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INFLUENCE OF COSTS ON THE OPTIMIZATION OF TRANSPORT ROUTES (CASE STUDY) – PASSENGER TRANSPORTATION COMPANY FROM ZAGREB

Abstract

Small and medium-sized road transport companies located in Croatia are faced with strong competition on the transport and logistics market. The problem of cost management in road transport enterprises is one of the most crucial ones for their efficient functioning. Enterprises operating on the market are very different, so it is important to analyse their cost structure in relation to their organization. To improve the system and reduce transport costs, a multi-level full cost allocation model has been set up and is analysed in this paper. The authors give an overview of the research results on the costs structure of a road transport company from Zagreb and present their components and differences. The authors establish and present the differences in the cost structure and the impact of costs on the optimization of transport routes and logistics management.

Keywords: Costs, transportation, optimization, logistics

1. Introduction

With the development of globalization and information technology there has been significant development of logistics. The development itself increases the importance of transport logistics, whose task is the quality management and planning of physical processes of goods and passengers moving from the beginning to the end point on the transport network. The transport network has an important function in the transport logistics business because it is transported between the starting and end points. This paper will analyse the optimization of the transport network, its costs and the ways it is used to maximize the efficiency of transport logistics. The first part of the paper involves defining the tasks of transport logistics as one of the primary problems in companies. Then the analysis of transport logistics of Croatia Bus Ltd. Zagreb will be carried out, which deals with the transport of passengers in internal and international traffic.

The Croatian transport market is mostly used by direct distribution, which shows the progress and the need to increase competitiveness. Also, direct distribution will be explained in more detail in order to better understand the need for a more quality transport network that would contribute to the achievement of the company's goals. The transport network and route planning are key items in all distribution companies. A well-planned route can contribute to the company's profitability, but also to its reduction if important cost parameters for certain transport routes have been overlooked. It is necessary to look at, and pay attention to, all parameters and possible costs when planning the transport network or its routes. Some of these parameters will be clarified and analysed in order to understand their importance. The focus of this paper is the proposal of optimization measures that will enable the creation of sustainable linear transport of people. Optimization measures will relate to technical, organizational and economic optimization. By applying these measures, the state of the linear passenger transport will change to a better one, which will result in greater capacity utilization of the buses offered by the carrier.

2. Analysis of costs in transport and planning transport routes

Company profitability greatly depends on logistics costs as they make up a significant part of the total operating costs. The share of logistical costs in the planning and realization of transport routes and distribution chains in the total costs differs from company to company and ranges from 15% to 25%. Logistics costs, on average, account for 8% of the company's total revenue, while some research shows that the structure of total logistics costs is: transport 45%, maintenance 25%, other costs 20% and administrative costs 10%, which does not have to be a rule for every business. A lot of these do not represent strategically important functions on which an organization's competitive advantage is founded, but are key to operational and profitable business operations. The costs for logistic functions are much more significant than in the manufacturing industry. Because of high costs, companies have begun to seek savings in developing their own logistics systems. Below will be mentioned some terms that affect the cost of transport logistics (Kolaković, 2005):

1. Economics - Development of logistics entities significantly reduces the need to retain their own logistics operations in transport companies. Based on volume economics, only the largest retailers on the market manage to reduce costs and compete at low prices. Due to small quantities and a large number of delivery points, it can be concluded that it is cheaper and simpler to find a reliable logistics partner who will provide a quality and complete logistics service.

2. Costs of lines - Most business entities in the calculation of logistics services do not count all costs of lines. Mainly fuel costs, tolls, and net payrolls are the most important items of transport, as well as all forms of vehicle maintenance. For example, depreciation of buses, registration, insurance, maintenance of transport equipment and direct transport costs (fuel, all travel costs, etc.).

3. Volume economies - Volume economies play a key role in achieving efficiency in logistics and ultimately the profitability of the company. Due to the large number of delivery points, a high number of vehicles is needed to ensure the quality and accuracy of the transport service. Usually, because of the large number of delivery destinations and the specific shape of Croatia, companies have a large number of vehicles, and low utilization. It is very easy to lose focus with the main goal being the creation of profitable logistics. For example, buses drive the passengers in one direction, return empty and insufficiently fill the route. Transport management includes management of delivery units, planning of incoming and outgoing embarkation, planning and optimization of embarkation and disembarkation, vehicle maintenance, worker/driver planning, and planning of required documentation, especially when it comes to international transport (Bukljaš et al., 2011).

Some examples of cost management include:

- Amortization of logistics infrastructure and supply chain, which includes office space, accessories and support (MOR - Maintenance, Repair and Operations),
- Logistics costs and supply chain management and planning of transport routes,
- Wages, including daily allowances for transport managers and transport workers,
- Specialized training and continuous learning activities.

2.1 Types of transport costs

Costs in companies represent a constant burden that they continually strive to minimize. The economies of volume result in better prices for users, namely better or lower prices resulting in higher demand. However, it is essential to sum up all the costs incurred when determining the sales price of the transport service. It is necessary to know the structure of the overall price so that it is possible to make decisions during negotiations with new and existing customers. Understanding the cost structure is necessary to calculate the cost of transport services and enable effective control as changes in the costs directly affect the profitability of the company (Šamanović, 1999).

There are various categories of costs that need to be considered:

1. Fixed costs

- Insurance of vehicles and goods
- Vehicle registration
- Vehicle maintenance costs
- Fixed salary
- Rental and energy costs
- Amortization of the means of transport

2. Variable costs

- Fuel costs
- Tires
- Lubricants
- Variable part of salary

3. Direct costs

- Tolls
- Tunnels
- Costs of the customs procedure
- Inspection costs.

Fixed costs are the costs that exist regardless of the movement of the vehicle. They are expressed by time, e.g. per hour or per day. Variable costs are the costs incurred when the vehicle is moving. They are expressed by distance (km). According to their characteristics direct costs also belong to variable costs that depend directly on the itinerary on which the vehicle is moving. The approach to pricing for a particular route can include price calculation for the whole route or A-B-C-A, or price calculation for the A-B route. Below, the characteristics of both approaches will be explained in detail (Zelenika, Pupovac, 2008).

1. Calculation of the price for the whole route A-B-C-A - Based on real indicators for each leg within the entire route, it burdens all customers at real costs, and allows the possibility to compensate profitability between individual legs of transport to make the entire route profitable. Calculation is not always possible because at the moment the calculation is done, the routing officer does not know how to close the route. This is used for major key buyers and for routes to be repeated.

2. Calculation of the price for the A-B route - Based on the planned exploitation indicators, real kilometres are increased by 20% to ensure that the enterprise plan is realised by 83% of kilometres.

A faster and simpler calculation - The route will be profitable if the company has a utilization plan. In the total number of kilometres spent per bus and the share of empty kilometres, all customers are equally burdened with planned empty kilometres and scheduled time of waiting.

When planning the transport routes or meeting passenger needs, several key points need to be addressed when answering the request for a transport service:

1. Define the route of the vehicle from the place of loading to the place of unloading

a) Increase kilometres by 20% relative to the required ratio

b) Provide the entire transport circuit (from garage to garage)

2. Define transit time

a) Estimate the vehicle's turnaround time (both for the required distance and for the entire transport circuit)

b) Consider the legal elements of mobile staff work

3. Include all costs on the transport route

a) Fuel prices – depending on the VAT in a particular country

b) Toll charges

c) Direct travel costs (FITO, Veterinary, Export Customs ...)

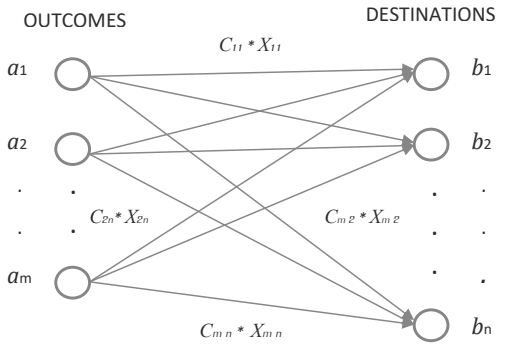
4. Enter the data in the calculation template

5. Compare the profits with the plan

3. Transport problem

By solving transport problems on the transport network, the optimal way of transporting between the larger supply centres and demand centres is obtained. The supply centre has its own capacity, and the centre of demand is the level of demand. The supply centre may, for example, be a specific distributor, and the demand centre may be the end-user, i.e. customer. Transport routes between these centres or nodes have different unit costs of transport, and by solving this problem, they want to choose the best quality solution for transport between nodes. In order to optimize the solution, the following two conditions must be met: the first requirement is that the demand within the network must be met, and the second requirement is to do so with minimum transport costs. When determining the optimal solution to a transport problem without application of software tools, the initial solution must first be found and then optimally determined. Methods such as the Northwest corner method, the least cost method, and Vogel's approximation method are used to determine the initial solution. Determining the optimal solution is carried out by applying a relative cost method or a stepping stone method (Carić, 2014).

Figure 1 Schematic representation of a transport problem



Source: Carić (2014)

Figure 1 shows the transport problem schema, transport between the different starting points (*am*) and the destination (*bn*), where C*ij* denotes the unit cost from the starting point (*i*) to the destination (*j)* and X*ij* the transported quantity from the starting point (*i*) to the destination (*j*). In addition to the application in transport between the two transport nodes, the transport problem is applied in the case of multiple capacity locations. The multiple locations represent the problem of finding the most convenient locations for a larger number of different capacity centres that can be accommodated on a larger number of locations. As with transport between nodes, a solution is required that will give the least transport costs. The problem is solved by accommodating an appropriate transport problem for each possible combination of accommodation centres in a group of possible locations, ultimately making for each such combination an optimal transport solution for which the value of total transport costs is minimal. A comparison of optimal solutions of different combinations of accommodation centres to a group of possible locations provides the location that is most convenient with regard to transportation costs.

In order to write the shortest mathematical problem, it is first necessary to set up a network that is intended to send a certain quantity of goods from node 1 to node *m* at the lowest expense. *b1* = 1, *bm* = -1, b*i* = 0 for and *i* ≠ 1 or *m*. Then the mathematical model reads:

Setting up a mathematical model:

- c_{ij} – cost of transporting from the starting point *i* to the destination *j*
- x_{ij} – the number of passengers to be transported from the starting point *i* to the destination *j*
- k – the shortest way (or route)

Function:

- $\min F = \sum_{i=1}^{m} \sum_{j=1}^{m} cij\ xij$ (1)

Limitations:

- $\sum_{i=1}^{m} xij - \sum_{k=1}^{m} xki = 1$

if *i* = 1, 0 if *i* ≠ 1, or *m* = -1, if it is *i* = *m* (2)

- Xij ≥ 0, *i,j* =1,...,m (3)

The described model is elaborated in the case study for the transport company Croatia Bus Ltd., Zagreb. Given that the implementation of the central infor-

mation system and the exchange of essential traffic data among the operators creates a data base for processing, the purpose is to optimize its management of the fleet. Better utilization of vehicle capacity, reduced vehicle and driver organization time, and faster vehicle re-routing should lead to a significant reduction in the overall transport cost.

The allocation of indirect costs goes from the highest level to the lower levels of the calculation hierarchy. The calculation is finished as soon as all indirect costs have been allocated to the profit objects. Here, the performance-independent fixed indirect cost items are not included into the multi-level indirect cost allocation. So the costs of a cost centre can be divided into fixed and variable parts, and at the same time variable costs can be divided into assigned primary and allocated secondary parts (Kaukler, 2011):

$$\mathbf{C_t = C_{ft} + C_{vt} = C_{ft} + C_{vt(p)} + C_{vt(s)}} \quad (4)$$

where:

C_t – cost of cost centre (company)
C_{ft} – fixed cost of cost centre
C_{vt} – variable cost of cost centre
$C_{vt(p)}$- variable primary cost of cost centre
$C_{vt(s)}$- variable secondary cost of cost centre

The variable secondary cost is the sum of allocated variable cost items coming from the serving cost centres on the basis of relative performance consumption. So the cost of a cost centre can be calculated as follows:

$$\mathbf{Ct} = C_{ft} + C_{vt(p)} + \sum_{i=1}^{n} \left(C_{vi} \frac{P_{ki}}{P_i} \right) \quad (5)$$

where:

C_{vi}- variable cost of service cost centre
P_i- performance of service cost centre
P_{ki}- performance consumption of cost centre

When using the traditional costing approach, the average fixed cost values and average cost values are elaborated at company level. The aggregate fixed cost of the company is averaged by time while the aggregate variable cost is averaged by transport performance. Having the generalised average cost values, the cost of a profit object can be calculated trough multiplying these values by the time consumption and by the transport performance.

$$C_j = C_{j(d)} + \frac{T_j}{\sum_{j=1}^{m} T_j} \sum_{k=1}^{n} C_{ft} + \sum_{i=1}^{n} C_{vi} \frac{P_{ji}}{P_i} \quad (6)$$

where:

P_{ji} - performance consumption on profit object
T_j - duration or transport service time of profit object

$$\mathbf{C_J} = \frac{\mathbf{C_{ft}}}{\sum_{j=1}^{m} \mathbf{T_j}} \mathbf{T_j} + \frac{\mathbf{C_{vt}}}{\sum_{j=1}^{m} \mathbf{D_j}} \mathbf{D_j} + \mathbf{C_{j(t)}} \quad (7)$$

where:

D_j – transport performance of profit object
$C_{j(t)}$ – dedicated cost of profit object

4. *Analysis of the transport network of Croatia Bus Ltd. Zagreb for the Region of Dalmatia*

Croatia Bus Ltd., Zagreb is engaged in linear transportation of domestic and international passengers. The fleet consists of 64 buses of an average age of 11.3 years. The company has been investing continuously in the renovation and modernization of the fleet in recent years. Croatia Bus Ltd., in order to increase the quality and maintenance of the vehicles, has invested in the modernization of the state-of-the-art garage space. Carriage services are performed on a daily basis on several lines (17 domestic and 6 international). The company currently has 154 employees who take care of safety, quality and maintenance, as well as organization and planning of the transport network on a daily basis. They continue to work for the purpose of improving and modernizing their means of transport as well as planning their transport routes. The next part of this paper will analyse the company's transport network in detail. The paper will focus more on the analysis of the distribution and transport network in the long-distance distribution of passengers for the region of Dalmatia. Passenger distribution and prioritization are performed by analysing the needs of previous years, according to predefined lines and the transport network. The company uses its own Garage Service Centre in Zagreb, and departures for all destinations are from the Zagreb Bus Station. Every day, distribution is done according to a certain location, and pre-planned route. In order to shorten travel time, the main factor in the transport route is the motorway connecting Zagreb with the final destination. The number of passengers being distributed depends primarily on the demand at a particular location, but regardless of the demand that can oscillate or be variable in certain cities, the transport plan does not change. Geographic Infor-

mation Systems (GIS) are used for presentations, and analysis of distribution and storage of spatial data, for the purpose of simpler and more efficient business planning, management and realization of the transport network in logistics (Bowersox et al., 2010).

5. Calculating model of the transport problem for Croatia Bus Ltd. (Region of Dalmatia)

Taking into account one starting point or the Bus Station in Zagreb and four destination locations, the cost of the trip will be analysed, which will be based solely on the distance parameter as the only route planning criterion. Although it is necessary to take into account a variety of parameters, such as vehicle capacity, demand, travel time, and in the case of route planning, in this case only the distance criterion (km) between the bus station in Zagreb and certain destination points will be used. It should be noted that all these parameters are equally important when planning the route and each individual needs to do a kind of analysis so that cost optimization or route planning is at an appropriate level of efficiency and reduces the cost of the results to get the best solution. In the next part of the paper, only one criterion, distance (km) will be analysed, and towns by distance will split the route into a satisfactory criterion of the shortest route or the time of travel, and the type of problem will be the passenger problem. The problem of route determination will be divided into Transport Problem (TP1), Problem (TP2), Problem (TP3) and Problem (TP4), and will be conducted in this way through the analysis.

In order to demonstrate the benefits of implementing the information system and optimizing the entire transport process, the actual data was used and entered in the algorithm. Input data is taken for Croatia Bus Ltd., Zagreb, a transport company engaged in the carriage of domestic and international passengers. The company currently has 64 units (vehicles) and 154 drivers. Technological management includes 18 persons (administration) and 9 persons (technical service of the company). In transport management, there are 6 road users, 3 controllers and 6 persons in charge of the retail and sales segment of tickets, a total of 15 persons.

Table 1 Costs structure of costs centres and profit objects

CALCULATION OBJECT	PRIMARY INPUT COSTS	DRIVER COSTS	
		INDICATOR	DIMENSION
CENTRAL MANAGEMENT(CM)	all cost items which cannot be connected to cost of the other objects	-------	------
TECHNOLOGY MANAGEMENT (TE)	semi-fixed: personnel costs	Working time (wt)	Man/hour
TRANSPORT MANAGEMENT (TR)	semi-fixed: personnel costs	Working time (wt)	Man/hour
MAINTENANCE (MA)	fixed: depreciation semi-fixed: personnel costs variable: material costs	Maintenance time (mt)	Man/hour
VEHICLE (VE)	semi-fixed: leasing costs, depreciation (own vehicles), insurances and taxes variable: material costs including outsourced maintenance	Vehicle running (vr)	Kilometre
DRIVER (DR)	semi-fixed: wage-related personnel costs variable: bonus or performance related personnel costs	Working time (wt)	Man/hour
TRANSPORT SERVICE (TS)	direct costs: dedicated (tolls charges, etc...) fuel costs (where appropriate)	-------	-------

Source: Bokor (2012)

The percentage of vehicles owned by the company is 90%. They fall into the group of material fixed costs, while the other percentage is part of the operational leasing and becomes part of the material variable costs of the company. Vehicle maintenance belongs to material variable costs as well as depreciation

costs, because the company owns a dedicated service centre which is an integral part of the business. In addition to the basic fixed salary, drivers are paid daily allowances per kilometre covered and per turnover of a particular route, which is a variable cost.

Now that all business costs are characterized and all relevant data are available, a cost algorithm of the transport process can be set and the use of company fleet can be optimized. In the future, information provided to passengers ahead of and during the journey will determine their choice of the trip and the operator. By establishing an IT system the technology and transport management will be better able to decide on vehicle usage, capacity utilization, cost reduction and handling time, ultimately leading to financial savings, increasing company competitiveness and facilitating business operations in any other sense. According to the above data, costs can be calculated on a monthly, quarterly and annual basis, depending on the company's business growth projection. The final set-up and cost calculation algorithm would be the following (Bokur, Markovits-Somogy, 2015):

$$C_j = C_{j(d)} + \frac{T_j}{\sum_{j=1}^{m} T_j}\left(C_{CM} + C_{(f)MA}\right) + \frac{Wt_{jDRy}}{Wt_{DRY}}\left(C_{DRY} + C_{TE}\frac{Wt_{DRyTE}}{Wt_{TE}}\right) + \frac{Vr_{jVEx}}{Vr_{VEx}}\left(C_{VEx} + \frac{mt_{VExMA}}{mt_{MA}}\left(C_{VMA} + C_{TE}\frac{Wt_{MA,TE}}{Wt_{TE}}\right) + C_{TE}\frac{Wt_{VExTE}}{Wt_{TE}}\right) + C_{TR}\frac{Wt_{jTR}}{Wt_{TR}} \quad (8)$$

Table 2 Input data from the original data collection mechanism

	TP1	TP2	TP3	TP4
CM	**Total costs (fixed):**17,257 kn			
VE (entire fleet)	**Tax & insurance (semi-fixed):** 1,120 kn **Driver wages (semi-fixed):** 1,690 kn **Material costs (variable):** 1,475 kn **Fuel (variable):** 10,190 kn **Infra. user charg. (variable):** 2,782 kn			
	Total km run: 3,222 km			
VE 1	Tax & insurance: 280 kn Driver wages: 245 kn Material costs: 290 kn Fuel:1,300 kn Infra. user: 340 kn	----------	----------	----------
	Total km run: 418			
VE 2	----------	Tax & insurance:280 kn Driver wages: 270 kn Material costs: 345 kn Fuel:1,890 kn Infra. user : 542 kn	----------	----------
		Total km run: 584		
VE 3	----------	----------	Tax & insurance:280 kn Driver wages:375 kn Material costs:400 kn Fuel:3,100 kn Infra. user:800 kn	----------
			Total km run: 940	
VE 4	---------	----------	---------	Tax & insurance:280 Driver wages: 800 kn Material costs:440 Fuel:3,900 kn Infra. user:1,100 kn
				Total km run: 1,280
distance	209 km	292 km	470 km	640 km
duration	**total duration of services:** 51 h			
	7 h	10 h	14 h	20 h

Source: Croatia Bus Ltd., Zagreb (internal data)

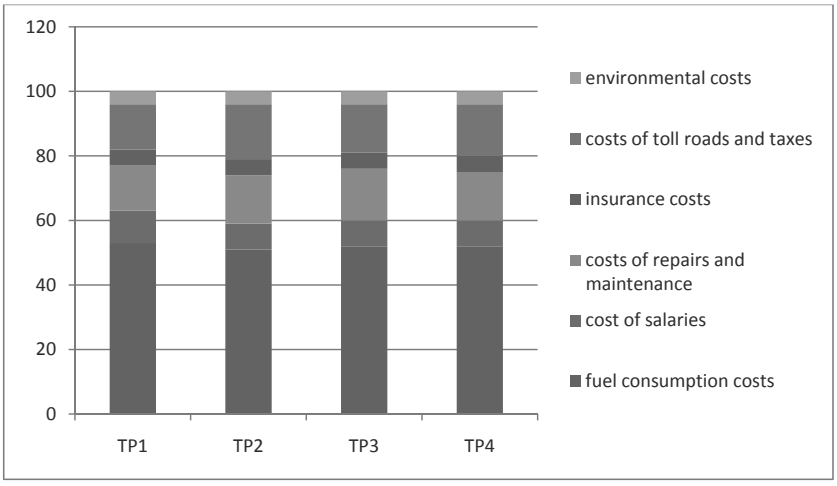
Table 3 Cost calculation results in HRK, based on the original data collection mechanism

EQUATION	Tr. service 1	Tr. service 2	Tr. service 3	Tr. service 4
(5)	2,490	3,296	4,865	6,626
(6)	2,447	3,370	4,997	6,510
(7)	2,578	3,471	4,826	6,691
(8)	2,402	3,411	5,088	6,573

Source: Croatia Bus Ltd., Zagreb (internal data)

Figure 2 shows the transport cost structure for individual lines for the region of Dalmatia shown for each item, especially expressed in percentages of the total cost. The research showed that the costs were proportional to the length of the transport line. By further analysis of the data it was determined that the total cost of bus transportation is about 6.5 HRK per kilometre of the line and that it varies more on average to 10 % depending on the influence of external factors which cannot be detected and controlled in a timely manner. By comparing the cost structure of other companies involved in the carriage of passengers, the deviations are minimal and dependent on the efficiency of the transport management that manages the fleet.

Figure 2 Transport cost structure for individual lines in [%]



Source: Authors' elaboration

6. Conclusion

Transport network planning is one of the most important tasks in a company that requires enough time and quality analysis to determine ways to reduce costs and increase efficiency. By developing information and computing technologies, the importance and use of software tools is increased in order to better utilize the transport network, as well as to optimize the entire logistic and traffic system. The increasing importance and use of software tools and solutions is characteristic for all activities, not just traffic. By optimizing and cost-cutting, despite the limitation of data disclosure, it should be said that using this analysis and cost calculation for the company Croatia Bus Ltd. Zagreb on a daily basis has achieved financial savings of 2.7% of total expenditures for these routes. Route planning is a complex process that needs to be thoroughly analysed to see possible weak points and to detect their causes and how to remove or minimize costs or find a solution. Further analysis of other parameters affecting the efficiency of transport routes can lead to a solution that could significantly reduce distribution costs and increase the company's profitability.

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Utjecaj troškova na optimizaciju transportnih ruta (case study) - Tvrtka za prijevoz putnika iz Zagreba

Sažetak

Male i srednje tvrtke za cestovni prijevoz putnika sa sjedištem u Republici Hrvatskoj suočene su s jakom konkurencijom na tržištu prijevoza i logistike. Problem upravljanja troškovima u cestovnim prijevoznim tvrtkama jedan je od najvažnijih za njihovo učinkovito poslovanje. Tvrtke koje djeluju na tržištu vrlo su različite pa je važno analizirati njihovu strukturu troškova u odnosu na njihovu organizaciju. Kako bi se unaprijedio sustav i kako bi se smanjili troškovi transporta, ovaj višestupanjski model troškova, postavljen je i analiziran u ovom radu. Autori daju pregled rezultata istraživanja o strukturi troškova cestovnoga prijevozničkog poduzeća iz Zagreba i predstavlja njihove sastavnice i razlike. Autori utvrđuju i prezentiraju razlike u strukturi troškova i utjecaju troškova na optimizaciju prometnih pravaca i logističko upravljanje prijevozničkog poduzeća.

Ključne riječi: troškovi, prijevoz, optimizacija, logistika