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An approach to the location of a warehouse distribution centre in the international environment: a Slovenian perspective

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Abstract
The article identifies the optimal location of the warehouse distribution centre for Slovenian companies in the international environment. The process of location selection takes into account a series of interconnected factors, including flows of goods between countries; the level of development of the transport system and transport infrastructure; the number of transport companies; labour costs and labour productivity; and the tax benefits existing in each country. Scientific literature mentions various methods for choosing a warehouse location, which differ in complexity and in the use of different qualitative and quantitative factors. However, the methods discussed have a disadvantage in that they use the current input variables when defining the optimal location. Choosing the optimal warehouse location is an important long-term logistics process, which should consider the fact that the environment in which companies operate is constantly changing. Using the proposed approach, future trends in the international environment are presented, which enables a better choice of warehouse location in the long run. Through this approach, companies can save on logistic costs, while also providing better quality logistics services. The analysis represents a starting point for deciding the location of a warehouse, but does not constitute a complete set of guidelines for companies to follow, as the choice of a particular location is dependent upon the complexity of the international environment in which a company operates.

Introduction

An integral part of the company's supply chain is the warehousing process, which functions as a coordinator between business functions in the material business of the company, to bridge the gap between the time of production and the time of use of various products. Warehousing has a major impact on costs, as several studies mention warehousing costs as the second largest category of logistics costs, following transport costs (Skerlic, 2017; Skerlic, Muha & Sokolovskij, 2017). One of the most important aspects of logistics management is selecting the optimal location for a warehouse. The right choice of location has a major impact on logistics costs and on the speed of supplying goods to the warehouse, as well as on the speed of supplying goods to the market or to the production facilities that require the goods stored in the warehouse. By optimizing warehouse location, companies can minimise the increase in total logistic costs that occurs over a long period of time.

Choosing a warehouse location is a challenging process that starts the moment a company is

established and takes into account several interconnected factors. Lambert, Stock and Ellram (Lambert, Stock & Ellram, 1998) note that the decision-making process when selecting the optimal warehouse location should take into account both macro and micro aspects. Macro aspects address the question of where to find an appropriate location for a warehouse which would enable the company to acquire the materials needed for production in a particular geographical area and, at the same time, allow for efficient supply from the company to the market. This study highlights a market-oriented strategy, a production-oriented strategy and a strategy between market and production. The authors singled out the micro decision-making aspects as the factors that directly affect the potentially selected location within a wider geographical area: the characteristics of the facility, warehouse services, accessibility, the proximity to transport terminals and the availability of local transport.

Several methods can be found in scientific literature that strive towards finding the optimal ratio between different qualitative and quantitative factors in the process of selecting the location of a warehouse. However, the methods discussed have a disadvantage in that they use the current values or variables when defining the optimal location. Choosing the optimal warehouse location is an important long-term logistics process, which should take into account the fact that the environment in which companies operate is constantly changing. Using the proposed approach, future trends in the international environment are presented, which enables a better choice of warehouse location in the long run. By using this approach, companies can save on logistic costs and provide better quality logistics services at the same time.

The applicability of the proposed approach has been proven to identify the best possible warehouse location for Slovenian companies in the international environment. The process of location selection takes into account a series of interconnected factors, including goods flows between countries; the development of the transport system and transport infrastructure; the number of transport companies in each industry; labour costs and labour productivity; and the tax benefits existing in each country. Temporal data were analysed by linear trend to obtain an assessment of future trends. Standardized regression coefficients were calculated and used for between-countries comparison. A positive standardized regression coefficient denotes a positive linear trend and expected future growth, while a negative standardized regression coefficient denotes a negative trend and expected future decline in the studied characteristics. Data processing was carried out with the IBM SPSS Statistics 25 software.

By testing the proposed approach, we aim to set new guidelines for the development of the methods used for selecting the location of a warehouse and to have a significant impact on the international logistics industry. Identifying the optimal location of a warehouse is a long-term and, above all, expensive process in terms of costs and is currently a topic of research in an increasingly globally connected business environment. It should be pointed out that the analysis represents an important starting point for deciding the location of a warehouse distribution centre, but does not constitute a complete set of guidelines for companies to follow, since the article, to illustrate the method, only analyses certain aspects of the macro environment.

Literature review

Schmenner (Schmenner, 1982) proposed an eight-step approach to selecting a warehouse location. The proposed approach emphasized the importance of the management of the company, which should first appoint a group of experts who are tasked with identifying potential warehouse locations on the basis of different criteria. Stock and Lambert (Stock & Lambert, 2001) then upgraded the approach and proposed a systematic process of selecting the location of a warehouse, which is also based on eight steps, including: the basic decision on the warehouse construction; the formation of a working group; the formation of an expert group; the determination of key criteria; the assessment of geographical regions; the identification of specific locations within geographical regions; the evaluation of each specific location and the final selection of a specific location.

Ballou (Ballou, 1999) introduces a model of localization of each single plant, terminal, distribution warehouse and central supply point. This has been variously known as the exact centre-of-gravity approach, the grid method, and the centroid method. The approach is simple, since the transport rate and the point volume are the only location factors. The applicability of the model is shown through the calculation of the warehouse location for Limited Distributors, Inc.

Vlachopoulou et al. (Vlachopoulou, Silleos & Manthou, 2001) propose a geographic decision support system for the warehouse site selection. This system allows managers to use different qualitative

and quantitative criteria for the optimal visualization of the optimal location of the warehouse. The use of the presented process in practice is illustrated by a practical example.

Simchi-Levi et al. (Simchi-Levi, Kaminsky & Simchi-Levi, 2007) highlight some important aspects of deciding the location of a warehouse: the location of the customers; the location of retailers; the location of existing distribution centres; the demand for individual products in relation to the location of the customers; warehousing costs, shipment size and other factors.

Due to the fact that various criteria for the selection of a warehouse location have been identified, both in theory and in practice, the production of different mathematical models has increased over the last decade. However, Demirel et al. (Demirel, Demirel, & Kahraman, 2010) point out that conventional approaches to the warehouse location selection problem do not take into account all the qualitative and quantitative factors affecting the warehouse location selection. Therefore, they propose a multi-criteria analysis method based on the use of the Choquet Integral, which is tested on a real-life example of a warehouse location selection problem faced by a Turkish logistics firm, where different, mutually interdependent, selection criteria are taken into account.

Ahmadi Javid and Azad (Ahmadi Javid & Azad, 2010) present the problem of designing a distribution network in the company's supply chain. The research objective is to reduce the total costs of location, inventory and delivery delays. Customer requirements are mostly random, and there are multiple levels of performance that are available for distribution centres. The problem is initially formed as a mixed-integer disciplined convex optimization program for solving medium-sized cases, and afterwards the heuristic process is used to solve large cases.

Tancrez et al. (Tancrez, Lange & Semal, 2012) developed a model that combines the decisions regarding the choice of location for the distribution centres, the distribution of goods flows, and the size of individual shipments. The objective of the model is to facilitate the choice of suitable distribution centres that effectively connect the locations of production facilities with the locations of final customers. This model focuses on the optimization of the cost of inventories and transport costs.

Askin et al. (Askin, Baffo & Xia, 2014) developed a mathematical model for facility location, which is designed to determine: the location and capacity level of warehouses to open, the distribution route from each production facility to each retail outlet and the quantity of products stocked at each warehouse and retailer. A genetic algorithm and a specific problem heuristic are designed, tested and compared in several realistic scenarios.

Durmus and Turk (Durmus & Turk, 2014) examine the factors affecting the location selection of warehouses at the intra-urban level on a case study of Istanbul, with the use of a logistic regression model. They found that location-specific factors are effective in the location selection of warehouses in the Istanbul metropolitan area, and warehouse location follows a certain economic rationality at the intra-urban level.

Huang et al. (Huang et al., 2015) have developed an integrated model for site selection and space determination for warehouses in a two-stage network in which products are shipped from part suppliers to warehouses, where they are stored for an uncertain length of time and then delivered to assembly plants. The objective is to minimize the total transport and warehouse operation costs. These include the fixed costs related to their locations and the variable costs related to their space requirements for given service levels.

Methods

Temporal data were analysed by linear trend to obtain an assessment of future trends in import–export activities (period from 2000 to 2016), road and railways infrastructure (period from 1990 to 2015), labour cost and productivity (period from 1995 to 2015). Standardized regression coefficients were calculated and used for between-countries comparison. A positive standardized regression coefficient denotes a positive linear trend and expected future growth, while a negative standardized regression coefficient denotes a negative trend and expected future decline in the studied characteristics.

Ten countries were compared in all available indicators, i.e., import and export activities in 2016 and future trends; development of infrastructure (actual length of roads and railways in 2015 and future trends, number of airports and ports and number of airports with above 5 million passengers per year); industry development (number of companies dealing with road freight and passenger transport, railways, pipelines, inland water transport, sea and air transport, warehousing and supporting activities and postal and courier activities); labour salary and productivity in 2015; and future trends in two taxes

(VAT and CIT – Corporate Income Tax). Each country's characteristics were compared to the median value of all countries or, in the case of the standardized regression coefficient, to the reference value of 0; the latter denotes no linear trend in the data. Countries were evaluated in all characteristics with regard to the median or reference value of the indicator. Data processing was carried out with the IBM SPSS Statistics 25 software.

Linear trend statistical analysis was only used for variables that indicated major changes over the analysed period. Static variables are only reported in a descriptive manner, as the use of the proposed statistical method would not be practical or sensible. The results obtained via the linear trend carry more weight for the conducted survey, as they indicate future trends in international trade, the development of the road and rail networks, wage growth and productivity growth by individual countries.

Results

The countries with the highest import-export activities with Slovenia are Austria, Croatia, Italy and Germany (Table 1). For all these countries, a positive trend in export-import activities is expected in the future. From the remaining countries, the only negative trend expected is in import activities from France.

Further development of road infrastructure is expected in all the countries considered (Table 2). This is also an important aspect, since dynamically changing economic conditions influence the growing demand for various freight transportation and public transport developments (Verseckiene, Palšaitis & Yatskiv Jackiva, 2017; Petraška, Ciziuniene & Prentkovskis, 2018).

A negative trend in railway infrastructure is expected in France, Germany, Poland and Slovakia. Germany, however, has a highly developed railway infrastructure already: the most developed roadways, airways and waterways are found in France, Italy, Germany and Spain.

The largest number of companies supporting distribution or warehousing activities can be found in France, Italy, Germany and Poland (Table 3). Germany has the largest concentration of companies in freight transport, passenger transport, railways, pipelines, inland water transport, sea transport, air transport, warehousing & support activities and postal & courier activities.

Labour costs are the lowest in the Czech Republic, Croatia, Hungary, Poland and Slovakia (Table 4). Trend analysis indicates future growth in wages in all countries in the analysed sample. The most substantial growth is expected in Austria, France, Germany, Poland and Slovakia.

Table 1. Trends in country import-export activities (Izvozno okno, 2017)

	AT	CZ	FR	HR	IT	HU	DE	PL	SK	ES
Export trend (std. β)	0.96	0.94	0.70	0.86	0.92	0.92	0.96	0.94	0.96	0.73
Import trend (std. β)	0.88	0.94	–0.79	0.93	0.81	0.95	0.89	0.98	0.96	0.39
Export 16	1976783	582085	1178835	2076048	2736476	705523	5158793	813770	473583	444595
Import 16	2713800	622350	943448	1506922	3715124	1011523	4638439	696197	411146	361084

AT – Austria, CZ – Czech Republic, FR – France, HR – Croatia, IT – Italy, HU – Hungary, DE – Germany, PL – Poland, SK – Slovak Republic, ES – Spain (green – beneficial characteristics with regards to median / reference value; red – disadvantageous characteristics with regards to median / reference value).

Table 2. Trends in country infrastructure development (EU, 2017; Wikipedia, 2018)

	AT	CZ	FR	HR	IT	HU	DE	PL	SK	ES
Roads trend (std. β)	0.97	0.99	0.96	0.96	0.95	0.98	0.98	0.95	0.98	0.99
Railways trend (std. β)	–0.89	0.10	–0.74	0.45	0.98	0.32	–0.24	–0.95	–0.91	0.97
Railways 15	59	120	53	46	57	85	109	59	74	32
Roads 15	20	10	21	23	23	20	36	5	9	30
No. of airports	6	3	42	5	33	1	25	12	2	32
Airports > 5 mio npy	1	1	7	0	9	1	9	1	0	10
No. of large ports/terminals	2	0	14	3	8	1	11	6	0	23

AT – Austria, CZ – Czech Republic, FR – France, HR – Croatia, IT – Italy, HU – Hungary, DE – Germany, PL – Poland, SK – Slovak Republic, ES – Spain (green – beneficial characteristics with regards to median / reference value; red – disadvantageous characteristics with regards to median / reference value).

Table 3. Number of Enterprises by Mode of Transport (EU, 2017)

	AT	CZ	FR	HR	IT	HU	DE	PL	SK	ES
ROAD freight transport	6767	30623	34773	5745	69121	13812	31019	79062	6282	102535
ROAD passenger transport	5405	3250	52692	1123	29634	7404	22944	45877	4189	61642
Railways	28	28	41	11	27	33	151	151	13	13
Pipelines	4	2	75	2	11	5	35	5	0	0
Inland water transport	99	83	1097	18	1008	105	1168	392	20	62
Sea transport	0	2	884	639	694	7	1554	257	0	290
Air transport	176	43	681	29	228	81	620	344	30	96
Warehousing & support activities	1392	4278	12110	1029	22560	3599	20288	11611	3179	19498
Postal & courier activities	440	301	3683	46	2405	1091	13618	3037	631	6343

AT – Austria, CZ – Czech Republic, FR – France, HR – Croatia, IT – Italy, HU – Hungary, DE – Germany, PL – Poland, SK – Slovak Republic, ES – Spain (green – beneficial characteristics with regards to median / reference value; red – disadvantageous characteristics with regards to median / reference value).

Table 4. Country labour costs (Eurostat, 2018b)

	AT	CZ	FR	HR	IT	HU	DE	PL	SK	ES
Salary trend (std. β)	1.00	0.96	1.00	0.92	0.98	0.90	0.99	0.99	0.99	0.96
Salary 15	28.7	8.8	32.2	8.4	22.6	6.7	30.5	6.3	9.3	19.3

AT – Austria, CZ – Czech Republic, FR – France, HR – Croatia, IT – Italy, HU – Hungary, DE – Germany, PL – Poland, SK – Slovak Republic, ES – Spain (green – beneficial characteristics with regards to median / reference value; red – disadvantageous characteristics with regards to median / reference value).

Table 5. Country labour productivity (Eurostat, 2018a)

	AT	CZ	FR	HR	IT	HU	DE	PL	SK	ES
Productivity trend (std. β)	–0.83	0.97	–1.00	0.98	–0.95	0.85	–0.86	0.99	0.95	0.46
Productivity 15	117.7	79.7	115.0	70.1	106.3	69.8	106.1	74.0	82.7	102.2

AT – Austria, CZ – Czech Republic, FR – France, HR – Croatia, IT – Italy, HU – Hungary, DE – Germany, PL – Poland, SK – Slovak Republic, ES – Spain (green – beneficial characteristics with regards to median / reference value; red – disadvantageous characteristics with regards to median / reference value).

Table 6. Country taxes (Fidata, 2017)

	AT	CZ	FR	HR	IT	HU	DE	PL	SK	ES
VAT	20	21	20	25	22	27	19	23	20	21
CIT	25	19	33	20	31	19	16	19	22	25

AT – Austria, CZ – Czech Republic, FR – France, HR – Croatia, IT – Italy, HU – Hungary, DE – Germany, PL – Poland, SK – Slovak Republic, ES – Spain (green – beneficial characteristics with regards to median / reference value; red – disadvantageous characteristics with regards to median / reference value).

The countries with the lowest levels of labour productivity are the Czech Republic, Croatia, Hungary, Poland and Slovakia (Table 5). However, trend analysis in these countries suggests that labour productivity will increase significantly in the future. Labour productivity is currently highest in Austria, followed by France, Italy, Germany and Spain, but growth in labour productivity is expected only in Spain.

Germany has the lowest taxes (Table 6). The countries with the highest CIT – Corporate Income Tax are France and Italy and the countries with highest VAT are Hungary and Croatia.

The best country for the establishment of a warehouse distribution centre would be Germany, as import-export activities are intensive and are expected to grow further. It has a highly developed transport infrastructure, high labour productivity and low taxes. Labour costs, however, are the highest among all the countries. Another country worth considering is Italy, which has similar indicators, but a labour force that is quite costly and relatively high taxes.

Discussion and Conclusions

Companies face decisions regarding warehouse location immediately from their inception and these are some of the most important strategic decisions that any company must make. In the past, the location of a company's warehouse would remain unchanged over the course of long-term business operations, but the intense changes happening in international trade in recent years require companies to pay particular attention to the careful planning of a potential warehouse facility. Therefore, the applied approach represents new guidelines in the theoretical development of the methods for selecting the location of a warehouse, as it takes into account at the planning stage any changes that may occur in the future. The location selection process can be supplemented with new data (qualitative and quantitative factors), such as warehouse rental costs, land costs and other relevant data that make it easier for a company to select the best possible location. The wide selection of possible data and the flexibility of the method give this approach an advantage over other mathematical methods, which are limited to predefined data parameters. This enables companies to make better choices regarding potential warehouse locations in the future.

The approach can also be used for selecting the location of a company's distribution warehouse. The first step in the location selection process consists in identifying the geographical areas where the company sells and supplies the majority of its goods. The next step is to determine the number of potential buyers and suppliers located in the area identified in the first step, as well as the amount of mutual revenues generated per year. The remaining data can remain the same (the level of development of a country's transport system, the number of enterprises by industry, labour costs, labour productivity and the tax benefits existing in the country).

Notwithstanding the advantages of the presented approach, the fact remains that it is difficult to find a future location for a warehouse which takes into account all the qualitative and quantitative aspects of the selection equally. Based on the analysed data, Germany can be identified as the country with the strongest long-term potential for establishing a warehouse distribution system for Slovenian companies. Germany's coverage of import and export flows with Slovenia is intense and is increasing over the years. The country also has a well-developed transport system and infrastructure, with the only negative aspect being the cost of labour, which is the highest in the analysed sample of countries. Labour productivity is high, but trend analysis predicts a decline in the future. A detailed data analysis also suggests that the Czech Republic and Poland could be potential locations in the future, as labour productivity is rising and labour costs are stable. The road network is also growing, while the ever-increasing network of toll roads gives new opportunities for the development of transport (Lewandowski, 2016). The final decision on the location of the warehouse, therefore, depends on the logistical knowledge of the decision makers within the company (Skerlic, 2017), who must analyse several different logistic aspects of the choice of location.

Thus, the presented analysis does not provide a clear answer on how to choose a suitable location for a warehouse distribution centre, since several aspects need to be taken into account in practice, which relate to the nature of the stored goods and of the facilities in the existing logistics network of a particular company. Nevertheless, the analysis represents an important starting point for deciding the location of a warehouse distribution centre, although it does not constitute a complete set of guidelines for companies to follow, since it only focuses on certain aspects in the macro environment. When identifying the optimal warehouse location, we must also not forget that every company has its own strategy and the use of any particular method should only function as an aid when the company's management is making its final decision. The example presented in this paper attempted to demonstrate the applicability of the suggested approach. Therefore, additional testing is required in various companies and using additional real-life examples.

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