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ASSESSING LOCATIONS FOR LOGISTICS SERVICES IN POLAND: A HELLWIG INDEX RANKING

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Purpose: To evaluate the investment attractiveness of selected Polish provincial capitals for logistics outsourcing and offshoring, and to build a transparent ranking that supports firms' location decisions and public policy.
Design/methodology/approach: Using 2021 data from the Polish Central Statistical Office's Regional Data Bank, we construct an Investment Attractiveness Model (IAM) comprising 18 indicators spanning labour market, local economy, and transport/real-estate infrastructure. Variables are screened via coefficient of variation and Pearson correlations to limit collinearity, then standardised and aggregated with the Hellwig development pattern. Cities are ranked by distance to the synthetic pattern and classified into four groups.
Findings: Most capitals exhibit medium or low attractiveness. Lodz attains the highest synthetic score, while Gorzow Wielkopolski records the lowest. Katowice and Lodz form the top group; Warsaw, Gdansk, Krakow, Lublin, Szczecin, and Rzeszow follow with high attractiveness. Spatial concentration of logistics employment and firms is stronger near Poland's western border. Key stimulants include expressway/rail density, cargo airport utilisation, warehouse supply, innovation intensity, and specialised human capital; higher labour costs act as destimulants. An outlier is Wroclaw, where firm counts exceed what the synthetic score would predict.
Research limitations/implications: Results rely on one country's official statistics and city coverage; international generalisation is limited. Future research should test the IAM with Eurostat data across European countries and examine sector-specific weights and temporal dynamics.
Practical implications: The IAM offers a reproducible screen for site selection, enabling firms to balance cost, access, and time-to-market, and helps city authorities prioritise transport and warehouse infrastructure and talent pipelines to raise attractiveness.
Social implications: Better-informed location choices can support regional cohesion, job creation, and quality of life through planned logistics development and reduced bottlenecks.
Originality/value: The research paper integrates a clearly specified, logistics-oriented IAM with the Hellwig index to deliver a ranked, policy-relevant picture of urban investment attractiveness in Poland; provides a replicable framework for managers and policymakers.
Keywords: investment attractiveness; location determinants; Hellwig index; logistics outsourcing; Poland.
Category of the paper: Research paper.

1. Introduction

Dynamic changes in the economic environment contribute to increased competition between companies in the fight for customers. One of the effects of globalisation is the increasing diversity of product ranges and lower prices. This phenomenon forces companies to adapt to changing operating conditions. As a result, managers should focus on seeking sources of competitive advantage that will improve the company's profitability, strengthen its market position, and ensure an adequate level of dividends for shareholders.

The specialisation of companies, resulting from a focus on their core business, is becoming increasingly important. To properly define this area, managers should analyse which areas generate value and should be carried out within the organisation, and which can be transferred in whole or in part to external entities (Srabotic, Ruzzier, 2012). One of the key areas is supply chain management, which is responsible for the efficient flow of materials, products, and information at every stage of its operation (Aktas, Agaran, Ulengin, Onsel, 2011). There is also a growing trend of outsourcing tasks to foreign entities, often located in regions that are culturally and geographically close (e.g., the transfer of services from Western Europe to Central and Eastern Europe), referred to as offshoring.

Companies that want to remain competitive in the market should seek solutions that enable them to adapt to a changing environment. One of the tools for increasing competitiveness is the effective use of both internal and external resources. Outsourcing is an increasingly common practice, the aim of which is to use cheaper or more technologically advanced resources. This strategy promotes flexibility and improves efficiency, which translates into increased competitiveness for the company. The topic of outsourcing is gaining increasing importance in the literature, which results from growing interest from both business practitioners and researchers (Merino, 2017; Paek, Kim, Park, Lee, 2019). This is influenced, among other things, by new concepts of supply chain management, advances in information and communication technologies, a decline in transport costs, and the development of the logistics industry.

The main reason for outsourcing addressed in the research is cost reduction (Quélin, Duhamel, 2003; Roza et al., 2011; Stringfellow et al., 2008). However, the following are also important: the ability to focus on the company's core business, market expansion, and innovation potential (García-Vega, Huergo, 2019; Görg, Hanley, 2009; Mazzola et al., 2019), increased operational flexibility (Merino, 2017; Paek et al., 2019), and gaining a competitive advantage (Quélin, Duhamel, 2003; Solakivi et al., 2013).

According to Bunyaratavej et al. (2007), companies that decide to outsource are looking for savings related to lower wages and other costs of doing business outside their country. The researchers point out that low labour costs in the host country are a positive or at least neutral factor when choosing an investment location.

Research by Bengtsson and Dabhilkar (2009) shows that, in addition to cost reduction, the main motives include the ability to focus on core activities and increased operational flexibility. An important factor in manufacturing companies is also the use of outsourcing for innovative activities: using the expertise of external entities can shorten the time it takes to bring new products to market and enable the adoption of innovative solutions from suppliers.

From the perspective of resource-based theory (RBV) and the competency-based concept, outsourcing provides an opportunity to acquire specialised external knowledge and can promote inter-organisational learning processes. Many studies have analysed the impact of outsourcing on the innovativeness of companies. Arvanitis and Loukis (2013) found that labour costs were not a key factor in the choice of outsourcing strategy, but in their models, they took into account the positive relationship between outsourcing and the propensity of companies to implement product and process innovations.

Hwang and Kim (2019), on the other hand, point to the flexibility that outsourcing offers in logistics. In addition to transport, it also includes activities related to management, control, and other logistics functions. Logistics outsourcing allows companies to provide customers with the resources they need, strengthens their strategic capabilities to adapt to changing market conditions, and enables them to respond to unforeseen market needs. Researchers also emphasise its role in dealing with business risks and taking advantage of market changes as opportunities. This approach gives companies a competitive advantage in a dynamic environment.

Research shows that separating specific processes and focusing on core activities enables companies to achieve numerous benefits and strengthen their competitive position. However, it is crucial not only to identify the processes that can be outsourced, but also to select the right partners and locations where the services will be provided.

City-level decision support for logistics in Poland is scarce. This article provides, to our knowledge, the first logistics-oriented, city-level Investment Attractiveness Model (IAM) for Poland. Methodologically, we assemble 18 indicators across labour, local economy, and transport/real-estate infrastructure and aggregate them using the Hellwig method after formal screening. Empirically, we juxtapose the synthetic Hellwig score (d_i) with per-capita firm intensity, revealing corridor/port deviations (western/coastal cities with high firm intensity despite moderate/low d_i) that national or regional composites do not detect. Substantively, we translate these findings into city-specific recommendations for infrastructure, real estate, and skills.

The aim of this article is to identify the factors determining the attractiveness of selected Polish cities, to rank their investment potential using the Hellwig method, and to answer questions about the spatial diversity of Poland's investment attractiveness and its impact on the location of logistics companies.

The following sections present the theoretical basis for outsourcing logistics services, the research methodology together with the characteristics of the Hellwig index, and then present an analysis of the investment attractiveness of provincial capitals in Poland, indicating their distance from the development model. The study concludes with conclusions and recommendations regarding the outsourcing of logistics services and the choice of location.

2. Literature Review

Outsourcing and offshoring are becoming increasingly common management tools that play an important role in the activities of modern enterprises. Their use promotes the growth of productivity, efficiency, and competitiveness of organisations (Bozarth, Handfield, 2008; Cheung, Rossiter, Zheng, 2008; King, Malhotra, 2000; Schniederjans, Schniederjans, Schniederjans, 2005). Thanks to offshoring, companies can target their investments more precisely, especially in areas that strengthen their competitive advantage in the market.

The use of this strategy enables companies to reduce operating costs, simplify organisational structures, improve the quality of services provided, focus on key competencies, and accelerate innovation processes. At the same time, outsourcing and offshoring also involve certain risks. The most frequently mentioned ones include: the risk of losing control over processes, reduced operational flexibility, and the possibility of transferring strategic information to suppliers who may become potential competitors in the future (Aktas et al., 2011). In the manufacturing sector, one of the most frequently delegated areas is logistics (Srabotic, Ruzzier, 2012). In this context, three models stand out: external logistics, Third Party Logistics (3PL) and Fourth Party Logistics (4PL).

The 3PL model is based on the provision of comprehensive logistics services by a logistics operator. On the other hand, 4PL means full integration of services – the operator becomes the main contractor and coordinator of all logistics activities in the company. Typical outsourced logistics services include warehousing, packaging, order picking, and transport to the recipient. They operate within the framework of so-called contract logistics, a term often used interchangeably with the concept of logistics outsourcing. In this arrangement, the logistics operator becomes the link responsible for ensuring the continuity of supplies for production, as well as for the further distribution of finished products.

The development of international trade, increased competition, and growing customer demands are driving the dynamic growth of the logistics outsourcing market. This phenomenon is particularly significant in the context of globalisation and advances in information technology. More and more often, companies decide to cooperate with specialised logistics operators, which allows them to focus on their core business and contributes to the growing popularity of outsourcing in this sector (Yeung, Zhou, Yeung, Cheng, 2012) (Table 1).

Table 1.
Advantages and disadvantages of long-term cooperation in logistics outsourcing

Advantages	Disadvantages
• improvement of efficiency, • the possibility of using the resources and information of the service provider, • reduction of warehouse costs, • the possibility of using knowledge related to the functioning of legal regulations, e.g. regarding customs clearance, • reduction of possible delays in delivery, • creating a competitive advantage, • the possibility of expansion into new markets, • change of fixed costs into variable costs.	• the risk of losing confidential information, • failure to achieve the expected reduction in warehouse costs, • no possibility to use the expanded scope of logistics services, • lack of use of advanced information technologies by the suppliers, • impaired communication between the company and the service provider, • no control over the distribution system.

Source: Own study based on Yeung, Zhou, Yeung, Cheng, 2012, pp. 741-753.

Both the benefits and limitations of outsourcing apply to companies that outsource their processes to external suppliers. At the same time, service providers themselves strive to reduce costs and seek optimisation by expanding their activities outside their home country. In this context, it is particularly important to analyse the attractiveness of cities as locations for establishing foreign branches and hiring highly qualified personnel. This is especially important when a company uses knowledge of the legal regulations in force in the country from which it imports or to which it exports its products and services.

Poland belongs to a group of countries where numerous service centres are located, or to which selected processes are outsourced. The outsourcing services provided here primarily serve customers from Western Europe. This is facilitated by, among other things, the adequate supply and quality of labour resources, i.e., the level of education of the workforce, wage relations, and the relatively low costs of doing business.

Maintaining a high level of expertise and operational excellence in every field generates significant costs, which is why companies that are aware of the value of advanced skills and modern technologies are willing to outsource such tasks to external entities. In this sense, outsourcing becomes a fundamental component of a company's operating strategy (Greer, Youngblood, Gray, 1999). The economic and organisational benefits of this model of cooperation are recognised not only by large corporations but also by smaller entities. As a result, more and more companies are establishing relationships with service centres located in various regions of the world (Budzyńska, 2017). The most recognisable outsourcing locations include India, China, Malaysia, Indonesia, Vietnam, and the United States. In the Top Countries for Outsourcing 2019 ranking compiled by A.T. Kearney, Poland was ranked 24th among the most attractive destinations for outsourcing services (Kearney, 2019).

According to the Deloitte Global Shared Services Survey Report 2019, companies are increasingly implementing onshore and offshore location strategies. The most frequently mentioned destinations include India, the United States, Poland, Costa Rica, and Mexico. Poland is among the top five most popular locations considered for service relocation (Deloitte, 2019). A similar assessment of Poland's position is presented in the Executive Brief – Outsourcing 2019 report prepared by 7N (7N, 2019).

The 7N report indicates the leading destinations for outsourcing companies, i.e., the Philippines, India, the Czech Republic, Hungary, and Poland. In the case of the Philippines, the report highlights the very high level of English language proficiency and the good cultural fit of employees with the expectations of companies. India has had a developed business services sector for years; its attractiveness is determined, among other things, by the large number of technical specialists, infrastructure facilities, and relatively convenient air connections compared to other Asian locations. The next positions are occupied by Central and Eastern European countries, the Czech Republic, Hungary, and Poland, where nearshoring is particularly strong, reinforced by geographical proximity and a maximum of two time zones difference from parent companies. The Czech Republic has been a leader in nearshoring services for years, thanks to the availability of skilled personnel and short flight connections to Scandinavia. Hungary, in addition to its relatively broad base of specialists, is experiencing rapid GDP growth in the ITO segment. Poland, in turn, has one of the largest groups of highly qualified IT specialists in Europe (7N, 2019).

Poland has a set of factors conducive to its leading position in the business services segment, especially in advanced forms of outsourcing and offshoring. According to a McKinsey analysis (McKinsey & Company, 2015), the country has significant potential for employment growth in this sector, and the more advanced services provided here further stimulate the economy. An additional advantage is the geographical proximity of suppliers to customers, which reduces operational risk. In recent years, there has been a relocation of some services from India to other countries, including Poland. Initially, investors located mainly basic processes in Poland, taking advantage of lower costs. (McKinsey & Company, 2015). However, city-level, logistics-oriented composite assessments for Central and Eastern Europe remain scarce; to address this gap, the next section operationalises a city-level Investment Attractiveness Model (IAM) and applies the Hellwig development pattern to evaluate Polish provincial capitals.

3. Methods

The aim of this study is to analyse the investment attractiveness of selected Polish provincial capitals using a method based on the Hellwig index. Based on data form the Regional Data Bank of the Central Statistical Office, the authors constructed an investment attractiveness model (IAM) that allows them to answer research questions related to the assessment of the investment potential of provincial capital.

3.1. The research questions

A review of the literature and identification of the motives for outsourcing made it possible to formulate the following research questions:

- Q1: What conditions favour or limit the choice of location for relocated logistics services?
- Q2: How does the spatial diversity of the investment attractiveness of Polish provincial capitals look in the context of the logistics outsourcing sector?
- Q3: Do outsourcing entities from the logistics industry tend to locate their operations in regions closer to the western border of the country?
- Q4: Does the level of investment attractiveness of a particular city influence the location decisions of companies in the sector in question?

To answer the above questions, a six-step research procedure was applied, on the basis of which an investment attractiveness model (IAM) was constructed.

3.2. The research procedure

The research process was organised in six consecutive stages: from a review of the literature, through statistical data analysis, to the formulation of conclusions and recommendations addressed to business owners and municipal authorities (Figure 1).

The indicators used reflected the investment attractiveness of the logistics outsourcing sector and described both the situation of individual cities and their regional hinterland. The regional approach was deliberate, as investors' decisions are shaped not only by strictly urban factors, but also by environmental conditions, for example, access to national roads, motorways or railway infrastructure at the provincial level, which is crucial for the location of entities from the analysed sector.

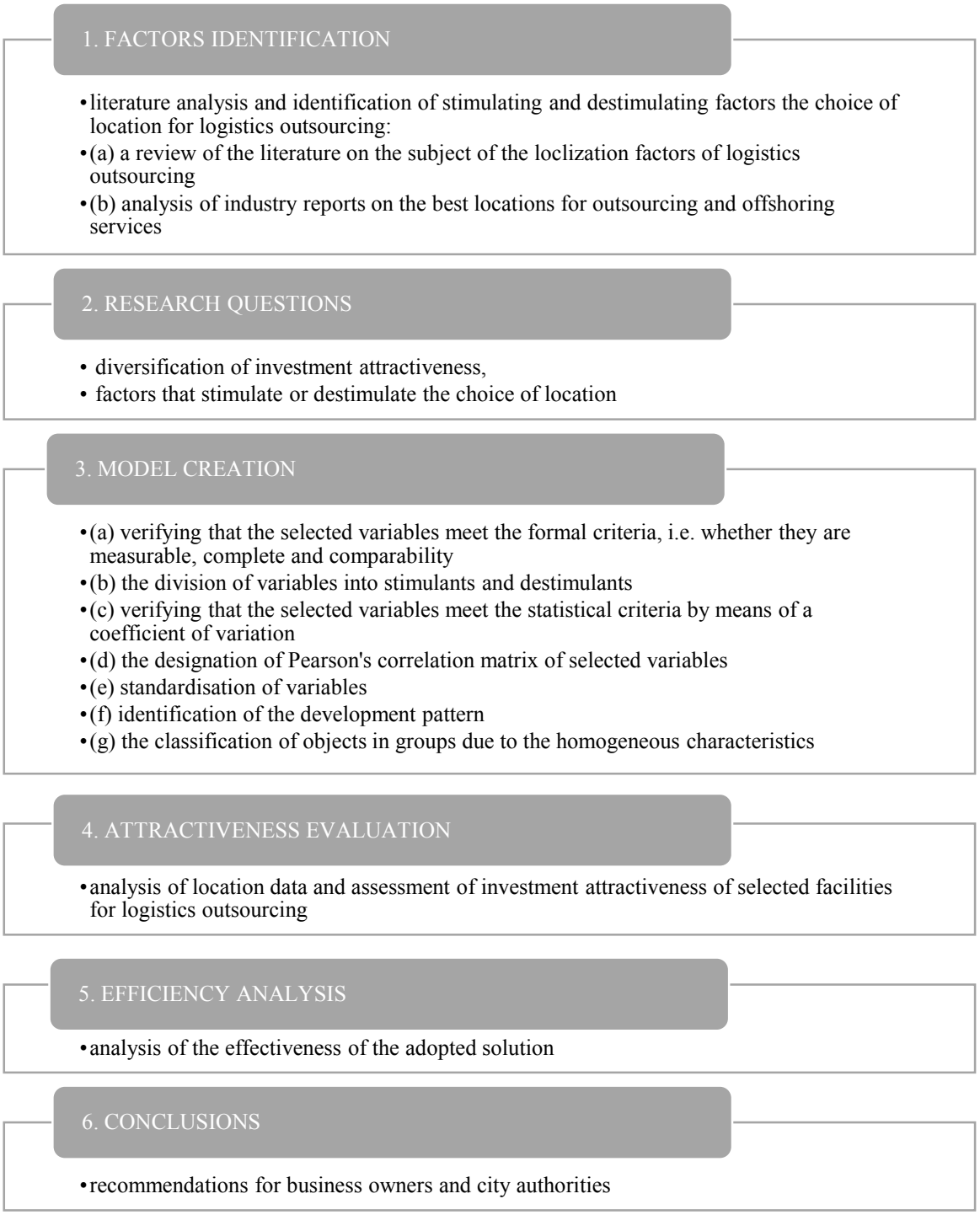

Figure 1. The research procedure.

Source: own study.

The conclusions from the literature review were supplemented with data from various industry analyses and reports. This allowed for a broader consideration of the degree of warehouse space development and the associated costs. Due to the lack of available statistical data for some provincial capitals (including Kielce, Opole and Olsztyn), they were excluded from the investment attractiveness assessment.

3.3. Hellwig's Index

The main element of the analysis was the use of the Hellwig method to determine the level of investment attractiveness of selected provincial capitals in Poland. This is a taxonomic measure of development proposed by Z. Hellwig in 1968, originally used for international comparisons of economic development levels. This technique allows for the measurement of sustainable development and the ranking of the objects under study (e.g. cities) from the least to the most developed, according to the level of the analysed phenomenon. The procedure involves constructing a matrix of diagnostic variables (indicators) selected on the basis of substantive and statistical premises, and then standardising them to obtain comparable values (Roszkowska, Filipowicz-Chomko, 2021). The schedule for applying the method is as follows:

a) A set of statistical variables to be evaluated is determined and divided into stimulants and destimulants: $\{X_1, X_2, \ldots, X_m\}$;
b) For each object, the values of X_j variables are standardised (according to formula (1) in the text), using the arithmetic mean and standard deviation of a given feature to bring the indicators to a comparable scale:

$$z_{ij} = \frac{x_{ij} - \overline{x_j}}{S_j} \tag{1}$$

where:
$\overline{x_j}$ – the arithmetic mean of the *j*th feature,
S_j – the standard deviation of the *j*th feature.

c) Next, a development pattern P_0 with coordinates $(z_{01}, z_{02}, \ldots, z_{0m})$, defined by relations (2) is determined, maximum values are taken for stimulants and minimum values for destimulants after standardisation:

$$\begin{cases} z_{0j} = \max\limits_{i} z_{ij,} \\ z_{0j} = \min\limits_{i} z_{ij,} \end{cases} or \begin{matrix} when\ X_j\ is\ a\ stimulant \\ when\ X_j\ is\ a\ destimulant \end{matrix} j = 1, 2, \ldots, m, \tag{2}$$

In this step, the set of variables is divided into stimulating (S) and destimulating (D) factors (Table 2).

Table 2.
Grouping by different ranges of synthetic variability of the development measure

Group	Development rate	Value
****	Very high development rate	$d_i \geq \overline{d_\iota} + S_{d_i}$
***	High development rate	$d_i + S_{d_i} > d_i \geq \overline{d_\iota}$
**	Low development rate	$\overline{d_\iota} > d_i \geq \overline{d_\iota} - S_{d_i}$
*	Very low development rate	$d_i < \overline{d_\iota} - S_{d_i}$

Note. † d_i – general expression for the values of the synthetic method indicator of Z. Hellwig's development pattern; $\overline{d_\iota}$ – the arithmetic mean of the synthetic indicator; S_{d_i} – standard deviation of the synthetic indicator.

Source: Own study based on Malinowski, 2017, pp. 178-197.

Stimulants, i.e. supporting factors and destimulants, i.e. barriers, are diverse and depend on industry, scale, country or region of investment. The concept of stimulants and destimulants was introduced by Z. Hellwig in 1968, and their definition is as follows: are two objects ω_1 and $\omega_2 \in \Omega$ and the attribute $\varphi_1 \epsilon \phi$. It is said that the object ω_1 is dominated by the object ω_2 (or the object ω_2 dominates the object ω_1) and is written symbolically as $\omega_1 \succ \omega_2$ if $x_{2j} \geq x_{1j}$. A feature φ_1 is a stimulant, when: $\wedge_{x_{rj},x_{sj}}(x_{sj} \geq x_{rj}) \Rightarrow \omega_s \succ \omega_r$. A feature φ_1 is a destimulant, when: $\wedge_{x_{rj},x_{sj}}(x_{sj} \geq x_{rj}) \Rightarrow \omega_s \prec \omega_r$ (Hellwig, 1981). An example of the attracting factors (stimulant) of foreign companies may be the quality and availability of technical or transport infrastructure. The availability of workforce in a given location, which attracts new businesses, is also an important element. The availability of the workforce can be measured by the number of students at universities, which should be directly proportional to the attractiveness of the region concerned. A very important factor is the availability of roads, which increases the level of investment in a given region, regardless of the sector. The density of roads is linked to the cost of doing business and the availability of the region (Popescua, 2013). On the other hand, the destimulant, which is a characteristic for which lower values are desirable, i.e. costs associated with doing business. Examples include labour costs, maintenance costs of technical (warehouse) or transport infrastructure. Companies will seek to reduce business costs (Graf, Mudambi, 2005).

The destimulant collection includes variables with the symbols: X_1 and X_2. Other variables were considered stimulants. Stimulants are those whose high values are desirable from a certain point of view, while low ones are undesirable. Destimulants are, however, features whose low values are a desirable phenomenon from a certain point of view, and high values are undesirable.

d) The next stage of the calculations was the calculation of the Euclidean distance of the distinguished objects from the standard established in the above manner, in accordance with the formula:

$$D_{io} = \sqrt{\sum_{j=1}^{m}(z_{ij} - z_{oj})^2}\ , i = 1, \ldots, n \tag{3}$$

On the basis of the obtained distance sequence D_{10}, D_{20}, …, D_{n0} – we determine:

$$\overline{D_o} = n^{-1}\sum_{i=1}^{n} D_{io}, \tag{4}$$

$$S_o = \sqrt{n^{-1}\sum_{i=1}^{n}(D_{io} - \overline{D}_o)^2}, \tag{5}$$

$$D_0 = \overline{D}_0 + 2S_0, \tag{6}$$

$$d_i = 1 - \frac{D_{io}}{D_o}, i = 1, \dots, n, \tag{7}$$

Values $d_1, d_2, \dots, d_n$ are ordered from the highest to the smallest value. The object is more developed, if the value of the development measure d_i approaches one (Fura, Wang, 2017; Maráková, Dyr, Wolak-Tuzimek, 2016; Reiff, Surmanová, Balcerzak, Pietrzak, 2016; Stec, 2008). The method of Z. Hellwig's development pattern allows determining the ranking of the examined objects according to the level of their development on the basis of calculated taxonomic development indicators. Synthetic values of development indicators (d_i) are in the range of 0-1.

e) The obtained values of indicators allow for the classification of objects, due to homogeneous groups, from the point of view of the achieved level of the studied phenomenon. The total range of variability of the synthetic measure of development was divided into four groups, to which individual examined objects were assigned according to the formula (Table 2).

3.4. Investment Attractiveness Model (IAM)

Investment attractiveness is multidimensional and consists of many partial variables, which makes it impossible to measure directly. Therefore, multidimensional statistical tools are used to assess it, which enable the construction of a synthetic measure. Such a measure replaces a set of features describing a given object with a single aggregate variable. This makes it possible to compare locations using a single indicator and to rank the cities.

To construct a synthetic measure, the Investment Attractiveness Model (IAM), a set of 18 ariables was proposed (Table 2). These covered various dimensions of regional development related to its attractiveness to investors: the labour market, the local economy and transport infrastructure. The key stages of model construction are presented in Figure 2.

Figure 2. Investment attractiveness model (IAM) development stages.

Source: own study.

In the first step, a review of the literature on logistics outsourcing and location conditions was conducted, identifying factors influencing the choice of service location. Next, the variables were grouped into areas reflecting different aspects of the region's level of development (Table 3) and identified as stimulants or deterrents to location choice (Q1).

Table 3.
Potential variables that characterize the investment attractiveness for the logistics outsourcing sector

The symbol of variable	The group of the variable	The name of the variable	stimulants (S) / destimulants (D)	Average	Coefficient of variation %
X_1	The cost of doing business	Share of the average gross wage in section H in Voivodeship in the average monthly gross wage in section H in Poland	D	0.93	13%
X_2		Rent rate	D	2.61	7%
X_3	Transport infrastructure	Roads with hard surface at 100 km^2	S	301.44	18%
X_4		Expressways and highways per 1000 km^2	S	16.26	41%
X_5		Total railway lines per 100 km^2	S	6.66	45%
X_6		Loading of cargo and mail at airports per 1000 companies in total	S	0.05	179%
X_7		Landing of cargo and mail at airports per 1000 companies in total	S	0.04	163%
X_8	The real estate	The area of industrial buildings in m2 calculated per 1 company from section H	S	2.65	124%
X_9		Supply of warehouse space per 1 company from section H	S	274.88	149%
X_{10}		Empty buildings	S	4.38	77%
X_{11}	The labour market	Share of the economically active unemployed with higher education in the total population in %	S	0.73	45%
X_{12}		Population density per 1 km2	S	2001.64	30%
X_{13}		University students transport services majors per 10,000 total students	S	119.18	67%
X_{14}		University graduates of transport services majors per 10,000 total students	S	133	67%
X_{15}		Balance of internal and foreign migration per 1 thousand population	S	-0.129	-2661%
X_{16}	The location market	Entities from section C for 10,000 residents	S	105.31	18%
X_{17}		The average share of innovative enterprises in the total number of enterprises in %	S	25.43	15%
X_{18}		The number of entities from section H per 1000 entities in total	S	59.44	12%

Source: own calculations based on Regional Data Bank of the Polish Central Statistical Office (2021).

The coefficient of variation was used to check whether the data met the formal requirements (measurability, completeness, comparability). The next step was to assess the strength of the linear relationship between the variables using Pearson's correlation; strongly correlated variables ($r > 0.7$) were eliminated to reduce collinearity.

The variables were then standardised and transformed to a comparable scale, which allowed the Euclidean distances from the development pattern to be calculated (Hellwig method). Finally, the values of the synthetic development pattern index were grouped using the arithmetic mean and standard deviation (Table 4), classifying the objects into four homogeneous groups.

Table 4.
Pearson correlation coefficient

	X_1	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}
X_1	1																
X_3	0.638**	1															
X_4	0.419	0.275	1														
X_5	0.462	0.399	0.799**	1													
X_6	0.235	0.352	0.625**	0.814**	1												
X_7	0.300	0.400	0.457	0.739**	0.951**	1											
X_8	0.274	0.214	0.285	0.274	0.283	0.248	1										
X_9	0.231	0.339	0.750**	0.877**	0.952**	0.843**	0.337	1									
X_{10}	0.314	0.444	0.689**	0.655**	0.571*	0.510*	0.518*	0.650**	1								
X_{11}	0.292	0.497*	0.060	0.206	0.213	0.236	0.190	0.183	-0.162	1							
X_{12}	0.546*	0.952**	0.269	0.333	0.373	0.404	0.242	0.329	0.427	0.510*	1						
X_{13}	0.402	0.261	0.121	0.353	0.355	0.413	0.327	0.335	-0.037	0.352	0.158	1					
X_{14}	0.320	0.261	0.127	0.330	0.332	0.373	0.191	0.328	-0.089	0.406	0.142	0.965**	1				
X_{15}	0.015	0.203	0.107	0.301	0.375	0.461	0.172	0.313	0.064	0.576*	0.288	0.291	0.292	1			
X_{16}	0.614**	0.608**	0.375	0.363	0.281	0.302	0.488*	0.334	0.364	0.330	0.553*	0.446	0.400	0.391	1		
X_{17}	0.211	0.256	0.391	0.459	0.401	0.375	0.231	0.366	0.327	0.270	0.313	0.338	0.309	0.168	-0.166	1	
X_{18}	0.669**	0.370	0.320	0.258	-0.005	-0.023	0.135	-0.020	-0.062	0.417	0.331	0.370	0.333	-0.088	0.264	0.465	1

Note. * Correlation significant at the level of 0.05 (two-sided). ** Correlation significant at the level of 0.01 (two-sided).

Source: own calculations based on Regional Data Bank of the Polish Central Statistical Office (2021).

Based on the coefficient of variation:

$$V = \frac{S(x)}{\bar{x}} \cdot 100, where \tag{8}$$

$$S(x) = \sqrt{\frac{\sum_{i=1}^{m}(x_i - \bar{x})^2}{m}} \text{ means standard deviation,} \tag{9}$$

$$\bar{x} = \frac{\sum_{i=1}^{m} x_i}{m} \text{ means the arithmetic mean} \tag{10}$$

for $i = 1, \ldots, m$ ($m - number\ of\ cities$), it was found for all indicators describing cities that the variable Rent rate (X_2) does not meet the differentiation threshold, its V did not exceed the assumed 10%. As a result, it was considered quasi-constant, with low variability and poor diagnostic properties, and was eliminated from further calculations. Next, Pearson's correlation matrix was determined within individual areas (Table 4).

Variables with high correlation coefficients (marked in grey) indicated excessive interaction; as a result, those for which $r > 0.7$: X_5, X_7, X_9, X_{12} and X_{13}. In accordance with the adopted procedure, the variables used in the model should be characterised by weak mutual correlation; in the case of significant interdependence, such a variable is eliminated, as high correlation suggests similar behaviour of the indicators and reduces the diagnostic value of the model.

4. Results

The regional aspect, including the availability of skilled personnel, is reflected in employment intensity. Figure 3 shows the number of employees in the section ‘transport and storage’ (H) per 1,000 total employees by voivodeship in 2021. The highest band is observed in Mazowieckie, with elevated levels also along the western border, including Lubuskie, Wielkopolskie, Pomorskie and Zachodniopomorskie.

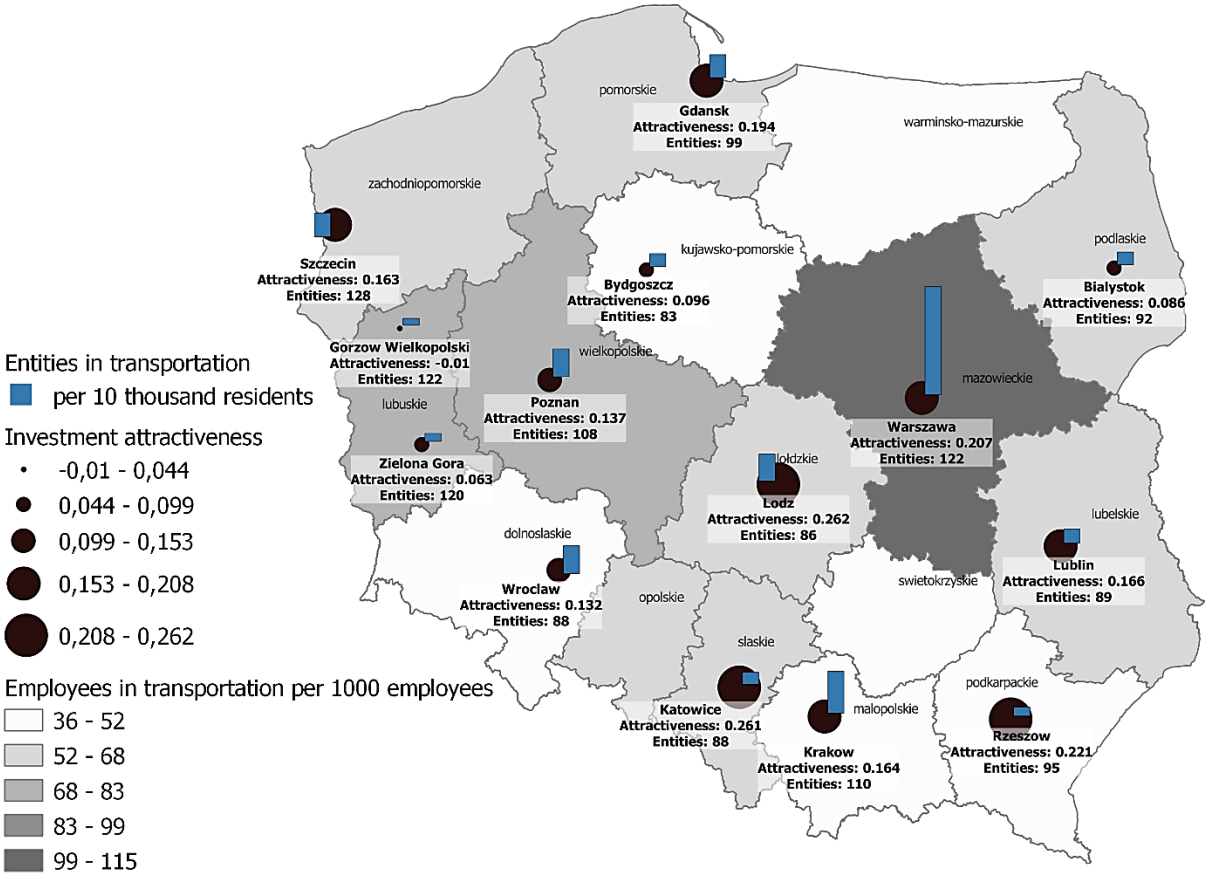

Figure 3. The number of employees in section transportation and storage per 1000 employees in total in 2021.

Source: own calculations based on Regional Data Bank of the Polish Central Statistical Office (2021). Visualised in QGIS.

For the 14 voivodeship cities, the per-capita density of section-H entities ranges from 83 to 128 per 10,000 residents in 2021. The highest values occur in Szczecin (128), Warsaw (122), Gorzow Wielkopolski (122) and Zielona Gora (120). Elevated levels are noted in Krakow (110) and Poznan (108). Mid-range outcomes cluster around 95-99 (e.g., Rzeszow 95, Gdansk 99), with several cities between 88–92 (Lublin 89, Katowice 88, Wroclaw 88, Bialystok 92). The lowest recorded value is in Bydgoszcz (83); Lodz reports 86.

For the 14 cities analysed, the synthetic investment attractiveness index (d_i) ranges from 0.262 to -0.010. As per formula (7), higher values of d_i index indicate greater investment attractiveness. The city-level calculated using the Hellwig method are presented in Table 5.

Table 5.

Value of the indicator of the synthetic level of investment attractiveness of voivodeship cities in Poland

City	*Variables*												d_i	*Ranking*	*Group^*
	X_1	X_3	X_4	X_6	X_8	X_{10}	X_{11}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}			
Lodz	-0.17	-0.28	1.78	0.37	1.64	1.12	-0.09	-1.19	-0.53	0.81	-2.44	-0.19	0.262	1	****
Katowice	0.36	0.16	1.90	3.20	-0.77	1.30	-0.71	0.43	-0.05	0.01	-2.34	-1.15	0.261	2	****
Rzeszow	-1.00	-0.50	-0.52	-0.37	-0.27	-0.94	2.41	0.12	2.01	-0.31	-2.32	-0.21	0.221	3	***
Warszawa	1.93	1.79	-0.38	0.82	-0.74	0.27	-0.09	-0.18	0.61	0.76	-2.27	-0.19	0.207	4	***
Gdansk	2.11	0.02	-1.06	0.01	2.23	0.55	-0.09	0.43	0.67	0.98	-2.30	-0.40	0.194	5	***
Lublin	-0.88	0.68	-1.21	-0.48	-0.61	-1.26	1.47	1.78	-0.29	-0.37	-2.41	-0.04	0.166	6	***
Krakow	-0.63	0.27	-0.63	-0.43	-0.65	-0.14	-0.09	-0.59	1.23	0.28	-2.33	-0.42	0.164	7	***
Szczecin	0.52	-0.73	-0.27	-0.48	0.43	-1.20	-0.40	1.89	-0.53	01.10	-2.62	01.06	0.163	8	***
Poznan	0.52	0.58	0.05	-0.32	-0.28	0.46	-0.71	0.60	-0.62	0.72	-2.45	-1.20	0.137	9	**
Wroclaw	0.03	0.37	0.94	-0.37	-0.22	1.01	-0.40	-1.09	0.46	-0.07	-2.32	-1.58	0.132	10	**
Bydgoszcz	-0.67	0.16	-0.12	-0.48	1.27	1.15	-1.03	-1.03	-1.72	-0.09	-2.51	0.16	0.096	11	**
Bialystok	-0.78	0.92	-1.24	-0.48	-0.67	-1.26	1.16	-1.21	-0.56	-0.84	-2.31	01.05	0.086	12	**
Zielona Gora	-0.67	-2.48	0.39	-0.48	-0.68	-1.26	-0.40	0.02	0.64	-0.14	-2.58	1.20	0.063	13	*
Gorzow Wielkopolski	-0.67	-0.94	0.39	-0.48	-0.69	0.18	-1.03	0.02	-1.31	-2.83	-2.58	1.91	-0.010	14	*

Note. ^ - level of attractiveness **** - high * - small

Source: own calculations based on Regional Data Bank of the Polish Central Statistical Office (2021).

In the group under study, Lodz is characterised by the highest attractiveness, while Gorzow Wielkopolski, which achieved the lowest synthetic measure value, is characterised by the lowest attractiveness (see Figure 4).

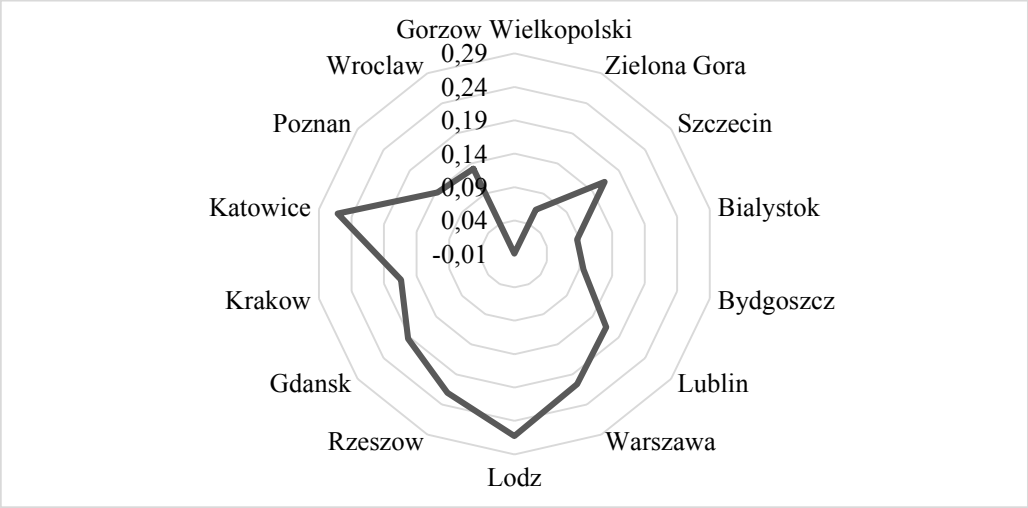

Figure 4. The distance (d_i) of provincial cities from the development pattern according to Hellwig in 2021.

Source: own calculations based on Regional Data Bank of the Polish Central Statistical Office (2021).

Based on the taxonomic measure of development d_i, provincial cities were divided into four groups (Table 5). The analysis shows that Katowice and Lodz achieve a very high level of investment attractiveness (group I). Six centres, Rzeszow, Warsaw, Gdansk, Krakow, Lublin and Szczecin, were classified in group II, characterised by high attractiveness. Most of the cities surveyed were classified in group III (low level of attractiveness). Zielona Gora and Gorzow Wielkopolski were classified in group IV, which means a very low level of attractiveness for logistics services compared to other units (Q2).

For individual indicators, the lowest value of X_1 (labour costs) occurs in Rzeszow, with Lublin, Bialystok, Bydgoszcz, Gorzow Wielkopolski, Zielona Gora, Krakow and Lodz are also below the sample average (4326 PLN/month), whereas the highest X_1 values are observed in Gdansk and Warsaw. In transport infrastructure, Warsaw records the highest X_3 (roads with hard surface at 100 km^2), while Katowice records the highest X_4 (expressways and highways per 1000 km^2), and the lowest X_4 values are in Bialystok and Lublin.

For air-cargo intensity (X_6), the highest level is in Katowice and the lowest values appear in Gorzow Wielkopolski, Zielona Gora, Bydgoszcz, Szczecin, Lublin and Bialystok. Regarding real-estate/warehouse metrics, Gdansk has the highest X_8 (industrial building area per firm in section H) and Katowice the lowest, while Katowice posts the highest X_{10} (vacant space), with the lowest X_{10} in Lublin, Bialystok and Zielona Gora.

In labour market availability, Rzeszow has the highest X_{11} (share of unemployed with higher education) and Gorzow Wielkopolski the lowest. For specialised human capital, Szczecin records the highest X_{14} (graduates in transport services per 10,000 students), with the lowest values in Lodz and Bialystok. Net migration (X_{15}) is highest in Rzeszow and lowest in

Bydgoszcz. Measures of economic activity show the highest X_{16} (number of manufacturing enterprises per 10,000 inhabitants) in Szczecin and the lowest in Gorzow Wielkopolski. The highest X_{17} (share of innovation enterprises) is in Warsaw, and the lowest is in Szczecin. The highest X_{18} (share of section H in the total number of companies) is in Gorzow Wielkopolski, and the lowest is in Wroclaw.

5. Discussion

This study introduces a city-level, logistics-oriented Investment Attractiveness Model (IAM) for Poland and explicitly juxtaposes the Hellwig score with per-capita firm intensity. In contrast with national-scale composites, we uncover corridor/port deviations – western/coastal cities with high firm intensity despite moderate/low d_i (Q1–Q3). Prior work emphasises costs, connectivity and talent as location determinants (Aktas et al., 2011; Graf, Mudambi, 2005; Hwang, Kim, 2019). National indices (Kearney, 2019; Deloitte, 2019) rank countries or broad regions. We confirm these drivers at city scale and show that cross-border corridors, port access and labour-market pooling can amplify siting beyond average attractiveness captured by d_i.

Similar to the literature, our high-ranked cities combine expressway/rail density and warehouse capacity. Unlike national-scale assessments, Szczecin, Zielona Gora and Gorzow Wielkopolski exhibit high firm intensity with only moderate/low d_i, signalling corridor/port and legacy-specialisation effects that attenuate the di-presence link. The IAM captures the baseline attractiveness channel, while infrastructure corridors and ports act as multipliers. This explains the weak, non-monotonic associations reported in the Results and guides place-specific policy (see Conclusions). Next steps include: (i) rank-based association tests (Spearman) with bootstrapped confidence intervals, (ii) sector-specific weights for IAM domains, and (iii) a multi-year panel (e.g., 2016-2023) using Eurostat to test rank stability and dynamics across European cities.

Our IAM operationalises location determinants for logistics outsourcing into a transparent set of stimulants (infrastructure, warehouse/real-estate stock, labour supply, local economy/innovation) and destimulants (business costs), consistent with prior work on cost, connectivity and talent (e.g., Aktas et al., 2011; Graf, Mudambi, 2005; Hwang, Kim, 2019) (Q1). The Hellwig index indicates marked spatial differentiation, two cities at very high levels, six high, most low, and two very low, underscoring uneven endowments in connectivity, warehouse stock and specialised human capital (Q2). While the Results section reports distributions only, their geography aligns with corridor and port adjacency: western and coastal regions display stronger logistics presence and labour pooling that can amplify attractiveness beyond cost fundamentals (Q3).

The association between the synthetic score and firm location is positive but non-monotonic. High-ranked centres (e.g., Warsaw) also show high firm intensity, yet several western-border cities (e.g., Szczecin, Zielona Gora, Gorzow Wielkopolski) record high per-capita firm counts despite moderate or low synthetic scores. This indicates that investment attractiveness matters, but corridor/port access, legacy specialisation and labour-market pooling also shape siting decisions (Q4).

Indicator patterns are consistent with these mechanisms. High road density (X_3) in Warsaw and expressway density (X_4) in Katowice and Lodz support market access and distribution. Airport cargo intensity (X_6) peaks in Katowice, echoing logistics-capability evidence (Hwang, Kim, 2019). On the warehouse market, Gdansk's high X_8 suggests abundant space relative to section-H firms, while Katowice's high vacancy (X_{10}) implies immediate availability that may compress onboarding times. Human-capital signals are mixed: Rzeszow shows high X_{11} (university-educated unemployed), Szczecin leads in transport-graduate output (X_{14}), and net migration (X_{15}) is positive in Rzeszow but low in Bydgoszcz. Broader economic activity (X_{16} - X_{18}) further highlights heterogeneity: manufacturing density (X_{16}) is highest in Szczecin, the innovation share (X_{17}) in Warsaw, and section-H specialisation (X_{18}) in Gorzow Wielkopolski.

Situating these findings in the literature, our city-level results nuance national indices (e.g., Kearney, 2019; Deloitte, 2019) by showing that medium or even low synthetic scores can coexist with high firm intensity along western corridors, an effect not visible in country-level composites. Consistent with location-determinant studies (Aktas et al., 2011; Graf, Mudambi, 2005), transport connectivity and labour-market depth act as strong stimulants in the IAM. Future work will (i) assess rank-based association (Spearman) between d_i and firm intensity, (ii) explore sector-specific weights, and (iii) extend the IAM with Eurostat time series to analyse dynamics across European cities.

6. Conclusion

This study identifies the determinants of location choice for logistics outsourcing (Q1) and develops a transparent Investment Attractiveness Model (IAM). Factors were grouped into stimulants (e.g., labour supply, population density, road/rail density, cargo-airport use, sectoral specialisation, innovation) and destimulants (wages in section H, warehouse rent). Using the Hellwig method, we ranked Polish provincial capitals and classified them into four groups (Q2). Most centres display medium or low attractiveness; Lodz attains the highest score, while Gorzow Wielkopolski records the lowest. These findings indicate where targeted improvements in transport and storage infrastructure, as well as talent pipelines, could raise attractiveness.

A key original contribution is a city-level, logistics-oriented composite that reveals patterns not visible in national indices: notably, corridor/port effects in western and coastal cities (Q3). We also juxtapose the synthetic score with per-capita firm intensity and find a positive but non-monotonic association; for Q4 we observe only partial alignment, investment attractiveness matters, yet proximity to west–east corridors and ports, legacy specialisation and labour pooling also shape siting.

Practical implications follow for both managers and city authorities. The IAM provides a reproducible screening tool to shortlist cities by cost–access and time-to-market; policymakers can prioritise expressway/rail density, cargo-airport capability, warehouse stock and targeted skills (transport/logistics graduates). Theoretically, the results support location-determinant perspectives that emphasise connectivity and human capital, while qualifying them with corridor/port adjacency effects.

Lodz should take advantage of its location on transport corridors by increasing intermodal capacity (rail and road terminals) and improving last-mile access to expressways in order to translate its high synthetic attractiveness into additional demand for warehouse space. Katowice can build on its advantages of a dense network of expressways and high cargo traffic at the airport by improving first and last-mile access to logistics parks; at the same time, it is worth monitoring vacancy rates (X_{10}) to maintain a competitive but not excessive supply of space.

In Warsaw, it is advisable to alleviate cost pressures through a spatial development policy that favours urban consolidation centres and night delivery windows; this will maintain accessibility advantages without escalating operating costs. In Gdansk and Szczecin, as port centres, the priority should be the throughput capacity of the port hinterland railway and the automation of gates, which will consolidate corridor effects and reduce dwell times. It is also worth reserving land for cross-docking and value-added services. Wroclaw should combine its strong exposure to transport corridors with increased innovation (X_{17}) and the development of staff training paths in order to reduce the gap between the intensity of companies and the synthetic attractiveness score.

Lublin can capitalise on its proximity to Warsaw by accelerating the expansion of expressways and ring roads, which will shorten transit times to the capital and major east-west routes. Zielona Gora and Gorzow Wielkopolski should strengthen north-south connectivity and develop modern, modular warehouse space to maintain a high number of companies per capita, while improving the quality of available infrastructure.

Limitations include reliance on official statistics for a single year and a reduced city set; unobserved factors (e.g., firm age, contract structures, cross-border demand) were not captured, which may attenuate the link between d_i and firm siting. Using a single cross-section (2021) also introduces temporal limitations: the IAM may be sensitive to short-run shocks (e.g., infrastructure openings, port disruptions) and cyclical labour-market conditions. A multi-year panel (e.g., 2016-2023) would allow us to test rank stability, re-estimate weights, and assess whether city positions converge or diverge over time. Consequently, the results

should not be generalised directly to other countries, though they complement existing research on urban logistics attractiveness.

Future work will extend the IAM with Eurostat data to test robustness across countries and time, explore sector-specific weights, and assess rank-based associations between d_i and firm intensity. Overall, we provide a logistics-specific, city-level composite for Poland and show where the synthetic score aligns and misaligns, with actual firm intensity, highlighting the distinct role of western transport corridors and port adjacencies.

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