



## METHODS FOR DETERMINING POTENTIAL SITES FOR THE LOCATION OF LOGISTICS CENTRES ON THE BASIS OF MULTICRITERIA ANALYSIS

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**ABSTRACT. Introduction:** The article presents the thesis that the selection of the optimal site for the location of a logistics centre requires the selection of a number of criteria that determine the success of the investment. In addition to the points of space where different types of transport, more complex traits should also be considered. These include the availability of markets, economic zones and the potential of the area in terms of by social and economic factors.

**Methods and Results:** The paper adopted the method of multi-criteria comparative analysis, which can be used in a simple and clear way to establish a hierarchy of the most favourable locations of logistics centres. In this method, the final set of criteria is not strictly defined and can be supplemented by criteria that are relevant to a particular investor and the investment. When deciding on financial investments, it is advisable to consider a number of criteria, (including all kinds of indicators simple and discounted stimulators and development), which were chosen on the basis of knowledge and literature, and tested on the example of the Lubuskie Province. This approach allows the use of the proposed method regardless of legal conditions and geographical location.

**Conclusions:** The problem of the choice of location, as well as connecting logistics centres within them, should be one of the most important tasks of planned developments in the field of spatial policy. The economic development of the region may depend on a logistics centre, which plans streamlined freight transport, reduces the cost of its operation and shortens delivery times. The applied optimization method allows to clearly determine the location of the logistics center together with the possibility of its use in various European and world countries.

**Key words:** logistics centre, space planning and regional politics, multi-criteria comparative analysis.

### INTRODUCTION

Poland is a transit country, crossed by its pan-European transport corridors in the east-west and north-south directions. Due to its geographical position, Poland is able to use virtually all modes of transport for the implementation of intermodal transport. An essential element of the organization of intermodal transport is an efficient transport infrastructure, both linear and hubs [Kazak et al. 2018]. In the case of Polish infrastructure, this should comprise of good quality rail lines

and a network of container terminals, allowing transshipment of units between the various means of transport. In Polish practice, intermodal transport using inland waterways is essentially non-existent. Solutions have been found, however, that combine shipping with rail and road. The main transportation difficulties (not only associated with the development of infrastructure [Krzyżaniak et al. 2012] are related to the lack of a coherent policy on the national level [Straka et al, 2018].

The availability of a transport infrastructure within an area requires development not only of the transport routes such as motorways, which play a great role in optimizing the flow of people and goods, but also important requires the identification of designated towns, where there are facilities for redirecting freight and expanded range of additional functions [Merkisz et al. 2014; Merkisz-Guranowska 2013, Hadas, Cyplik, Adamczak 2015].

The aim of the study is to present the possibility of using methods of multi-criteria analysis as a tool for decision support, to choose the optimal area for future investment, which will be a logistics centre. Methods of multi-criteria analysis also allow the search for compromise solutions which take into account both the analyzed criteria and preferences of stakeholders [Nielsen et al. 2017; Żak, Węgliński 2014]. The study uses: research potential economic and social, based on correlations of statistical analysis of the differences in the development of competitive advantage municipalities (based on strategic documents of municipalities, as a case study and identify factors topography. A similar method enables multi-criteria decision support, presented Witkowski, Kiba-Janiak, Hajduk, Żak and pointing to the relationship taking into account the specific set of criteria [Witkowski, Kiba-Janiak 2014; Hajduk 2017; Żak 2011, Hadas, Stachowiak, Cyplik 2011]. Described in section fifth example, the location of the logistics centre in Lubuskie given to illustrate the method.

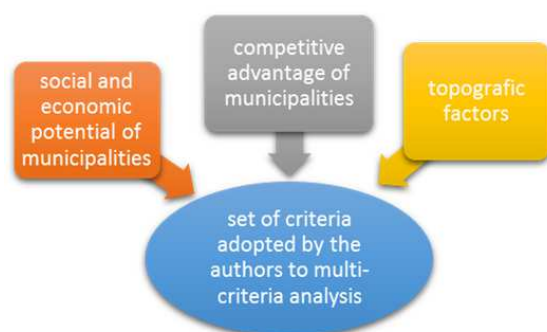


Fig. 1. The scheme of criteria selection applicable to the analysis of the location of logistics centers

In Lubuskie, the second-smallest Polish province in terms of population (just over 1 million inhabitants), there is a lack of both intermodal and multimodal logistic centres and are only a limited number of container transfer stations operated by PKP CARGO [Kazak et al. 2018]. Transshipment points include, among others, the cities of Zielona Góra, Gorzów Wielkopolski, Kostrzyn, Świebodzin, Sulechów and Nowa Sól. The main hubs in Lubuskie are located in the following cities: Świebodzin (Node Świebodzin) - motorway A2 (E30), national roads: 3 (E65), 92 provincial 276, 303, railway line 2 (E20 - CE20), and the airport of international importance in Babimost, 15 km away from the European Moscow-Berlin corridor [Witkowski et al. 2016].

Documents indicating the direction of spatial development in the province of Lubuskie indicate that the optimum place to be designated for the location of the logistics centre is Świebodzin. The spatial development plan for Lubuskie province in the direction of politics No. 8 indicated Świebodzin as a node of the European multimodal transport network [Resolution No XXII/191/12].

## LOGISTICS CENTRES IN STRATEGIC AND REGIONAL POLICY

The decision to set up a logistics centre (in terms of both time and place), should be the result of a consciously adopted action plan based on an analysis of the status and potential of the economies of individual regions of the country. The optimal location of logistics centers requires selection of the many features that meet some of the criteria adopted in the article. The study took into account only the internal conditions for several cities in the province lying at the crossroads. Due to the accepted test method, external conditions were completely omitted.

Many studies in the field of engineering and road safety as well as studies on flows of traffic indicate that the hub is a necessary condition, but not sufficient alone, for the location of the logistics center, and the value

of a transport hub is also due to the hierarchy of roads and their superiority in relation to railways [Wiśniewski 2015; Francik et al. 2017]. In literature, the choice of location of the logistics center is associated with the selection criteria for formation of a complex project (the classical theory of central place theory: nodes of road and rail transport, availability of infrastructure, the density of the regional transport network, throughput and quality standards and the theory of institutional and regional development: transaction costs, growth poles, economic base, regional innovation systems, related diversity and others [Krzyżaniak et al. 2012; Wichmann et al. 2015]). A distinction is made between local (radius of interactions 5 - 8 km), regional (radius of interactions 50 - 80 km) and international logistics centres (radius of interactions of 500 - 800 km). This indicates a relationship between the size of the area of the logistics centre and the potential scale of the freight, as well as the nature of the expected logistic services. It also presents the features of topographic and land development as an essential element of the cost of preparing the investment. Also important are: the availability of location and type of ownership relations, as well as the status of the potential investment as related to the cost and time of the investment [Kabashkin et al. 2005; Wiśniewski 2015; Wichmann et al. 2015].

In the experiments described in Western Europe we can observe different forms of management processes in the development of logistics centres and use of instruments to support development through:

- networking cooperation with centres in the global economy,
- awareness of the public sector to support and accelerate the processes of creating centres,
- creating a model based on close collaboration between public and private sectors, for example in Germany, the government partially or completely covers the cost of construction of logistics centers,
- alongside the support of the national government, support is received from local authorities and regional chambers of commerce and may even include actions aimed at – for example – the quick

legislative initiative needed to support the swift development of logistics centres [Kaźmierski 2012].

The need to involve the public authorities in the implementation of investments in logistics centres, should result primarily from the need:

- to regulate the real estate market (increasing the competitiveness of allocative centres in the region) - as an initiative of the government and local government, i.e. Sector Understanding contained in the National Development Plan, the National Strategy of Regional Development Concept for National Spatial Planning, State Transport Policy and by initiatives of the regional authorities concerning spatial development plans of the region, the development strategies of transport and technical infrastructure and local government authorities, the relevant findings in studies of conditions and directions of spatial development of municipalities and the provisions of the local spatial development plans, as well as the strategies and programs for development of technical infrastructure and transport;
- to support the implementation of this type of investment, through quick and clear responses (including administrative decisions), entailing the use of instruments which the community authorities have available for such purposes. This may include assessing the possibilities and economic effects of the investment in large logistics centres in the area (the current state of spatial policy confirms a lack of research and knowledge on the possible use of logistics centres for the development of the local market and a lack of regulations on a national, regional, local level indicating solutions relating to the scale of the location and above all investments and conditions of their implementation within the areas of individual municipalities);
- to determine the activities in which logistics centres will operate, on the basis of relevant changes in article 6 of the Act of 21 August 1997 on real property management [Journal of Laws of 2015, item 1774 - as amended]. This allowed for the introduction of a group of public purpose investment, thereby

obtaining the statute making investment a priority within legislature, under article 2 Section 5 of the Act of 27 March 2003 on spatial planning and development [Journal of Laws of 2015, item 199 - as amended], defined as "The effect of local (municipal) and supra-local (county, provincial and national) and national (including the international investment and trans-regional) (...) regardless of the status of the entity performing these activities and sources of funding (...)"

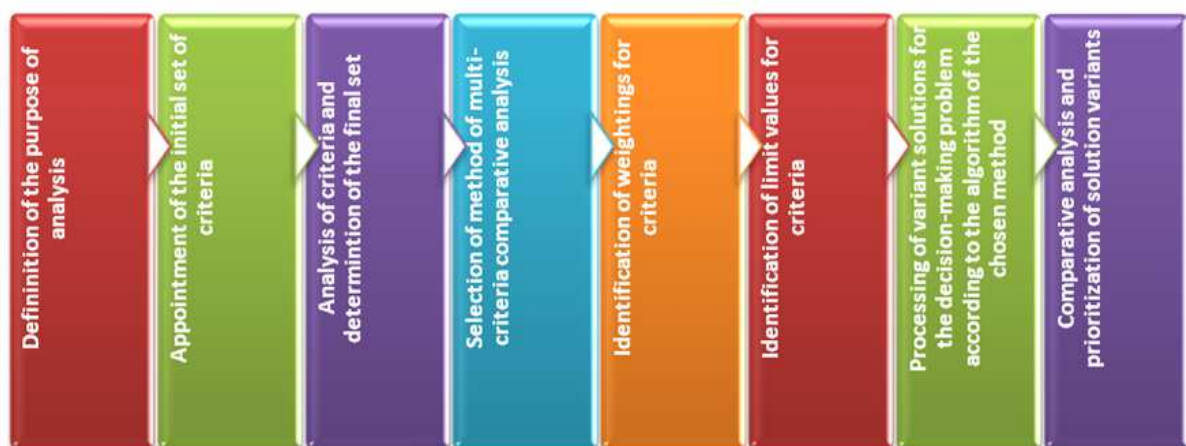
- establishing public - private cooperation for the disbursement of funds for public purposes. This means that there is a need for a system within the public administration, which allows for intervention in matters of public finances close to their place of execution, assuming that the course of action matches the objectives at the regional level, and is thus consistent with the policy of the country.

Regional policy has steadily gained importance since the mid 1960s. Regions have received more and more powers and tasks, especially in the wake of the dispersion of EU and national funds. Regional planning is growing in importance, and regional spatial policy now plays an important role in the economic development of the region. Kaźmierski [2012] wrote that "The experience of developed countries shows that the centres operating in regional companies usually take over the implementation of the basic logistics functions, such as forwarding, transport and

storage.". The task of logistics centres is to create added value in the flow of goods, mitigating or eliminating the negative impact that logistics activities have on the environment, as well as supporting and initiating positive trends and business development. Logistics centres affect the growth of efficiency and effectiveness of logistics processes, customer service, create value in the supply chain and reduce logistics costs. Regional logistics centres or centres of logistics services (CUL) may specialize in comprehensive services to different customer groups, and perform the function of an additional link that integrates the entire system of logistics, eliminating potential disruption of the supply chain, which can arise, for example, in the use of foreign distribution channels [Jedliński 2000].

## RESEARCH METHOD

The problem with the decision to place the location of logistics centers can be analyzed in different categories e.g. the approach in the formulation of the decision problem, the number of criteria for evaluating potential locations taken for analysis approach on the issues of risk and uncertainty and the number of analyzed potential sites for location or depending on topographical and statistical occurring in the analyzed areas [Żak, Węgliński 2014; Hajduk 2017].



Source: own study based on Jezierski et al. 2016

Fig. 2. Algorithm for decision support using MCDA

Modelling issues of decision-making involves a sequence of steps consisting of mapping a set of allowable decisions based on a set of benefits, taking into account conditions relevant to the decision-maker, also called states of the external world [Jeziarski et al. 2016]. Models of decision-making issues, depending on the type of model, can be built and solved using methods such as differential calculus, linear programming and nonlinear probabilistic methods and mathematical statistics, game theory, and fuzzy systems and neuro fuzzy networks [Aouam et al. 2003; Mardani et al. 2015].

In order to perform the encoding process in this article we used coding according to Neumann-Morgenstern, who applied the following formulas:

$$y_{ij} = \frac{x_{ij} - x_{j\min}}{x_{j\max} - x_{j\min}} \quad (\text{for stimulant}) \quad (1)$$

$$y_{ij} = \frac{x_{j\max} - x_{ij}}{x_{j\max} - x_{j\min}} \quad (\text{for destimulant}) \quad (2)$$

where:

$y_{ij}$  – coded measure of the  $i$ -th embodiment of the  $j$ -th test.

$x_{ij}$  – a measure of the  $i$ -th variant of the  $j$ -th criterion,

$x_{j\min}$  – minimum value of measure for fractional  $j$ -th criterion,

$x_{j\max}$  – the maximum value of measure for fractional  $j$ -th criterion.

In contrast, synthetic evaluation presented alternative solutions for the best location of the logistics center using a summation index  $J_i$ , recorded as [Jeziarski et al. 2016]:

$$J_i = \sum_{j=1}^m y_{ij}. \quad (3)$$

## SELECTION OF THE BEST LOCATIONS TO ILLUSTRATE THE USE OF THE MULTI-CRITERIA METHOD

The approach used in the work is based on multi-criteria analysis methods requiring the pre-definition of a coherent set of criteria, a set of feasible solutions (variants) and the determination of the results allowing the best location to be determined, taking into account the criteria and preferences of stakeholders. A characteristic feature of the location decision is the fact that it is taken in relation to the particular system and economic development that already exists. This creates consequences for efforts to optimize the deployment of newly designed buildings [Całczyński 1992]. As a result of this, to fulfil the needs of the article 13 villages lying on the crossroads of transport corridors in Lubuskie were selected as an example to illustrate the applied research methodology (Table. 1). The study does not take into account the weighting and impact of places beyond the borders of the Lubuskie province and the influence of external conditions. The method of assessment of the weighting of the transport corridor modelling was adopted from grading submitted by Witkowski, [Witkowski et al. 2016].

The participation of Lubuskie province in national exports in terms of its value in 2015 is as follows. The province is ranked 9th in the country with a value of close to EUR 4 billion. In this respect, Lubuskie was only slightly lower than the Lodz voivodship (4.3 billion) and Podkarpackie (4.04 billion EUR). Lubuskie has maintained an uninterrupted surplus of exports over imports since 2010, which can be considered a win-win situation.

By analyzing the location of exporters (i.e. Heat map) in the development of Bluehill Analytical Centre of Customs Administration, attention can be paid to the large concentration of exporters in the municipalities of Zielona Gora (157 subjects) and Gorzów Wielkopolski. (135). Another cluster of entities exists along the national road No. 12, including the

Municipality of Żary (64) and along the north-south near the S3 expressway, on the terrain of, among others, Nowa Sól (49) Sulechów (22), Świebodzin (26) and Międzyrzecz (22). Other areas with a concentration of exporters are the border areas, including Kostrzyn (36). Few subjects are located in the immediate vicinity of the A2 motorway and the national road No. 18 (connecting the A4 motorway in Lower Silesia with a border crossing with Germany in Olszyna). The location of both routes is not conducive to the development of the cities, since they bypass the major cities in the region and run through substantial areas of forest.

According to the analysis contained in the updated documents for the Provincial Spatial Development Plan for Lubuskie (PZPWL project in May, 2016), [Resolution No XXII/191/12] (...). Compliant with Project Investment Plan and Economic Promotion of the Lubuskie Province [Investment attractiveness of regions 2015], 13 centers have been analyzed as locations for logistics centres. The largest area of investment sites - over 100 ha - can be found in Kostrzyn, Świebodzin, Sulechów, Zielona Góra, Nowa Sól, whilst over 50 hectares is available in Żagan. The communities connected to these centres, according to PZPWL, have the greatest investment potential. The basic economic centers of Lubuskie province are considered to be Gorzów Wielkopolski., Zielona Góra, Żary, Żagan and Nowa Sól. These cities are also places where economic zones, technology parks and business incubators have been developed. The leading number of sectors among the 13 analyzed cities was seen in Gorzów Wielkopolski. (According to the Polish Classification of Activities, notable activities include the production of machinery and equipment, motor vehicles and electrical appliances, as well as chemicals and chemical products and pharmaceutical substances and drugs). Following this were Zielona Góra (manufacture of food products and beverages), Żary and Żagan (manufacture of wood and furniture, glass and glass products, construction, textiles and motor vehicles), Nowa Sól (foodstuffs, motor vehicles, machinery and electrical equipment). Centres

with a smaller development of production were Kostrzyn and Świebodzin.

According to PZPWL, "in addition to the development of production, Lubuskie has potential for the development of transport services. Areas that have a predisposition in this regard are the nodes, and in particular the nodes of rzepiński, świebodziński, kostrzyński, nowosolski, zielonogórski, sulechowski, żarski and żagański." Location service centres in the transport Lubuskie depend on the A2 motorway, S3 expressway, national roads and the use of river ports for economic purposes. "(...) in addition to being located in designated areas with adequate availability of transport (road and rail), they are located in places where there are special economic zones and where companies specializing in freight forwarding and logistics operate (Świebodzin (...))."

In order to solve the given problem which was the choice of an optimal location for a logistics centre in the province of Lubuskie, which is a form of analysis of the correlation of the socio-economic potential of the 13 selected locations for their ability to attract planned centers in the preliminary stage were used as research methods, statistical methods (based on the local database and Internet System Analysis of local Government). Policy and planning documents (including projects from 2016) were analyzed to determine the characteristics and criteria of impacts, which are subject to weighting and hierarchy. To identify the criteria for selecting the optimum location, the research assumed the location factors proposed by Górecka [Górecka, Maksymiuk 2017], which can be divided into three groups: natural factors (raw materials, availability of land, ecological barriers) economic and technical factors (market, labour force, the benefits of agglomeration) and socio-political factors (social, political, strategic and military).

The work includes measurable criteria for location factors, namely: the geographical location of the region and its topographic features, access to a wide range of infrastructure (e.g. Educational, scientific, legal, administrative, and performance and

quality of operation of this infrastructure), location and connection to an external network infrastructure and technical services, size,

quality and diversity of human capital, industry structure, size and type of ownership of existing businesses.

Table 1. Selection of the town and the criteria adopted in the modeling of alternative solutions using a multi-criteria analysis

	Czerwiensk	Gorzów Wlkp.	Kostrzyn	Krosno Odrz.	Międzyrzecz	Nowa Sól	Rzepin	Sulechów	Świebodzin	Zbąszynek	Zielona Góra	Żagań	Żary
	1	2	3	4	5	6	7	8	9	10	11	12	13
The administrative hierarchy - seat: stimulant	Community	Voivodeship	County	County	County	County	Community	Comm	County	Community	Autonomy	County	County
Availability of multi-drop communication infrastructure stimulus	rail I rail II	road I road II harbor	road II rail I rail II harbor	road II rail II harbor.	road I rail II	road I rail I harbor	road I rail I rail II	road I road II rail II airport	road I road II rail I rail II airport	road I road II rail I rail II	road I rail I rail II	road II rail II	road II rail II
Population stimulant	4129	124116	18097	18269	18464	39413	6662	17242	21988	5068	138763	26365	38392
Availability of economic zones stimulant	yes	yes	yes	yes	yes	yes	yes	yes	no	no	yes	no	yes
Average wages in the corporate sector CSO FOR XI 2015. <i>De-stimulant</i>	4164,01	4164,01	4164,01	4164,01	4164,01	4164,01	4164,01	4164,01	4164,01	4164,01	4164,01	4164,01	4164,01
The rate of property tax on the land associated with running a business. Regardless of the classification of land and buildings in PLN / m <sup>2</sup> <i>destimulant</i>	0,89	0,88	0,72	0,82	0,73	0,75	0,80	0,87	0,78	0,87	0,70	0,87	0,80
Availability of market outlets Zielona Góra [Travel time in hours.] <i>de-stimulant</i>	0,22	1,15	1,42	0,43	0,49	0,29	1,11	0,32	0,41	0,57	0	0,46	0,43
Availability of market outlets Gorzów Wlkp. [Travel time in hours.] <i>De-stimulant</i>	1,26	0	0,52	1,22	0,33	1,27	0,56	0,57	0,49	1,03	1,15	1,55	1,54
Availability of qualified staff stimulant	654	11405	1267	1594	2169	3870	608	2205	2378	512	12685	2212	3031
Development plans * stimulant	SUIKZP (AG)	SUIKZP (AG)	SUIKZP (AG)	SUIKZP (AG)	SUIKZP (AG)	SUIKZP (AG)	SUIKZP (AG)	SUIKZP (AG)	SUIKZP (AG)	SUIKZP (AG)	SUIKZP (AG)	SUIKZP (AG)	SUIKZP (AG)
Records of planning documents ** stimulant	MPZP (AG)	MPZP (AG)	MPZP (AG)	MPZP (AG)	MPZP (AG)	MPZP (AG)	MPZP (AG)	MPZP (AG)	MPZP (AG)	MPZP (AG)	MPZP (AG)	MPZP (AG)	MPZP (AG)
Economic zones in. ha (PZPWL) stimulant	6,7	121,4	237,9	43,6	11,5	149,2	4,52	44,0	5,8		141,4	63,7	88,7
Size of exports market (number of entities) (PPI) stimulant		135	36		22	49		22	26		157		64
Investment attractiveness of regions 2015 (Report by SGH) Class A and B stimulant		A	A			A		B	B	B	A	A	A

\* Development plans: Study of conditions and directions of spatial management on the basis of which the selected areas are designated for development: SUIKZP (AG) - economic activity or SUIKZP (CL) - logistic centres

\*\* Enrolment planning documents: valid local zoning plan for the area: the Unitary Development Plan (AG) - the economic activity (stores, warehouses, production, industry, services) and LDP (CL) - logistic centers

The use of decision-making methods based on multi-criteria comparative analysis requires the formulation of a preliminary set of criteria, which should be the critical parameters, allowing for recognition of a decision on the location as acceptable, or eliminating it from the set of possible locations. These critical features (in the case of the search for the optimal location for logistics centres) may include: costs of land purchase (which cannot exceed the capacity of the financial investor), planning provisions, availability of land for this type of investment or the maximum distance of communication infrastructure. To perform the analysis, an initial set of criteria

consisting of the following factors determining the location of logistics centers was used:

- the administrative hierarchy - the seat of the municipality, county, governor,
- availability of multi-drop communication infrastructure,
- population,
- availability of economic zones,
- the price of land,
- the cost of labour,
- the amount of property tax,
- availability of market,
- availability of qualified staff,
- development plans,

- records of planning documents,
- size of economic zones,
- number of players (exporters) in the resort,
- the attractiveness of investment in 2015, according to the report SGH;

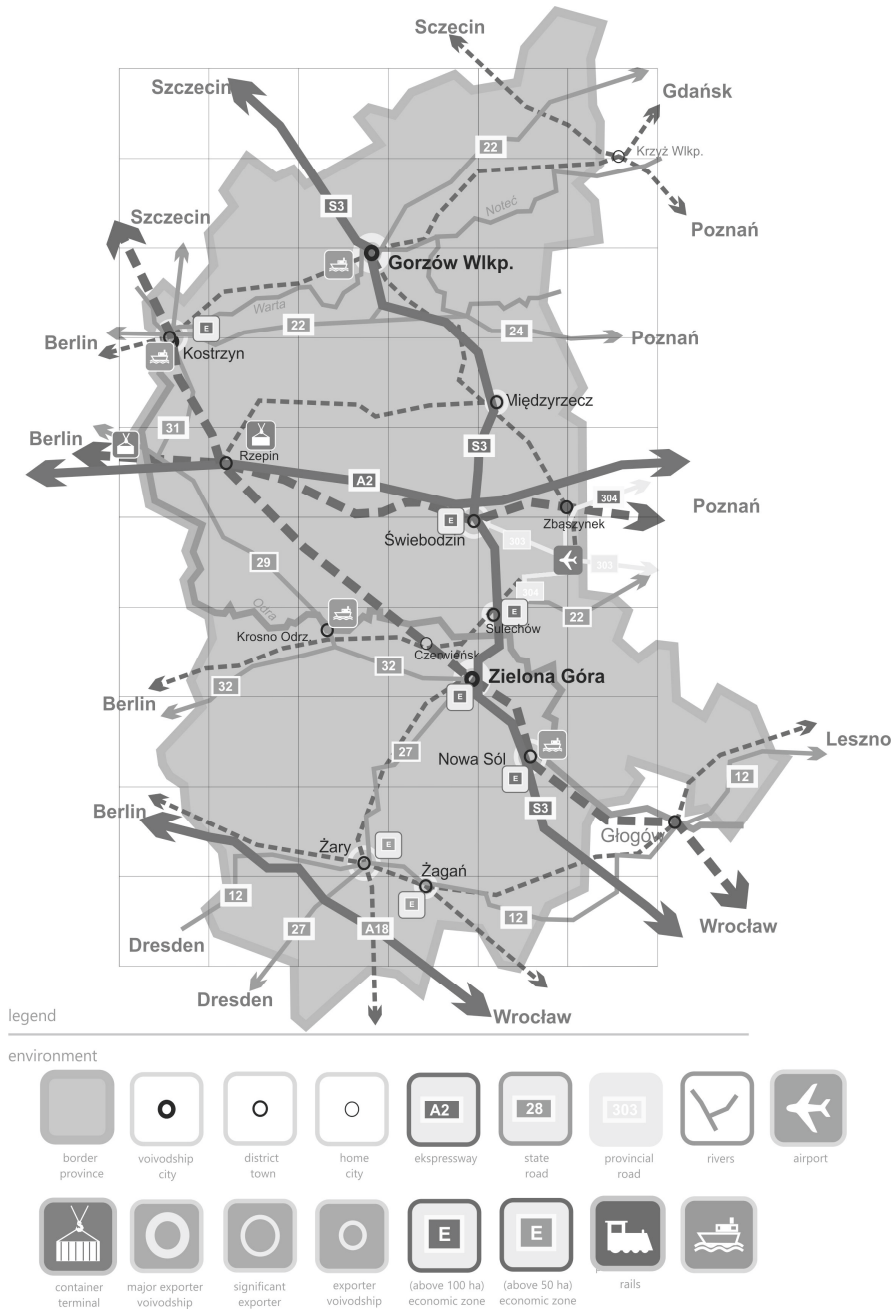


Fig. 3. Scheme of communication in Lubuskie and location of the cities that were selected for testing potential site locations for logistic centres



Table 2. The final set of criteria encoded according to Neuman-Morensterna

	Czerwieńsk	Gorzów Wlkp.	Kostrzyn	Krosno Odrz.	Międzyrzecz	Nowa Sól	Rzepin	Sulechów	Świebodzin	Zbąszynek	Zielona Góra	Żagań	Żary
	1	2	3	4	5	6	7	8	9	10	11	12	13
Administrative Hierarchy – Seat: <i>Stimulant</i>	0,0	1,0	0,5	0,5	0,5	0,5	0,0	0,0	0,5	0,0	1,0	0,5	0,5
Availability of multi-drop communication infrastructure <i>Stimulant</i>	0,2	0,8	0,8	0,4	0,2	0,8	0,6	0,8	1,0	1,2	0,8	0,0	0,0
Population <i>stimulant</i>	0,00	0,89	0,10	0,10	0,11	0,26	0,02	0,10	0,13	0,01	1,00	0,16	0,25
The rate of property tax on the land associated with economic activity, regardless of the classification of land and buildings in PLN/m <sup>2</sup> <i>De-Stimulant</i>	0,00	0,05	0,89	0,37	0,84	0,74	0,47	0,10	0,58	0,10	1,00	0,10	0,47
Availability of skilled workforce <i>Stimulant</i>	0,01	0,89	0,06	0,09	0,14	0,28	0,01	0,14	0,15	0,00	1,00	0,14	0,21
Size of economic zones <i>Stimulant</i>	0,03	0,51	1,0	0,18	0,05	0,63	0,02	0,18	0,02	0,0	0,59	0,27	0,37
Availability of economic zones <i>Stimulant</i>	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	0,0	0,0	1,0	0,0	1,0
Availability of market outlets Zielona Góra <i>De-Stimulant</i>	0,84	0,19	0,00	0,70	0,65	0,80	0,22	0,77	0,71	0,60	1,00	0,68	0,70
Availability of market outlets Gorzów Wlkp. [czas dojazdu w godz.] <i>De-Stimulant</i>	0,19	1,00	0,66	0,21	0,79	0,18	0,64	0,63	0,68	0,34	0,26	0,00	0,01
Sum of Indicators	1,27	5,34	4,02	2,56	3,28	4,18	1,98	2,73	3,78	2,25	6,65	1,85	2,51

After analyzing the initial set of criteria a number were selected to form the final set. These were chosen to be administrative hierarchy, the availability of multi-drop communication infrastructure, the population, the rate of property tax, the availability of qualified staff, the size of economic zones and the availability of markets in relation to provincial cities: Zielona Gora and Gorzów Wielkopolski. The value of individual criteria is presented in numerical form and encoded according to the Neumann-Morgenstern rule (1) and (2), and compiled in Table 2. The next step was to evaluate using a synthetic index of summation by the formula (3).

## RESEARCH RESULTS

On the basis of an analysis of the results obtained by the methods of multi-criteria analysis, shown in Table 3, we can conclude that the most favourable conditions for the location of logistics centres (taking into account the final set of criteria presented in Table 2) were offered by the towns of Zielona Gora, Gorzow Wielkopolski, Nowa Sól and

Kostrzyn, and the least favourable were Żagan and Czerwieńsk. It can be seen that the strategic documents of the province from just a few years ago include a Political Declaration for a regional multimodal centre in Świebodzin. This location, however, was misguided and not verified by economic reality. Perhaps if the A2 motorway did not bypass the city, a logistics centre could arise.

Table 3. Value of the summation index for each locality sorted in descending order

Location	Value Summation index
Zielona Góra	6,65
Gorzów Wlkp.	5,34
Nowa Sól	4,18
Kostrzyn	4,02
Świebodzin	3,78
Międzyrzecz	3,28
Sulechów	2,73
Krosno Odrzańskie	2,56
Żary	2,51
Zbąszynek	2,25
Rzepin	1,98
Żagań	1,85
Czerwieńsk	1,27

The author's selection criteria, together with the underlying analysis indicated that, the most advantageous location for logistics center in

the region Lubuskie, characterized by the city: Zielona Góra, Gorzów Wielkopolski, Nowa Sól and Kostrzyn. Obtained, using the above method, the information also allowed to predict the town (Świebodzin, Międzyrzecz), which have significant potential but require actions to strengthen their economic development for the location of logistics centers.

The authors realize that the method is limited by data availability. With accurate data, mathematical methods can be used for solving the problem (including multi-criteria analysis), but the uncertainty and inaccuracy inherent in the structure of information makes it to solve such problems are a better use of models based on fuzzy reasoning and approximate [Mardani et al. 2015; Aouam et al. 2003] that should be an indication for future research. Nevertheless, the use of methods of multi-criteria decision support allowed a ranking of cities with regard to the criteria included in the study.

## CONCLUSIONS

A logistics centre can have a significant impact on the labour market, the size and type of new business investment and the environment. The economic development of the region may depend on a logistics centre, which plans streamlined freight transport, reduces the cost of its operation and shortens delivery times when fully equipped with technical infrastructure, for example. Logistics centres, as well as promoting activity, can contribute to an increase in investment in economic zones.

The use of a decision-making method for multi-criteria comparative analysis can be a simple and clear way to establish a hierarchy of the most favourable locations for logistics centres. In this method, an important advantage is that the final set of criteria is not strictly defined and can be supplemented by criteria that are relevant to a particular investor. By analyzing data available from Lubuskie province the most favourable locations (considering criteria) were: Zielona Góra, Gorzów Wielkopolski, Nowa Sól and Kostrzyn. The information obtained also

allowed for the towns of Świebodzin and Międzyrzecz to be recognised as having significant potential, but first require actions to strengthen their economic development for the location of logistics centres.

To strengthen the development of the region based on the activities of logistics centres, their activation through closer cooperation between companies operating within the economic zones in the sphere of regional science and companies in the field of Small Medium Enterprises is necessary. It is also necessary to monitor the functioning of economic zones in order to determine the demand for investment areas and possibly increasing the area of investment in the individual subzones. Meanwhile, even after the organization of the county workshops, whose aim was to identify the developmental needs of each part of Lubuskie, in the context of carrying out the mid-term assessment of the impact of the Regional Development Strategy for Lubuskie, within Lubuskie Maps of Needs and Aspirations (2011), the idea of logistics centres was not well supported. Although one of the strengths was a well-developed, dense network of roads and rail infrastructure identified as a growth potential, significant issues were raised. These include the very bad technical condition of most of the buildings and facilities referred to collectively as the railway infrastructure, along with the negatively rated technical condition of roads of all categories. In addition, direct interventions to support investment in the field of comprehensive communication infrastructure only created P & R type nodes (park and ride), with logistics centres being omitted.

It can be observed that municipalities and cities are willing to take decisions on grants for the construction and modernization of roads in the vicinity of planned investments such as large service complexes (hypermarkets and shopping centers), so the same could happen in the event of a network of logistics centres [Stanczyk et al. 2015].

In accordance with the provisions of the RPO-L2020, the concentration of operations should be among following areas:

- support the creation of investment areas, which could translate into further development of existing SMEs and to attract new investors, the emergence of more jobs and the development of subcontractor networks;
- support the diversification and expansion of activities of local firms, especially in foreign markets, through the introduction of new business models, especially those enabling international economic cooperation;
- support in the area of export business enterprises, which promotes the internationalization of the offer, strengthening the position on the global market;
- promotion of the region as a place of profitable investment opportunities, which will result in intensification of economic cooperation, increase trade exchange and attracting new capital investment to the region;

It can therefore be concluded that a logistics centre is a desirable and significant investment which, with the support of the region and the individual cities, should become an economic priority.

Logistics centres are a very important factor in the development of cities. The meaning and scope more often goes far beyond the distribution of goods. These operations combine logistics and integrate many areas of the supply chain.

It is worth noting that the presented method is versatile and can be easily implemented and used to optimize the location of logistical infrastructure (e.g. warehouses, routes and hubs, commercial buildings). The multi-criteria analysis method, used to determine the optimal location of logistics centers in Poland, can be used to determine the optimal locations in other European countries and the world. The universality of the method, based on an unambiguous way of choosing variants of places of location, building a set of criteria and the method of data coding and obtaining the best solution, allows to transfer the proposed method into any geographical space. The proposed solution allows users to extend the

set of criteria with elements characteristic of a given country, both due to legal and geographical conditions.

The very process of selection of the optimal location is a complex process, and the analysis presented relates to specific locations in Lubuskie (i.e. a micro analysis).

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## METODYKA WYZNACZANIA MIEJSCA LOKALIZACJI CENTRÓW LOGISTYCZNYCH Z WYKORZYSTANIEM ANALIZY WIELOKRYTERIALNEJ

**STRESZCZENIE. Wstęp:** Artykuł przedstawia tezę, że wybór optymalnego obszaru dla lokalizacji centrum logistycznego wymaga doboru wielu kryteriów, które warunkują powodzenie inwestycji. Oprócz punktów przestrzennych, gdzie krzyżują się różne rodzaje transportu: drogowy, kolejowy, morski i lotniczy oraz bardziej złożonych wyróżników, jak dostępność rynków zbytu, stref ekonomicznych, na potencjał miejsca mają wpływ czynniki społeczne w postaci: wykwalifikowanych pracowników, umiejętność współpracy z jednostkami administracji państwowej i samorządowej, objęcie programami wspierającymi rozwój oraz ekonomiczne, jak cena gruntu, wysokość podatków, niskie koszty pracy, niskie koszty ekologiczne i środowiskowe.

**Metody i rezultaty:** W artykule przedstawiono podstawowe założenia poszukiwania optymalnej lokalizacji centrum logistycznego w województwie lubuskim. Wykorzystując przy podejmowaniu ww. decyzji metodę wielokryterialnej analizy porównawczej można w prosty i czytelny sposób ustalić hierarchię najbardziej korzystnych miejsc lokalizacji centrów logistycznych. W metodzie tej istotną zaletą jest to, że ostateczny zbiór kryteriów nie jest ściśle zdefiniowany i może zostać uzupełniony o kryteria, które są istotne z punktu widzenia konkretnego inwestora. Takie podejście pozwala na wykorzystanie zaproponowanej metody bez względu na uwarunkowania prawne oraz położenie geograficzne.

**Wnioski:** Problem wyboru lokalizacji, a także łączenia centrów logistycznych w sieć, powinien wynikać z najważniejszych zadań planowanych kierunków rozwoju w zakresie polityki przestrzennej. W wielu krajach europejskich planowanie regionalne wspiera rozwój zrównoważonej logistyki, które obsługuje rynek. Krajowe systemy logistyczne mogą tworzyć jednolity organizm zintegrowanych gospodarek, mogą one wywierać znaczący wpływ na rynek pracy, wielkość i rodzaj nowych inwestycji gospodarczych oraz na środowisko naturalne. Rozwój gospodarczy regionu może zależeć od centrum logistycznego, które w zamierzeniach usprawnia transport towarowy, obniża koszty jego funkcjonowania i skraca czas dostaw. Zastosowana metoda optymalizacji pozwala w jasny sposób na określenie lokalizacji centrum logistycznego wraz z jednoczesną możliwością jej zastosowania w różnych krajach Europy i świata.

**Słowa kluczowe:** centra logistyczne, planowanie przestrzenne, polityka regionalna, wielokryterialna analiza porównawcza

## METHODEN ZUR LOKALISIERUNG VON LOGISTIKZENTREN MIT INANSPRUCHNAHME DER MULTIKRITERIEN-ANALYSE

**ZUSAMMENFASSUNG. Einleitung:** Der Beitrag stellt die These dar, dass die Auswahl eines optimalen Standortes für die Lokalisierung eines Logistikzentrums die Berücksichtigung einer Reihe von Kriterien erfordert, die den Erfolg einer Investition mitbestimmen. Zusätzlich zu den räumlichen Belangen, wo verschiedene Arten von Transport: Straßen-, Eisenbahn-, See- und Lufttransport mitspielen, sollten auch komplexere soziale Belange berücksichtigt werden. Dazu gehört die Verfügbarkeit von Märkten, Wirtschafts- und Industriegebieten, örtlichen Potenzialen, die durch entsprechende, soziale und ökonomische Faktoren charakterisiert sind.

**Methoden und Ergebnisse:** Der Beitrag nahm die Methode der Multikriterien-Vergleichsanalyse in Anspruch, die auf einfache und übersichtliche Weise angewendet wird, um eine Hierarchie von günstigsten Standorten für die Logistikzentren zu etablieren. Bei dieser Methode ist der endgültige Satz von Kriterien nicht streng definiert und kann durch Kriterien ergänzt werden, die für einen bestimmten Investor und eine Investition relevant sind. Bei der Entscheidung über Finanzinvestitionen ist es ratsam, eine Reihe von Kriterien (einschließlich aller Arten von Indikatoren, einfachen und diskontierten Entwicklungsstimulatoren) zu berücksichtigen, die auf der Grundlage von Wissen und Literatur ausgewählt und am Beispiel der Woiwodschaft Lebus getestet wurden. Dieser Ansatz ermöglicht die Inanspruchnahme der vorgeschlagenen Methode, und zwar unabhängig von den rechtlichen Bedingungen, Voraussetzungen und der geografischen Lage.

**Fazit:** Die Fragen der Standortwahl sowie die gegenseitige Vernetzung von Logistikzentren sollten eine der wichtigsten Aufgaben geplanter Entwicklungen im Bereich der Raumpolitik sein. Die wirtschaftliche Entwicklung einer Region kann von einem Logistikzentrum abhängen, das den Güterverkehr optimiert, die Betriebskosten reduziert und die Lieferzeiten verkürzt. Die angewandte Optimierungsmethode erlaubt es, den Standort eines Logistikzentrums samt der Möglichkeit deren Inanspruchnahme in verschiedenen europäischen und außereuropäischen Ländern eindeutig zu bestimmen und einzusetzen.

**Codewörter:** Logistikzentrum, Raumplanung und Regionalpolitik, Multikriterien-Vergleichsanalyse

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