OPTIMIZATION OF TOTAL LOGISTICS COSTS USING THE EXAMPLE OF TRANSPORT ACTIVITY

Agnieszka Lisowska, Tadeusz Waściński, Marek Sobolewski

Abstract:

The research problem discussed in the article concerns the analysis of the total costs of logistics in dynamic terms using the example of transport company. The utilitarian objective of the article is to indicate what are the possibilities of optimizing logistics costs in the surveyed company. On the other hand, the methodological goal is to determine whether the current logistics cost scheme at the enterprise allows for their optimization. Answering these questions required an analysis of the literature on the subject, conducting own research and the using secondary research. The following methods, techniques and research tools were used: induction and deduction method, document analysis, descriptive modelling. The method of induction and deduction was used to correctly draw conclusions from the multi-criteria analysis (AHP), statistical data and tables. The analysis of documents, literature and thematic magazines was the source of information about the costs of logistics. Descriptive modelling was used to formulate and describe the collected information and statistical data.

Keywords:

logistics, costs, transport, transport optimization

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Introduction

The article analyses the costs of logistics, assuming that they are expressed in monetary units, that it is purposeful to use the company's resources and incur financial expenses resulting from the flow of material goods, maintaining inventories and processing information related to logistic activities in the company.

Recognition of logistics costs is a complex process, but necessary to be carried out in practice. The efficiency and effectiveness of logistics processes requires keeping logistic cost accounting on a unit and dynamic basis.

Systemic changes in macroeconomic functioning force economic units to move from a quantitative growth strategy to a strategy in which it is primarily important to increase profitability while maintaining the required level of customer service. The efficient functioning of logistic processes requires incurring appropriate time, personnel and material expenditures, which economy expresses in the category of measurable costs. In this case, it is about logistics costs. In this area, there are the greatest opportunities to reduce the costs of an enterprise, so the importance of logistics costs in the process of efficient enterprise management and the implementation of its basic goal, which is profit maximization, becomes an extremely important issue. The article justifies the essence and role of such an important group of costs as logistics costs in the enterprise management process.

Maintaining the appropriate level of total logistics costs is a strategic objective of all business entities that are organizationally related in this business profile. Due to the fact that the subject of this issue is too rarely discussed – this article can be used to compare, analyse and evaluate issues in this field.

The research problem undertaken in the article concerns the analysis of the total costs of logistics in dynamic terms using the example of a transport company. The utilitarian aim of the article is to indicate what are the possibilities of optimizing the incurred logistics costs in the examined enterprise. On the other hand, the methodological objective is to determine whether the current logistics cost scheme in the enterprise allows for their optimization.

Answering such questions required an analysis of the literature on the subject in the field of logistics costs, conducting own research and the use of secondary research. The following research methods, techniques and tools were used:

- induction and deduction method, document analysis, descriptive modelling,
- induction and deduction method was used to correctly draw conclusions from the multi-criteria analysis (AHP), statistical data and tables,
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Descriptive modelling was used to formulate and describe the collected information and statistical data.

Transport costs issue

Transport plays a key role in the socio-economic development of the country by enabling the relocation of products and increasing the openness of regions, and the lack of a precise focus on its development significantly limits the possibilities of further development of the economy. In the literature on the subject, there are a number of definitions of transport. In a functional sense, transport can be defined as „the technological process of any distance transport, that is, the movement of people, objects or energy"[1]. This is a classic approach presented by I. Tarski, in which the author emphasizes purposeful transportation, displacement, causing a change in space and time.

In the subjective aspect, transport is defined as „technically, organisationally and economically separated from other activities, deliberate movement of all loads and people"[2]. This definition shows that transport is closely related to the use of specific means of transport and transport infrastructure, the presence of certain economic entities that provide transport services and obtain a financial result related to the conduct of transport activities[3].

The universal model of the logistics system allows to calculate the sum of costs of the logistics system per one item of cargo during one delivery cycle (TLC)[4]. It is the sum of five components.

$$TLC = PRC + TRC + CSC + ITC + SSC$$

Where:
PRC – shipment preparation costs,
TRC – transport costs,
CSC – inventory costs related to the delivery cycle,
ITC – inventory costs on the way,
SSC – Safety Stock Costs.

[1] I. Tarski, Ekonomika i organizacja transportu międzynarodowego, PWE, Warszawa 1993, s. 11.
[2] M. Madeyski, E. Lissowska, J. Marzec, Wstęp do nauki o transporcie, SGPiS, Warszawa 1971, s. 10.
[3] A. Koźlak, Ekonomika transportu. Teoria i praktyka gospodarcza, WUG, Gdańsk 2008, s. 11.
[4] B. Wiśnicki, *Analiza kosztów systemu logistycznego w transporcie intermodalnym, „Logistyka"* 2007, nr 4, s. 8.

This model is of universal character, so it can be applied to both simple and complex logistics systems. Thanks to modifications, it is suitable for the analysis of the economic efficiency of the transport of non-unit loads: large-size, semi-processed liquid, bulk, etc. This model can also be applied to the analysis of internal logistic systems or supply and distribution systems using various means of transport[5].

In turn, the social costs of transport are those borne by the country and society through the functionality of transport. The third group, which is also burdened with transport costs, are their users themselves. These costs are called the costs of meeting a transportation need. It is extremely important to know them, because it affects the rationality of decisions related to transport performance and the adaptation of appropriate modes of transport to them, as well as estimating fees related to the use of infrastructure and the use of solutions covering external costs[6].

When analysing the costs of transport companies, attention should also be paid to the preferences of owners as to the way the company operates. The cost analysis in the transport process may be based on:

- optimizing the transport route according to the cost criterion,
- selection of transport means for transporting people or loads,
- optimizing its duration,
- considering the use of external carriers services.

The company has to determine whether it is more important for it to reach the customer on time or to shorten the duration of the transport, or whether to reduce its own costs without taking into account the transport time-consumption[7].

B. Piechota pointed out the following benefits of using activity-based costing in logistics costs management:

- the ability to detect manifestations of ineffective decisions;
- proper planning of the demand and consumption of resources in the production processes of individual products and logistics services;
- forcing logistic unit managers to analyse their processes and designate value-creating activities;
- possibility of comparing the costs of processes carried out in-house with the costs of processes carried out by other enterprises;
- the ability to identify costly activities, the performance of which can be reduced or eliminated;
- effective resource management by focusing attention on value-creating activities;
- accurate calculation of unit costs;
- the ability to correctly calculate the costs of products or services, taking into account logistics costs[8].

The structure of generic costs incurred by transport enterprises is diverse. It depends mainly on the mode of transport in which the company operates. There are also visible differences in the cost structure between carriers of the same mode of transport. The generic system makes it possible to calculate the total costs of services provided by a given enterprise[9].

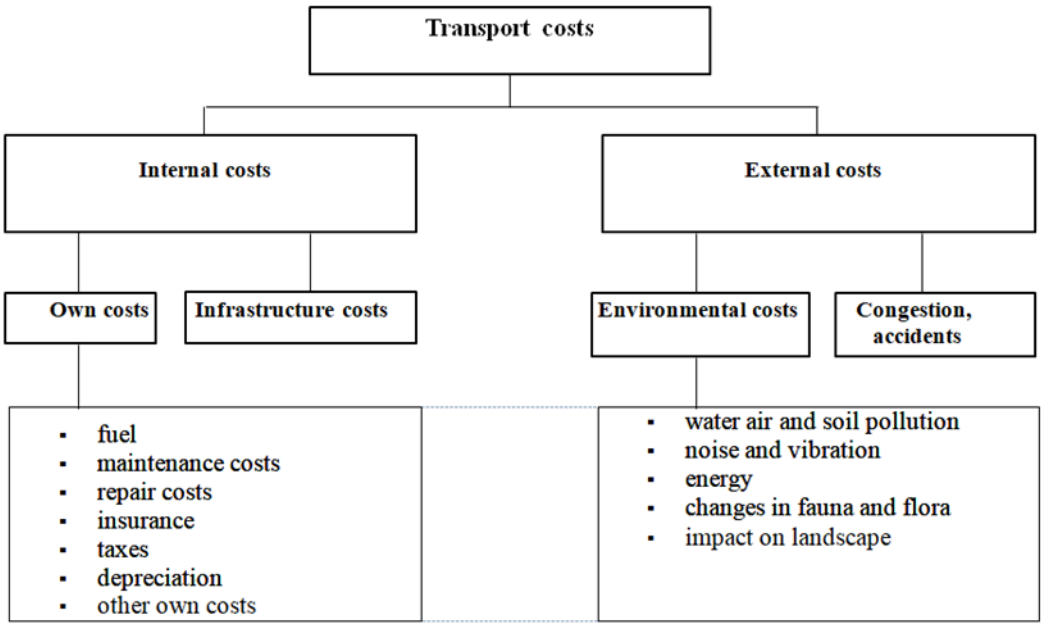
Logistics cost structure analysis

(the research was carried out in the period 2017-2021)

A good criterion for allocating costs is their breakdown by type. Team 4 accounts are then used – Costs by type. These types of accounts include (Figure 1):

- depreciation,
- usage of materials and energy,
- external services,
- salaries,
- social security and other benefits,
- taxes and fees,
- other generic costs [10].

Fig. 1. Structure of transport costs



Source: A. Koźlak, Ekonomika transportu. Teoria i praktyka gospodarcza, Wydawnictwo Uniwersytetu Gdańskiego, Gdańsk 2010, p. 297.

[5] Tamże, s.3.
[6] A. Koźlak, *Ekonomika transportu. Teoria i praktyka gospodarcza*, Wydawnictwo Uniwersytetu Gdańskiego, Gdańsk 2010, s. 297- 298
[7] K. Michałowska, *Znaczenie i sposoby rozliczania kosztów logistycznych*, Zeszyty Naukowe Uniwersytetu Szczecińskiego nr 765 Finanse, Rynki Finansowe, Ubezpieczenia nr 61, Szczecin 2013, s.329.
[8] E. Nowak, R. Piechota, M. Wierzbiński, *Rachunek kosztów w zarządzaniu przedsiębiorstwem*, PWE, Warszawa 2004, s. 113-114.
[9] I. Urbanyi-Popiołek (red.), *Ekonomiczne i organizacyjne aspekty transportu*, Wydawnictwo Uczelniane Wyższej Szkoły Gospodarki w Bydgoszczy, Bydgoszcz 2013, s. 20.
[10] G. Zimon, *Analiza kosztów w przedsiębiorstwach transportu samochodowego*, Zeszyty Naukowe Uniwersytetu Szczecińskiego nr 873, Finanse, Rynki Finansowe, Ubezpieczenia 2015, nr 77, s. 350.

Depreciation relates to the gradual impairment of fixed assets value, which is transferred as a cost to the provision of transport services. By means of depreciation, expenditure on the purchase of fixed assets is included in the costs of individual time periods in the form of depreciation write-offs. This gives an opportunity to accumulate funds for the purchase of new fixed assets.

Material and energy costs include items such as fuel, oil, lubricant, energy, electricity, water, as well as office and advertising materials.

External services include various types of services and works provided by other entities, for example, reloading operations, repair, IT and banking services. In the long run, these costs show an upward trend in the total costs in the enterprise. It is related to the use of outsourcing, i.e. separating narrow areas from the company's operations and outsourcing them to specialized companies. In many cases, outsourcing leads to lower operating costs of the enterprise.

The costs of salaries include payments of remuneration in cash and in kind, which are received by employees regardless of the form of employment. Social insurance and compulsory contributions to, for example, the Labour Fund are counted as a percentage mark-up on salaries.

Another cost is taxes and fees, which include such elements as: property tax, tax on means of transport, fees for permits and licenses. Other costs relate to various items that may be borne by the transport company, such as accommodation costs, business trips expenses, property insurance[11].

Team 4 accounts provide little information on the costs incurred in relation to logistics, let alone transport. If we would like to receive information about the costs related to logistics activities, it is worth creating appropriate analytical accounts. Examples of analytical accounts for logistics that should be offered to the company are presented in Table 1.

Tab. 1. Typical Team 4 Chart of Accounts with Secondary Accounts for Logistics Costs

Synthetic accounts	Analytical logistic account
Depreciation	– depreciation of transport means – depreciation of other fixed assets related to logistics
Consumption of materials and energy	– consumption of logistic materials and energy for logistic purposes
External services	– transport – loading and unloading – leasing
Salaries	– drivers' salaries – salaries of other logistics employees
Social security and other benefits	– social security and other benefits for drivers – social insurance and other benefits of other logistics employees
Taxes and charges	– taxes on transport means – real estate taxes related to logistics
Other generic costs	– insurance – business trips of logistics employees

Source: G. Zimon, Analiza kosztów w przedsiębiorstwach transportu samochodowego, Zeszyty Naukowe Uniwersytetu Szczecińskiego nr 873, Finanse, Rynki Finansowe, Ubezpieczenia no. 77 (2015), p. 351

The costs of logistics processes are grouped in the enterprise on analytical accounts in the accounting records. The table shows the costs of logistic processes by type, while the analysis of the costs of logistic processes by type refers only to operational activities related to logistics activities. The evolution of the costs of logistics processes by type in the analysed enterprise in the years 2017-2021 is presented in Table 2.

Tab. 2. Costs of logistics processes in the analysed enterprise in the years 2017-2021 (in PLN)

Types of costs	2017	2018	2019	2020	2021
Total costs of logistics processes	23178216,6	23642451	24144821	23525046	25613678,5
Depreciation	35000	35000	35000	38000	45000
Consumption of materials and energy	21454786	21854221	22194547	21554784	23457932,5
External services	256425,6	234589	315648	217954	287945
Salaries	1200548	1284747	1357842	1457984	1547850
Social security and other benefits	231457	233894	241784	256324	274951

Source: own study based on internal materials of the analysed enterprise.

[11] I. Urbanyi-Popiołek (red.), *Ekonomiczne i organizacyjne aspekty transportu*, Wydawnictwo Uczelniane Wyższej Szkoły Gospodarki w Bydgoszczy, Bydgoszcz 2013, s. 20-21.

Based on the analysis of the table, it can be concluded that the largest share in the total costs of logistics in the surveyed company are transport costs. This is undoubtedly due to the nature of the business, the pillar of which is the transport of metal elements. Constantly changing fuel prices significantly increase the share of transport costs in the entire structure of logistics costs. The components that significantly increase the share of transport costs are also depreciation of transport means and remuneration for personnel employed in transport.

The results of further analysis of logistic costs are presented below. The analysis was made by comparing five years of operation of the surveyed transport company.

The logistic costs were divided in the company into:

1) Costs of general infrastructure – they determine to a large extent the activity of the enterprise, because they include costs related to the maintenance of buildings and utilities; this group includes costs (Table 3):
   - rent (they also include fees for physical security and monitoring services of the facility),
   - water and sewage,
   - electric energy,
   - car rental,
   - mobile telephony,
   - garbage collection,
   - costs of office supplies consumption.
2) Transport costs – the specificity of the activity requires to deliver products from the customer to his recipients, therefore this group was separated in order to carefully analyse its impact on all costs incurred in the enterprise; these include the following costs:
   - fuel,
   - depreciation,
   - labour,
   - third party liability insurance,
   - repairs and maintenance,
   - technical inspection.

Tab. 3. The structure of infrastructure costs in the analysed enterprise (in PLN)

	2017	2018	2019	2020	2021
Rent	83252,25	83746,3	83005,96	83257,63	85951,54
Water and sewage	4111,32	3943,32	4754,4	4338	4838,4
Car rental	58240	58240	58240	72410	72410
Mobile telephony	48612,52	49122,33	48152,65	49475,88	49713,62
Waste collection	1055	1055	1055	1345	1345
Consumption of office supplies Costs	14578,68	15247,99	14889,64	17481,62	18451,78
Total	209849,77	211354,94	210097,65	228308,13	232710,34

Source: own study based on the materials of the surveyed enterprise.

Cost analysis allows the company's management to choose those that it has most influence over (costs of telephony, office supplies, car rental, rent), and the reduction of which will not reduce the quality and it will only contribute to the rationalization of logistics activities. However, such an approach requires constant monitoring and the search for opportunities.

Another important group of logistics costs in the surveyed company are transport costs. Their size is presented in Table 4.

Tab. 4. The structure of transport costs in the analysed enterprise (in PLN)

	2017	2018	2019	2020	2021
Fuel	18254786	18754221	18994547	19154784	20357932,5
Labour	123000	110000	118000	126000	133000
Depreciation	35000	35000	35000	38000	45000
Repairs and maintenance	450000	245000	615000	478000	517620
Technical inspections	44000	44320	44320	45120	46000
Liability insurance	230000	235000	240000	255000	280000
Total	19136786	19423541	20046867	20096904	21379552,5

Source: own study based on the materials of the surveyed enterprise.

Having broken down the total costs of logistics processes, one can see what consumes the most funds in your company. In the following, one of the possible methods of better financial management at the surveyed transport company is presented.

Selected possible directions of optimizing the costs of transport activities at the enterprise

The AHP (Analytic Hierarchy Process) multi-criteria analysis method was used to evaluate the decision variants in terms of improving the functioning of the transport process.

Making decisions according to the AHP method relies on:

- decomposition of the decision problem and description of the criteria,
- evaluation, i.e. comparing in pairs of criteria and decision variants using the Saaty dominance scale (Table 5),
- determining mutual priorities of criteria and decision options,
- ordering in terms of participation in meeting the requirements [12].

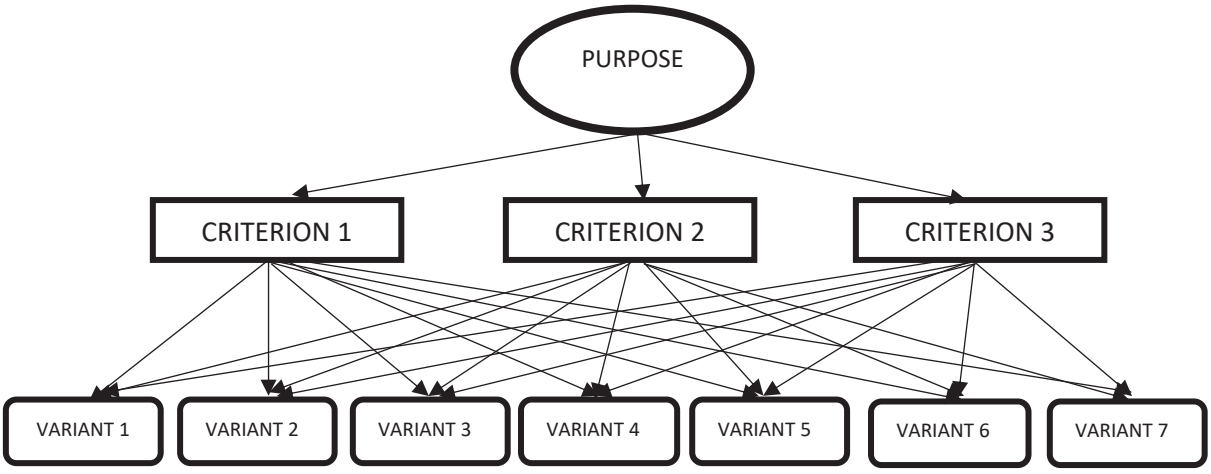
Tab. 5. Scale for evaluating criteria

Variant evaluation	Scale of importance
1	Equal importance
3	Slightly more important
5	Clearly more important
7	Very clear importance
9	Absolutely more important
2, 4, 6, 8	Intermediate values

Source: C. Bozarth, R.B. Handfield, Wprowadzenie do zarządzania operacjami i łańcuchem dostaw, Helion, Gliwice 2007, p. 403

The analytical hierarchy procedure began with formulating overarching goal, which is a high level of customer service at the lowest logistics costs. Then, the main risk categories that affect the amount of logistics costs were formulated. The last elements of the hierarchical representation of the problem are variants that enable to achieve the overarching goal, i.e. maintaining the level of customer service, while maintaining the lowest logistics costs. The decomposition of the examined problem is presented in Figure 2.

Figure 2. Hierarchical representation of the problem



Source: Own elaboration based on empirical data.

The factors presented in Table 6 were considered to be important criteria and variants within the amount of total logistics costs.

[12] T. Waściński, P. Bartosiewicz, Wybór środków transportu wewnętrznego dla przedsiębiorstwa usługowego w aspekcie poprawy efektywności procesu magazynowego, Zeszyty Naukowe Uniwersytetu Przyrodniczo-Humanistycznego w Siedlcach, Politechnika Warszawska, Wydział Zarządzania 2017, nr 115, s.78.

Tab. 6. Criteria and variants for the AHP analysis

No.	Criteria	No.	Variants
1.	organization and coordination of the transport process	1.	cooperation with external entities
2.	condition of transport infrastructure	2.	developing a map of transport network
3.	level of salaries	3.	transport monitoring
		4.	modernization and reconstruction of the transport network
		5.	marking of transport routes for heavy goods vehicles
		6.	employee training
		7.	activities of control services and institutions

Source: Own elaboration based on empirical data.

Based on the comparisons in pairs, of variants and criteria, appropriate matrices of relative grades are formulated, saved in the matrix with dimensions , where: – means the number of elements at a given level.

Such a matrix has the following properties:
1) The figures on the diagonal of the matrix have the value 1 because the same criteria are compared.
2) Figures lying above the diagonal – the results of comparisons of two criteria.
3) Figures lying below the diagonal – the opposites of these comparisons[13].

The ranking of categories and variants was made on the basis of subjective feelings about the amount of total logistics costs. The comparison according to the rating scale with pairs of importance of the parameters of the analysed criteria is presented in Table 7.

Tab. 7. Relative assessment matrix for the analysis criteria

	K1	K2	K3	Total
K1	1	6	0,25	7,25
K2	0,167	1	0,2	1,367
K3	4	5	1	10
Total	5,167	12	1,45	

Source: Own elaboration based on empirical data.

For example, the K1 criterion is preferred to K2 taking the value 6 (position $K_{1,2}$), the K3 criterion is preferable to K2 taking the value 5 (position $K_{3,2}$), etc.

Then, pairwise comparisons were made of the variants for each criterion, and separate matrices for each criterion were obtained. As in the matrix in Table 2, preferences were given according to the Saaty scale. First, individual variants were considered in relation to the criterion linked to the organization and coordination of the transport process. The evaluation matrix determined on this basis is presented in the form of Table 8.

Tab. 8. Relative assessment matrix for logistics costs with respect to K1

	W1	W2	W3	W4	W5	W6	W7	Total
W1	1	5	0,25	5	0,25	0,2	1	12,7
W2	0,2	1	0,333	3	4	0,25	0,2	8,983
W3	4	3	1	5	4	5	1	23
W4	0,2	0,333	0,2	1	0,2	0,25	0,167	2,35
W5	4	0,25	0,25	5	1	0,25	2	12,75
W6	5	4	0,2	4	4	1	6	24,2
W7	1	5	1	6	0,5	0,167	1	14,667
Total	15,4	18,583	3,233	29	13,95	7,117	11,367	

Source: Own elaboration based on empirical data.

Subsequently, individual variants were considered in relation to the criterion related to the condition of the infrastructure. The evaluation matrix determined on this basis is presented in Table 9.

[13] J. Sordyl, K. Brzozowski, Zastosowanie metody AHP do oceny poszczególnych etapów transportu materiałów niebezpiecznych, „Logistyka" 2012, nr 3, s 2070.

Tab. 9. Relative assessments matrix for logistics costs with respect to K2

	W1	W2	W3	W4	W5	W6	W7	Total
W1	1	5	0,25	3	1	3	0,333	13,583
W2	0,2	1	0,25	3	0,25	3	5	12,7
W3	4	4	1	0,25	0,2	3	3	15,45
W4	0,333	0,333	4	1	4	0,25	3	12,916
W5	1	4	5	0,25	1	3	3	17,25
W6	0,333	0,333	0,333	4	0,333	1	0,333	6,665
W7	3	0,2	0,333	0,333	0,333	3	1	8,199
Total	9,866	14,866	11,166	11,833	7,116	16,25	15,666	

Source: Own elaboration based on empirical data.

As the last step, individual options were considered in relation to the criterion linked to the level of employees' remuneration. The evaluation matrix determined on this basis is presented in Table 10.

Tab. 10. Relative assessments matrix for logistics costs with respect to K3

	W1	W2	W3	W4	W5	W6	W7	Total
W1	1	0,2	0,2	0,14	6	0,167	0,25	7,957
W2	5	1	4	4	5	0,167	0,333	19,5
W3	5	0,25	1	4	4	0,333	0,25	14,833
W4	7	0,25	0,25	1	4	0,333	0,2	13,033
W5	0,167	0,2	0,25	0,25	1	0,25	0,167	2,284
W6	6	6	3	3	4	1	1	24
W7	4	3	4	5	6	1	1	24
Total	28,167	10,9	12,7	17,39	30	3,25	3,2	

Source: Own elaboration based on empirical data.

For individual criteria and variants, the procedure of determining mutual priorities was applied. The designated priority vectors allow to rank individual variants with regard to the significance of a given factor in relation to a single criterion. This is done by adding up the score values in each column and writing down that value in the additional row below, then dividing each score in columns W1 through to W7 by the sum of the scores in that column and overwriting the score in each cell. Then, the weight for a given criterion is calculated by adding up the values from the fields from W1 to W7 and dividing the obtained sum by the number of items and entering the result in the value rank field. The result of such a procedure for K1 is presented in Table 11.

Tab. 11. Calculating the rank values of individual variants for the K1 criterion

	W1	W2	W3	W4	W5	W6	W7	Rank value
W1	0,065	0,269	0,077	0,172	0,018	0,028	0,088	0,103
W2	0,013	0,054	0,103	0,103	0,287	0,035	0,018	0,088
W3	0,260	0,161	0,309	0,172	0,287	0,703	0,088	0,283
W4	0,013	0,018	0,062	0,034	0,014	0,035	0,015	0,027
W5	0,260	0,013	0,077	0,172	0,072	0,035	0,176	0,115
W6	0,325	0,215	0,062	0,138	0,287	0,141	0,528	0,242
W7	0,065	0,269	0,309	0,207	0,036	0,023	0,088	0,142
Total								1,000

Source: Own elaboration based on empirical data.

When evaluating the amount of total logistics costs in relation to criterion 1, the most important factor was the use of material transport monitoring systems. Equally important, and with a slightly lower rank value, is option 6, i.e. employee training. The modernization and restoration of the transport network was considered to be the least important factor in considering this criterion. The determined matrix of grades with the calculated rank value for K2 is presented in the form of Table 12.

Tab. 12. Calculating the rank values of individual variants for the K2 criterion

	W1	W2	W3	W4	W5	W6	W7	Rank value
W1	0,101	0,336	0,022	0,254	0,141	0,185	0,021	0,151
W2	0,020	0,067	0,022	0,254	0,035	0,185	0,319	0,129
W3	0,405	0,269	0,090	0,021	0,028	0,185	0,191	0,170
W4	0,034	0,022	0,358	0,085	0,562	0,015	0,191	0,181
W5	0,101	0,269	0,448	0,021	0,141	0,185	0,191	0,194
W6	0,034	0,022	0,030	0,338	0,047	0,062	0,021	0,079
W7	0,304	0,013	0,030	0,028	0,047	0,185	0,064	0,096
Total								1,000

Source: Own elaboration based on empirical data.

In the case of referring to the criterion related to the condition of the infrastructure, the marking of transport routes for heavy goods vehicles was considered the most important factor. This plays a key role when choosing the right freight route. Improper road marking, incl. information signs placed too close to possible exits may cause anxiety among drivers and thus confusion on the road due to the impossibility of braking the road train in order to perform the planned manoeuver. Immediately after that, the modernization and reconstruction of the transport network were classified. This affects the planning of the direct route course, taking into account the available routes, i.e. in particular avoiding routes running through city centres. The least important variant resulting from the analysis turned out to be employee training related to the condition of the infrastructure. The determined matrix of grades with the calculated rank value for K3 is presented in Table 13.

Tab. 13. Calculating the rank values of individual variants for the K3 criterion

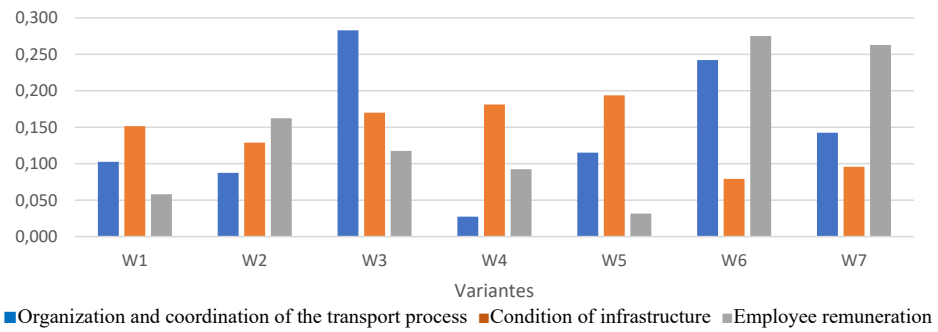
	W1	W2	W3	W4	W5	W6	W7	Rank value
W1	0,036	0,018	0,016	0,008	0,200	0,051	0,078	0,058
W2	0,178	0,092	0,315	0,230	0,167	0,051	0,104	0,162
W3	0,178	0,023	0,079	0,230	0,133	0,102	0,078	0,118
W4	0,249	0,023	0,020	0,058	0,133	0,102	0,063	0,092
W5	0,006	0,018	0,020	0,014	0,033	0,077	0,052	0,032
W6	0,213	0,550	0,236	0,173	0,133	0,308	0,313	0,275
W7	0,142	0,275	0,315	0,288	0,200	0,308	0,313	0,263
Total								1,000

Source: Own elaboration based on empirical data.

The last (third) criterion analysed was employee remuneration, which affects not only the amount of total logistics costs, but also the overall level of target customer service. The use of the AHP method made it possible to state that the most important decision option in this respect is the training of employees, mainly drivers, and the full involvement of control services and institutions. They have procedures in place by which employees should perform their duties properly in order to reach their final destination safely. Additionally, an important element considered in this criterion is the development of a map of the transport network. Thanks to it, drivers can immediately plan both routes without exposing the load to damage or additional costs related to, for example, fines for choosing the wrong road. In turn, the decision variants with the lowest impact on the amount of remuneration are the marking of transport routes – employees have the least influence on it.

Figure 3 presents a collective summary of the previously analysed values of ranks determined for all three considered criteria for the total costs of logistics.

Fig. 3. Juxtaposition of the size of ranks



Source: Own elaboration based on empirical data.

The next stage of the procedure is to determine the relative assessment matrix with regard to the significance of each of the three considered criteria, and at the same time to calculate the rank values and obtain the vector of the priorities under consideration. It is needed to rank the final variants when considering the main objective of the analysis. Table 14 shows the rank values vector for individual criteria, calculated based on the adopted matrix of relative evaluations.

Tab. 14. Rank values vector for individual criteria

	K1	K2	K3	Rank value/distribution vector
K1	0,194	0,500	0,172	0,289
K2	0,032	0,083	0,138	0,103
K3	0,774	0,417	0,690	0,627
Total				1,000

Source: Own study.

The final ranking of variants requires aggregation[14] of the designated assessments of individual factors with regard to individual criteria, taking into account their significance. The values obtained as a result of the aggregation process are elements of the main priority vector, which determine the final ranking of decision variants in terms of the amount of total logistics costs. The main priorities constituting the vector elements determined by applying the AHP method for individual modes of transport, ranked from the highest to the lowest, are shown in Table 15.

Tab. 15. Main priorities determined for the AHP analysis

Variant	Rank value
employee training	0,22
activities of services and institutions	0,21
transport monitoring	0,15
developing a map of the transport network	0,15
modernization and restoration of the transport network	0,11
cooperation with external entities	0,09
marking of transport routes for heavy goods vehicles	0,09

Source: Own study.

The method of the analytical hierarchical process enables to decompose the problem of the amount of total logistics costs from the point of view of the criteria analysed. However, creating the final arrangement of variants in order, requires to define the weight values of each of the considered criteria. The advantage of using this method is, above all, the possibility of taking into account both quantitative and qualitative factors in the analysis process and direct reproducing of the significance of the adopted risk assessment criteria. As a result of the application of the procedure described in this paper, the variants were ranked in the order of decreasing values in relation to the amount of total logistics costs. Seven decision options were assessed against the three main criteria affecting the amount of logistics costs.

The analysis conducted shows that the most important decision variants in terms of shaping the amount of total logistics costs are: employee training and the activities of services and institutions.

Fuel costs are one of the highest and most unpredictable costs. Currently, fuel prices are fluctuating even on a weekly basis. The difference between individual days is even a few hundreds of a Zloty. However, based on the prices of individual fuel prices in other parts of Europe, it can be concluded that Poland has one of the lower prices[15].

As one of the methods of reducing fuel expenses, the company uses innovative solutions of the car fleet. However, it is still a high percentage of absorbed expenses. Fuel costs are largely determined by the driving style and economy of drivers. The more economical the drive, the lower the fuel consumption and the lower the fuel costs. That is why the awareness, knowledge and skills of drivers are so extremely important.

The best solution for a transport company to improve fuel economy, as shown by the multi-criteria analysis, will be to propose Eco-driving training systems offered by manufacturers of the rolling stock make that the company is equipped with and to practice the use of IT technologies. The basic assumption of the training system offered by the manufacturer is to provide knowledge on the proper use of vehicles to achieve better results in lower fuel consumption, increase the service life of consumable car parts and the safety of the transport process. After obtaining a positive result in the training, drivers achieve an average increase in savings of up to 15%. As the main cost factor in transport is fuel, the difference obtained after the training is pure profit for the company. If the driver improves his driving technique in accordance with the tips obtained during the training, saving on one truck will generate a slight profit, but with the number of vehicles owned by the tested company, this profit is significant.

Table 16 shows the data on the cost of average fuel consumption – 31L/100km before the introduction of Eco-driving training for 1 vehicle and the entire fleet.

[14] Data aggregation relies on calculating one or more statistics for the groups of cases determined by categories of grouping variables. As a result of this procedure, a new data matrix is formed. Source: https://pl.wikipedia.org/wiki/Agregacja_(statistics) (access date: 15/01/2018).
[15] http://www.e-petrol.pl/notowania/rynki-zagraniczne/stacje-paliw-europa/on (accessed on December 2, 2020, 4:00 p.m.)

Tab. 16. Simulation prior to the introduction of the eco-driving training program

Number of vehicles	Annual mileage	Annual consumption in l/100 km/car	Annual fuel cost The current average fuel cost 4.23 PLN/l
1	135000 km	31 l	177025,5 PLN
115	15525000 km	31 l	20357932,5 PLN

Source: Own elaboration based on empirical data.

Table 17. presents the data obtained after the introduction of the program on the principles of economic driving, assuming that fuel consumption decreased by 15% over a distance of 100 km. The simulation was carried out both, for 1 vehicle and for the entire fleet.

Tab. 17. Simulation following the introduction of the economic driving training program

Number of vehicles	Annual mileage	Annual consumption in l/100 km/car	Annual fuel cost The current average fuel cost 4.23 PLN/l
1	135000 km	26,5 l	151328,25 zł
115	15525000 km	26,5 l	17402748,75 zł

Source: Own elaboration based on empirical data.

The simulation after conducting Eco-driving training generates annual savings for the Company X for 1 vehicle in the amount of PLN 25,697.25, for 115 vehicles in the amount of PLN 2,955,183.75.

These financial simulations show what savings the company is able to make.

Summary and final conclusions

The research problem undertaken has been solved, and the goals defined at the beginning – achieved.

Based on theoretical considerations and the multi-criteria analysis carried out, it is possible to formulate the following conclusions:

1) Optimization of logistics costs is the basic element of the company's financial management.
2) Logistics costs are a constant element of controlling logistic processes at an enterprise.
3) Information on the total costs of logistics is used in decision-making processes, which constitute the basis for the construction of planning and control systems for the valuation of production or services provided.
4) The use of accounting tools such as cost accounting makes the information on unit costs more accurate and provides an information basis for the management.
5) Research shows changes in the structure of generic costs at the transport enterprises.
6) Making decisions on transport issues, due to their increasingly complex nature, becomes more and more difficult and forces the use of newer and newer solutions – this mainly concerns the optimization of transport issues.
7) The most important decision variant in terms of shaping the amount of total logistics costs at the examined enterprise is employee training.
8) Fuel savings equate to financial savings. In order to improve the financial situation, it is recommended to reduce fuel expenses by conducting regular training courses for employees to acquire and expand the skills of economic driving.
9) Publications in the areas of logistics and cost accounting present various approaches to the definition of costs. Most of the authors of the analysed definitions pointed to the ambiguity of the concept of "logistics costs".

The analysis presented and inference allow to confirm the methodological assumptions made in the introduction regarding the optimization of logistics costs at the examined transport company.

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