kisiel et al., 2016; Jaworek et al., 2016). The picture of the investment attractiveness of Poland's regions in terms of labor costs presented in figure 3 was also confirmed in the results of the Chidlow et al. (2009) study.

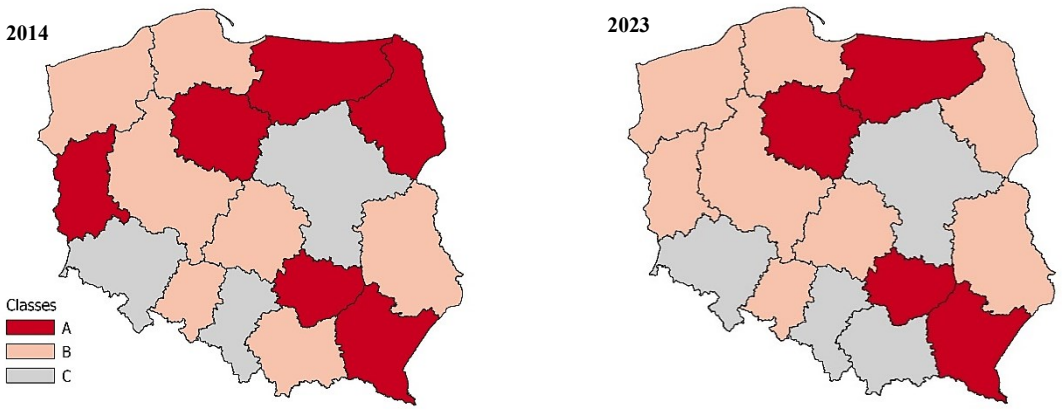


Figure 3. Class of Polish voivodeships in terms of "average monthly gross wages and salary in relation to the average domestic" factor in years 2014 and 2023.

Source: own study based on (Local Data Bank of the Statistics Poland, 2024).

Particularly important in the context of investment attractiveness is the availability of labour resources. In general terms, this availability is potentially greater in regions with higher unemployment. In 2014 the registered unemployment rate ($F_{res.}1$) in Poland was relatively high, reaching 11.4% compared to 5.1% in 2023. At the beginning of the analysed period, the highest unemployment rate was registered in northern Poland, in the Warmińko-Mazurskie (18.7%), Kujawsko-Pomorskie (15.5%) and Zachodniopomorskie (15.5%) voivodeships. These regions were also among the voivodeships with the highest unemployment in 2023, but it was much lower, with Warmińsko-Mazurskie at 8.3%, Kujawsko-Pomorskie at 7.1% (class A) and Zachodniopomorskie at 6.7% (class B). In 2023, a relatively high unemployment rate (class A) was also recorded in the Podkarpackie (8.7%), Świętokrzyskie (7.8%) and Lubelskie (7.6%) voivodeships. The region with the lowest registered unemployment rate was Wielkopolskie, with a rate of 7.6% in 2014 and 3.0% in 2023.

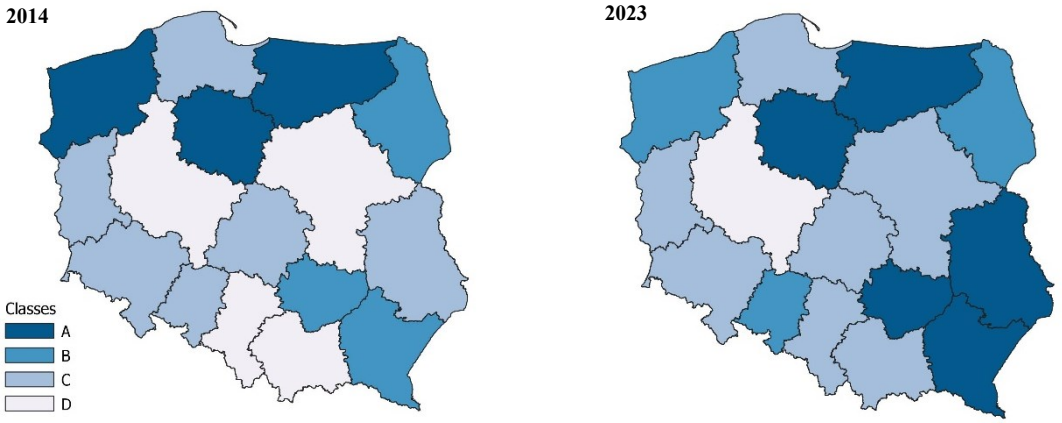


Figure 4. Class of Polish voivodeships in terms of "registered unemployment rate" in years 2014 and 2023.

Source: own study based on (Local Data Bank of the Statistics Poland, 2024).

Research studies conducted by the authors, in particular one of the most recent ones on the investment attractiveness of the Kujawsko-Pomorskie Voivodship, showed that for investors the qualifications of labour resources are particularly important, including above all education that prepares them well for future work. The labour market is especially in demand for people with vocational and technical skills. In 2014 in Poland the percentage of graduates from stage I sectoral vocational schools and technical secondary schools in the total number of graduates upper secondary and post-primary schools ($F_{res.}2$) amounted to 45.6%, compared to 50.2% in 2023. In the years analysed, the Opolskie, Kujawsko-Pomorskie, Wielkopolskie, and Lubuskie achieved the highest described rate (class A), and in 2023 the Warmińsko-Mazurskie joined to them. The leader in terms of graduates of stage I sectoral vocational schools and technical secondary schools was the Opolskie Voivodeship with an analysed indicator at 53.9% in 2014 and 60.2% in 2023. On the contrary, the lowest percentage in this field registered in Mazowieckie Voivodeship was 37.1% in 2014 (class D), 36.6% in 2023 (class C). The high attractiveness of the Wielkopolske and Kujawsko-Pomorskie, in terms of labour force qualifications, was confirmed by the results of a survey of foreign investors, who ranked this factor among the most important determinants of FDI location choice (Pawlak et al., 2015; Jaworek et al., 2016, 2023).

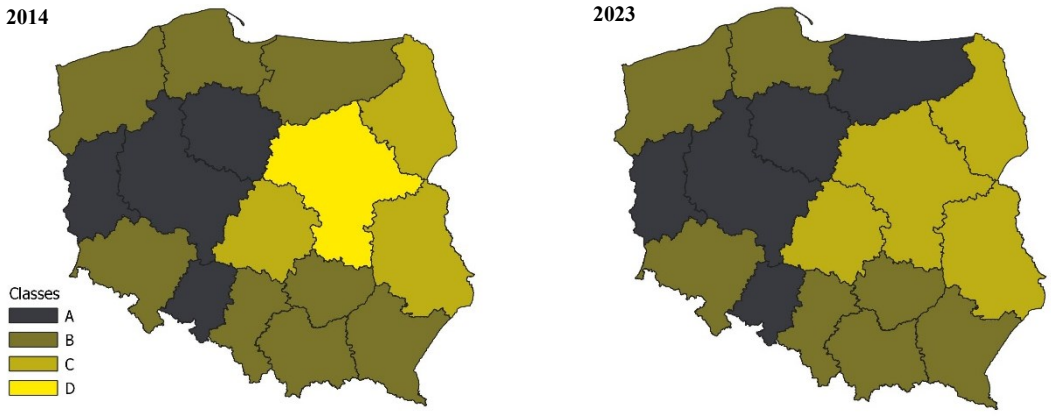


Figure 5. Class of Polish voivodeships in terms of "the percentage graduates of stage I sectoral vocational schools and technical secondary schools in total number of graduates upper secondary and post-primary schools" in years 2014 and 2023.

Source: own study based on (Local Data Bank of the Statistics Poland, 2024).

An important indicator of the quality of labour resources is the percentage of graduates in the fields of biological sciences, environment, health, physical sciences, mathematics and statistics, information and communication, engineering and engineering trades, architecture, and building ($F_{res.}3$). Significant saturation of well-qualifited resources is particularly important for investors from innovative high-tech sectors. In Poland in 2015 the percentage of graduates from this type of study was 21.7%, falling to 19.6% in 2022[1]. Among the regions with the

[1] The time period adopted for this indicator is determined by the availability of data.

highest described indicator (class A) were Dolnośląskie (27.5% in 2015 *versus* 25.8% in 2022), Świętokrzyskie (27.5% *versus* 21.1%), Małopolskie (27.0% *versus* 25.4%), and in 2015 also Pomorskie (25.1% *versus* 18.8%). The high attractiveness of Małopolskie in terms of this factor was indicated in the research by Domański et al. (2006, 2008). The authors concluded that it is the region's main asset for FDI deposits. In 2015 the lowest percentage of graduates in the fields of biological sciences, environment, health, physical sciences, mathematics and statistics, information and communication, engineering and engineering trades, architecture, and building (class D) was registered in the Opolskie (16.3%), Mazowieckie (17.4%), and Kujawsko-Pomorskie (17.6%), while in 2022 it was Warmińsko-Mazurskie (13.2%) and Kujawsko-Pomorskie Voivodeship (14.0%).

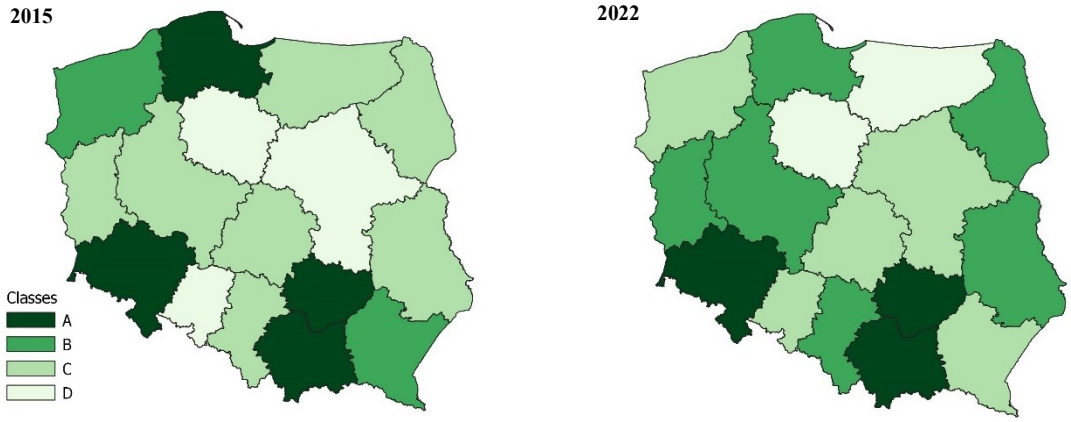
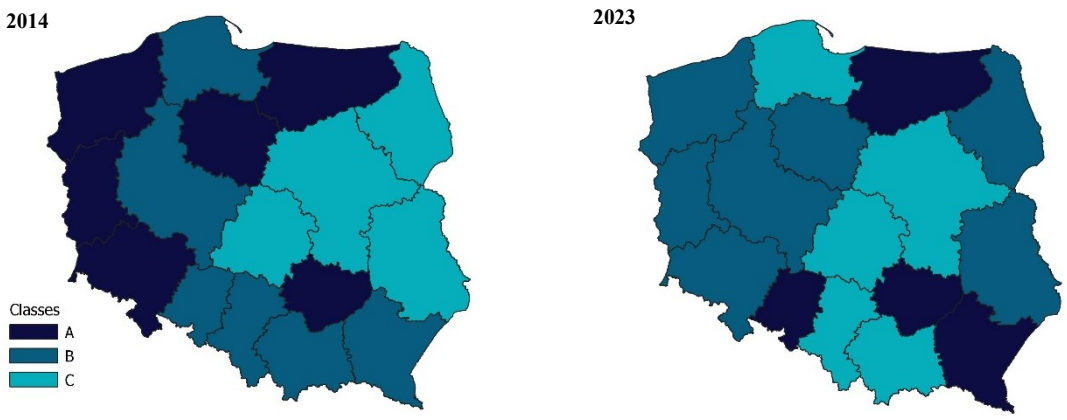


Figure 6. Classes of Polish voivodeships according to "the percentage of graduates in the fields of biological sciences, environment, health, physical sciences, mathematics and statistics, information and communication, engineering and engineering trades, architecture and building" factor in years 2015 and 2022.

Source: own study based on (Local Data Bank of the Statistics Poland, 2024).

Based on the numerical values of the synthetic parameter, calculated as the average value of partial parameters characterising individual factors, three classes of voivodeships were distinguished. At the beginning of our analysis the highest level of potential investment attractiveness in the labour resources (class A) had six voivodeships: Warmińsko-Mazurskie, Świętokrzyskie, Lubuskie, Dolnośląskie, Kujawsko-Pomorskie and Zachodniopomorskie, in 2023 this included only four units: Świętokrzyskie, Podkarpackie, Opolskie and Warmińsko-Mazurskie. In both years analysed, the worst summary result was achieved by the Mazowieckie Voivodship due to its high cost of labour and relatively low intensity of well-qualified potencial employees. In 2014, the following voivodeships were also in the lowest class (C): Lubelskie, Łódzkie, Podlaskie, and in 2023: Łódzkie, Śląskie, Pomorskie and Małopolskie.



Notes: the gross value added per 1 employed person data were available up to 2021 ($F_{eff.}1$), and the percentage of graduates in the fields of biological sciences, environment, health, physical sciences, mathematics and statistics, information and communication, engineering and engineering trades, architecture and building ($F_{res.}3$) covered the years 2015 and 2022.

Figure 7. Potential investment attractiveness of Polish voivodeships in the labour resources area.

Source: own study based on (Local Data Bank of the Statistics Poland, 2024).

5. Summary

The investment attractiveness of a region is due to the interaction of numerous factors and barriers. Their identification is essential in formulating action programmes for the economic and social development of the region. The results may be useful in this regard, indicating that the variability of the attractiveness factors over time implies the need for continuous research, the results of which should be considered by organisations involved in supporting entrepreneurship and, above all, by institutions responsible for formulating economic policy instruments.

The picture of potential investment attractiveness in the context of labour resources is not adequate to the actual state. Indeed, the results of our study indicated that the voivodeships with the highest potential investment attractiveness in the area of labour resources are those in which FDI are relatively small. The greatest ability to attract investment is characterised by the Mazowieckie Voivodeship. This is largely due to the high investment attractiveness of this province in other pillars and the unquestionable advantage associated with having within its borders the capital of Poland. Although from the point of view of investors, high wages, characteristic of this province, are not a stimulant to locate capital there, they are a regional asset that increases the ability to attract workers with the appropriate skills. The voivodeships that bear the effort to generate this resource are drained of it, thus deprived of their locational advantage. This advantage is shifted affecting the investment attractiveness of high-wage voivodeships that do not generate the appropriately skilled labour resources sought by investors.

Hence, regional decision-makers must make efforts for effective promotion in order to attract investors capable of implementing locally educated labour resources, thus intensifying local development.

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Appendix

Table 2.
Determinants of labour resources attractiveness of Polish voivodships

Voivodeship	$F_{eff.}1$				$F_{eff.}2$				$F_{res.}1$				$F_{res.}2$				$F_{res.}3$			
	2014		2021		2014		2023		2014		2023		2014		2023		2015		2022	
	Fi	Fij	Fi	Fij	Fi	Fij	Fi	Fij	Fi	Fij	Fi	Fij	Fi	Fij	Fi	Fij	Fi	Fij	Fi	Fij
	PLN	%	PLN	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Dolnośląskie	123,787	71.03	170,858	69.86	101.0	57.40	103.4	43.16	10.4	25.23	4.4	24.56	46.5	55.95	48.6	50.85	27.5	100.00	25.8	100.00
Kujawsko-Pomorskie	97,497	29.91	140,805	29.51	85.9	96.62	88.5	88.45	15.5	71.17	7.1	71.93	52.5	91.67	57.9	90.25	17.6	11.61	14.0	6.35
Lubelskie	78,373	0.00	118,828	0.00	90.0	85.97	89.2	86.32	12.6	45.05	7.6	80.70	38.8	10.12	48.4	50.00	20.2	34.82	19.9	53.17
Lubuskie	105,305	42.13	144,717	34.76	85.5	97.66	90.6	82.07	12.5	44.14	4.3	22.81	53.4	97.02	57.8	89.83	20.1	33.93	20.0	53.97
Łódzkie	99,526	33.09	145,260	35.49	90.4	84.94	92.9	75.08	11.8	37.84	5.4	42.11	41.6	26.79	46.8	43.22	18.2	16.96	17.6	34.92
Małopolskie	94,523	25.26	140,410	28.98	92.4	79.74	101.9	47.72	9.7	18.92	4.2	21.05	47.6	62.50	51.6	63.56	27.0	95.54	25.4	96.83
Mazowieckie	142,305	100.00	193,307	100.00	123.1	0.00	117.6	0.00	9.6	18.02	4.0	17.54	37.1	0.00	36.6	0.00	17.4	9.82	15.3	16.67
Opolskie	104,156	40.33	149,726	41.49	90.7	84.16	91.8	78.42	11.8	37.84	5.9	50.88	53.9	100.00	60.2	100.00	16.3	0.00	18.4	41.27
Podkarpackie	80,379	3.14	125,529	9.00	85.2	98.44	84.7	100.00	14.6	63.06	8.7	100.00	46.3	54.76	53.2	70.34	23.2	61.61	18.4	41.27
Podlaskie	86,491	12.70	124,390	7.47	88.2	90.65	89.6	85.11	12.9	47.75	7.0	70.18	42.2	30.36	47.8	47.46	21.1	42.86	19.8	52.38
Pomorskie	112,002	52.60	157,236	51.57	100.2	59.48	99.4	55.32	11.1	31.53	4.6	28.07	48.3	66.67	53.5	71.61	25.1	78.57	18.8	44.44
Śląskie	114,735	56.88	163,597	60.11	102.4	53.77	100.2	52.89	9.6	18.02	3.6	10.53	48.6	68.45	51.6	63.56	20.3	35.71	19.4	49.21
Świętokrzyskie	82,366	6.25	127,784	12.02	85.8	96.88	86.7	93.92	14.1	58.56	7.8	84.21	46.4	55.36	53.9	73.31	27.5	100.00	21.1	62.70
Warmińsko-Mazurskie	97,159	29.38	136,600	23.86	84.6	100.00	84.9	99.39	18.7	100.00	8.3	92.98	47.4	61.31	55.3	79.24	20.8	40.18	13.2	0.00
Wielkopolskie	105,617	42.61	148,316	39.59	89.9	86.23	89.2	86.32	7.6	0.00	3.0	0.00	50.0	76.79	57.4	88.14	21.3	44.64	20.8	60.32
Zachodniopomorskie	110,704	50.57	150,710	42.81	91.1	83.12	92.3	76.90	15.5	71.17	6.7	64.91	43.7	39.29	52.2	66.10	21.7	48.21	18.6	42.86

Note. F_i – level of the variable; F_{ij} – level of the standardised variable; $F_{eff.}1$ – gross value added per 1 employed person (PLN); $F_{eff.}2$ – average monthly gross wages and salary in relation to the average domestic (Poland = 100%); $F_{res.}1$ – registered unemployment rate (%); $F_{res.}2$ – graduates of stage I sectoral vocational schools and technical secondary schools in total number of graduates upper secondary and post-primary schools (%); $F_{res.}3$ – percentage of students in the fields of biological sciences, environment, health, physical sciences, mathematics and statistics, information and communication, engineering and engineering, architecture and building (%).

Source: own study based on (Local Data Bank of the Statistics Poland, 2024).