UNIVERSITY OF PARDUBICE

FACULTY OF TRANSPORT ENGINEERING

CALCULATION OF LOGISTICS COSTS OF WAREHOUSING

DOCTORAL THESIS PRECIS

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Doctoral study programme

P3710 Technique and Technology in Transport and Communications

Field of study

3708V024 Technology and Management in Transport and Telecommunications

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Doctoral thesis has arisen at the supervising

Department of Transport Management, Marketing and Logistics

CONTENT

1 INTRODUCTION

Logistics costs are the link between the economy and the company's logistics. Rosová (2007) mentions that with the growing division of labour, the share of logistics costs increases in the company's total costs. Almost all product and production decisions affect logistics processes in some way and thus more or less affect logistics performance and costs.

Heskett, Glaskowsky and Ivie (1973) identified transport, warehousing, supply, and administration as activities that affect logistics costs, but it is currently unclear which cost components are included in logistics costs because a number of logistics cost items are reported within overheads together with other business expenses.

An essential step in the process of monitoring and evaluating logistics costs is the definition of business processes, the costs of which will be included in logistics costs and their assignment to cost objects for decision-making tasks (orders, services, departments, processes, etc.). After determining the relevant processes, it is necessary to select suitable quantities for the expression of logistics performance, resp. logistics services corresponding to these costs, because from the point of view of management, indicators expressing the relationship between costs and outputs are more important for the company (e.g. the share of logistics costs per unit of output). The specific conditions of the company must be carefully considered when designing and recording logistics services and costs, as the scope of the processes involved strongly influences the size of the reported logistics costs and their share in the company's total costs. The problem is also the significant problem for logistics service providers.

Gros, Barančík and Čujan (2016) appeal that the provided logistics services must be a source of value not only for the end customer, but for all interested stakeholders. A necessary prerequisite for evaluating the effectiveness of all activities is the monitoring of costs in the entire supply system, including logistics service providers.

As Richards and Grinsted (2013 and 2016) state, warehousing, as an integral part of the logistics system, is a dynamic and interactive activity that focuses on the level needed to meet demand. When providing logistics services, it is important to make efficient use of both time and warehouse or local space. According to Accorsi, Manzini and Bortolini (2012) and Accorsi, Manzini and Maranesi (2014) the emphasis should be on planning all warehousing activities, including receiving, warehousing, assembling, kitting, picking and sending orders from customers; warehouses make it possible to unify, distribute bulk costs of goods, translate and complete partial shipments (cross-docking) and provide value-added services.

The concept of logistics costs is defined by many authors. According to Straka and Malindžák (2005) logistics costs are expressed as the sum of all costs associated with the implementation of logistics processes. These costs are associated with the implementation of material flows, mostly costs related to transport, warehousing, financial security, insurance and information flows. According to Bazala et al. (2006) logistics costs can be understood as the sum of all costs associated with the organization, control and actual implementation of the logistics process, within all links in the supply chain. Pražská and Jindra (2002) divide logistics costs into the same groups as Schulte (1994); the authors agree on the definition of logistics costs: these are supply costs, warehousing costs, transport costs and handling costs.

Within the structure of the doctoral thesis, the topic of calculation of logistics costs of warehousing will be divided into five sub-chapters. The first chapter will be based on a literature search, which will use scientific resources focused on the issue of the thesis. The second chapter will define the main goal and sub-goals. The third chapter will contain an overview of scientific methods that will be used to meet the defined goal. The fourth chapter will have its results. The last fifth chapter will evaluate and discuss the results obtained in the doctoral thesis.

2 CURRENT STATE OF THE ART

The second chapter is focused on the analysis of the current state of the existing knowledge and the critical evaluation of the analysis of the current state is performed.

2.1 Analysis of the current situation of the existing knowledge

Cojocariu (2012) and Janatka et al. (2017) emphasize that logistics is an important factor in promoting globalization and developing international trade flows. Bokor (2011, 2012a, 2012b) points out that logistics has become one of the main factors determining the competitiveness of the economy. As stated by Richardson (1995) and later emphasized by Gilmore (2002), logistics affects a large part of corporate assets, has a direct impact on cash flow and creates added value for the customer.

Bokor (2008 and 2009) states that the requirements for the quality of logistics services are getting higher and higher. At the same time, however, the financial resources available to companies are quite limited. In such a business environment, according to Bokor (2013), logistics companies must pay special attention to the optimal allocation of resources

in various decision-making tasks. Feng et al. (2007) and Tu and Wang (2011) find that finding effective methods in the process of calculating corporate logistics costs is very difficult today, but it is a current topic in the field of logistics cost management.

Yuqin (2007) and Yin (2007) present that through the cost management process, costs can be effectively reduced, and resources allocated efficiently. The goal of logistics cost management is to reduce costs and increase the competitiveness of logistics service providers.

Much of the logistics tasks are performed by logistics service providers; these companies play a key role in running more efficient and effective selected industries. Therefore, their operation must be sufficiently efficient, which means that logistics service providers must be aware of the main operational factors of logistics processes. These processes should be monitored and evaluated through management information systems. Pernica et al. (2005 and 2008) consider logistics service providers as specialized companies involved in logistics chains, usually either supply or distribution parts of chains, as external partners, most often to producers of tangible products to which they provide individual services.

Bokor (2009) points out that the calculation of logistics costs has become a real challenge in the field of logistics and supply chain management. Bokor and Markovits-Somogyi (2015) state that it is necessary to obtain reliable and accurate information on the structure of the calculations in order to achieve an efficient allocation of resources within the logistics service provider. Traditional calculation approaches may not be sufficient to achieve this goal in the case of complex and heterogeneous logistics service structures. It is very important to know the real costs of services as well as the cost-effectiveness of the activities contributing to the production of services. This information is needed to assess profitability and to price services. Bokor (2012c) and Bokor and Markovits-Somogyi (2015) argue that traditional calculation methods are not always able to provide the information necessary to support decision-making in the required quality. They can even disrupt the cost calculations of the logistics services, so there is a need to implement appropriate cost calculation methods that improve the accuracy and reliability of the data obtained. According to Bokor and Markovits-Somogyi (2015) one of the applicable methods is activity-based costing.

2.2 Critical evaluation of existing knowledge in the field of doctoral thesis

From the analysis of the current state of the problem, it is clear that the calculation of logistics costs is given attention and companies are aware of the importance and severity

of this problem. Many authors report that controlling logistics costs has become increasingly important in recent decades for companies seeking a competitive advantage. Furthermore, it is clear that there is an effort to create pilot projects (case studies) that deal with the calculation of logistics costs, but it is only an application to a specific problem without a broader context. At the same time, many companies consider the reduction of logistics costs to be an important area of their business, see e.g. Bednarčík (2007). It can be stated that the authors often differ in the structure of logistics costs and logistics costs of warehousing, as well as in estimates of their share in total costs. According to various authors, the amount of logistics costs ranges from 10% to 30% of the company's total costs. The authors classify logistics costs according to various aspects. Rosová (2011) divides logistics costs into: costs according to the continuity of processes in the logistics chain and costs according to the efficiency of the flow. Many authors state that in logistics, managers face the need to distinguish between logistics fixed and variable costs. According to other authors, it is possible to look at logistics costs in terms of logistics activities, which are described in more detail in the analysis of the current situation. The set of logistics activities consists of the so-called logistics system and the individual subsystems of the logistics system represent a relatively independent economic activity interconnected with other activities. The implementation of logistics activities requires resources and thus incurs logistics costs, which Gros (1996) divided into four groups: costs associated with the implementation of logistics activities, costs associated with tying up capital resources in stocks, financial logistics costs and losses related to logistics activities. The analysis of the current situation focused on warehousing costs in more detail, as these are a significant component of logistics costs. Kazimírová and Kazimír (2015) claim that warehousing costs and inventory costs represent approximately 36% of logistics costs. The authors agree that warehousing costs can cover the entire cycle of warehousing activities. The individual activities are described in more detail in the analysis of the current situation. The analysis of the current situation showed that in order to solve different decision-making tasks, logistics costs and warehousing costs need to be classified differently in accordance with the breakdown of costs to support decision-making, both within individual companies and logistics service providers, and within the supply chains. Furthermore, the analysis of the current situation paid attention to the allocation of costs to the subject of calculation. The authors agree that the purpose of costs allocation is to provide information on costs that are relevant to a particular decision. From the point of view of logistics service providers, the calculation of logistics costs of warehousing is an effort to obtain detailed information on the cost intensity of individual

logistics activities or services that they provide to their customers. Many authors state that traditional calculation methods are not always able to provide sufficient information to support decision-making. The authors agree that the traditional cost methods used by many companies do not usually provide the data in the form needed to make right warehousing decisions. Graham (2003), for example, argues that it is necessary to provide information to support pricing, to identify potential cost reduction targets in order to adequately assess new technology investment and focus on the overall management of all assets. According to many authors, activity-based costing is therefore a suitable calculation method. Several case studies have already been published in this area. Some case studies have shown that activity-based costing is a useful tool for managing operating costs. The authors also point out some of the disadvantages that activity-based costing can bring. It is especially difficult to define activities. The activity-based costing method is based on monitoring various specific parameters that require additional funds. The last part of the analysis of the current situation was devoted to the theory of systems and the stages of the decision-making process. The authors agree that it is appropriate to focus on a systematic decision-making process; systems can be understood and described in terms of systems theory as diverse fields and models. Based on the analysis of the current situation, it was found that the issue of calculating of the logistics costs of warehousing is not systematically addressed.

3 GOAL OF THE DOCTORAL THESIS

The main goal of the doctoral thesis will be to create the calculation system of logistics costs of warehousing at the logistics service provider. To fulfil the main goal of the doctoral thesis, it is necessary to meet the following sub-goals:

- Analyse and evaluate the current state of affairs using a literature search.
- Identify and specify existing approaches to calculations of logistics cost of warehousing for logistics service providers.
- Define decision-making tasks, to support which the calculation system will be used in the case of logistics service providers.
- Characterize the individual elements of the calculation system and define their common features and differences.
- Design the method of activity-based costing in the calculation of logistics costs of warehousing within the calculation system for the needs of logistics service providers and further:

  - identify the subject of calculation (calculation unit and calculated quantity) of logistics costs of warehousing,
  - determine the method of allocating the costs of the subject of calculation,
  - define the cost structure in the individual calculations that make up the calculation system.
- Present the proposed calculation system on the case studies in the conditions of selected logistics service providers.
- Apply the case-based reasoning method to the case study in the conditions of selected logistics service provider.

4 PROCESSING METHODS

The scientific methods theoretically defined in this chapter are used in the elaboration of the doctoral thesis.

Zhao, Ma and Wang (2006) argue that logistics deals with quantitative management, which must highlight bottlenecks in material flow. Logistics and especially warehousing cannot be done without the ability to use many methods, especially according to Sixta and Žižka (2009) these methods are:

- exact,
- heuristic.

It is also necessary to use logical methods in the elaboration of the doctoral thesis. These are mainly methods such as analysis, synthesis and comparison.

Janok et al. (1996) consider that calculation in the broadest sense is a set of procedures and methods by which the means necessary to achieve a specific economic goal of market entities (enterprises) are determined and calculated. The calculation methods are diverse and very differentiated, depending on the purpose of the calculations.

The methods of qualitative research are also used in the doctoral thesis, specifically expert interviews will be conducted, brainstorming methods and the Delphi method will be used, as well as case studies.

The case-based reasoning method is based on the principle of analogy. Watson (1997) states that the method of case-based reasoning brings a different approach to the decision-making process, which is based on problem solving and human decision-making. The source of knowledge is not a set of rules, but a set of events stored in memory.

5 RESULTS

Based on the facts already described in the analysis of the current state in the topic of the doctoral thesis (chapter 2), it can be stated that the area of calculations of logistics costs of warehousing is theoretically developed but not systematically addressed, either at the level of individual companies or logistics service providers. Thanks to this, it is necessary to focus on the calculation system of logistics costs of warehousing at logistics service providers. Figure 1 shows a proposal for a new system concept of calculating logistics costs of warehousing, which should take place as a basic step in the approach to the calculation of logistics costs of warehousing at the logistics service provider.

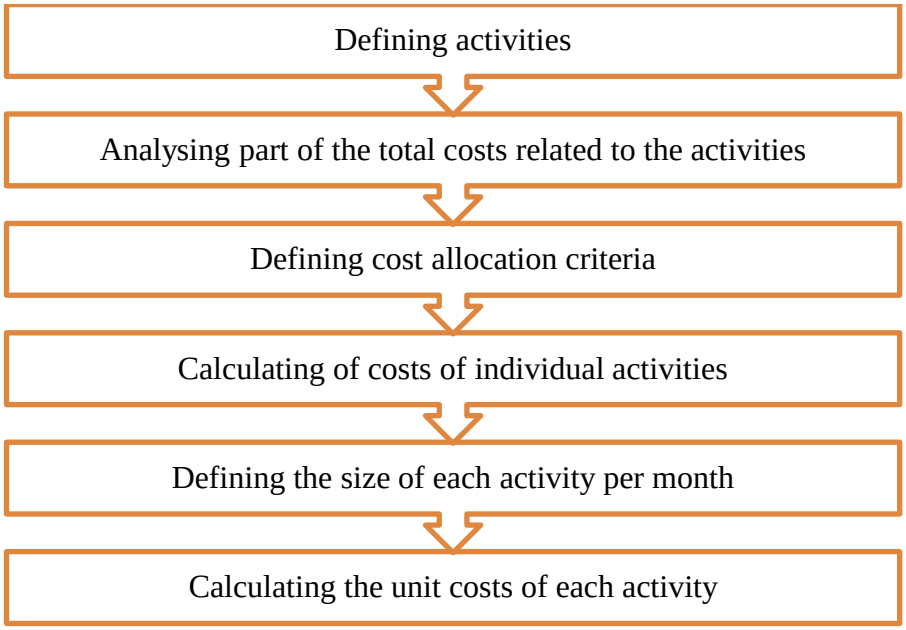

Figure 1 System concept of calculating logistics costs of warehousing (author)

5.1 Case study number one

The practical application of activity-based costing is shown in Table 1 as a calculation of logistics costs of warehousing in the automotive industry at the specific logistics service provider. The application points to the positive and negative use of this method in a practical case study, which is one of the main qualitative scientific methods. The selected logistics service provider in the automotive industry provides transport services to a large number of customers. In addition to transport, it provides other logistics services. The services offered in logistics are:

- internal logistics (warehousing and delivery of assemblies),
- receipt of goods and dispatch,
- warehousing and supply of production plants,

- repacking, picking and packing, material sorting,
- serial and data messages,
- picking, including kitting (i.e. assembling components into sets),
- sorting and inspection of all components,
- First in first out, Kanban,
- Just in time and Just in sequence delivery,
- cross-docking,
- light pre-production,
- packaging cleaning, handling and removal of empty packaging.

This is a trend towards the use of new approaches in calculations of logistics costs at logistics service providers with regard to the automotive industry in recent decades. The industry is one of the leading players in advanced economies. With a correct calculation of warehousing costs, a significant competitive advantage can arise. Logistics service providers monitor the appropriate use of innovative approaches and new calculation methods. As part of the calculations, the logistics service provider uses preliminary calculations from the entire computer system to support price decisions. Calculations of logistics costs always reflect the specific requirements of customers in the automotive industry. It is always a specific type and scope of service provided. Within the calculation of logistics costs of warehousing, the cost structure of the calculation is created, more in Table 1. The final calculation is always per one unit of measure (product, euro pallet). Logistics costs are precisely structured to meet the specific needs of automotive customers. All requirements and wishes of the customer for the required service must always be met.

The calculation of logistics costs of warehousing includes the following elements:

- area,
- racking system,
- energy,
- handling equipment,
- transport,
- warehouse staff,
- other costs,
- hardware and software.

Table 1 Calculation of logistics costs of warehousing in the automotive industry at the selected logistics service provider

Open book calculation				Budget/month	Budget/month
Contract: 5 years		€ exchange rate 26.50 CZK/€			
Subtotal numb. 1 – Area:				0 CZK	0 €
Racking system					
		leasing fee/month			
Racking system		0 CZK		0 CZK	0 €
Set-up racking system		0 CZK		0 CZK	0 €
Other (rack repair marking)		300 CZK		300 CZK	11 €
Subtotal numb. 2 – Racking system:				300 CZK	11 €
Subtotal numb. 3 – Energy:				0 CZK	0 €
Handling equipment: (rent, service fee, gas)					
Type		cost/unit/month	units		
Forklift	1.5 t (max. 3 500 MtH/year)	20 085 CZK	4 x	80 340 CZK	3 032 €
Forklift	2.5 t	25 956 CZK	1 x	25 956 CZK	979 €
Pallet truck	2 t	11 176 CZK	2 x	22 351 CZK	843 €
Order picker		6 526 CZK	1 x	6 526 CZK	246 €
Hand pallet truck		2 563 CZK	1 x	2 563 CZK	97 €
Other (gas forklift)		18 540 CZK	1 x	18 540 CZK	700 €
Subtotal numb. 4 – Handling equipment:				156 276 CZK	5 897 €
Transport					
Type		cost per unit/month	units		
Shuttle truck incl. drivers – fix costs		202 982 CZK	1 x	202 982 CZK	7 660 €
Shuttle truck incl. drivers – fix costs		205 632 CZK	2 x	411 264 CZK	15 519 €
Transport to more		1 314 CZK	2 x	2 628 CZK	99 €
Car		10 300 CZK	1 x	10 300 CZK	389 €
Subtotal numb. 5 – Transport:				627 174 CZK	23 667 €
Warehouse staff	3 shifts operation				
White collar	leader	72 650 CZK	1 x	72 650 CZK	2 742 €
White collar	administrator	43 136 CZK	6 x	258 817 CZK	9 767 €
Blue collar	warehouseman	37 347 CZK	17 x	634 897 CZK	23 958 €
		Total	24 x		
Provider employee insurance		121 CZK	24 x	2 892 CZK	109 €
Working protective equipment		288 CZK	24 x	6 922 CZK	261 €
Subtotal numb. 6 – Warehouse staff:				976 178 CZK	36 837 €
Insurance (material, liability, racking system)				2 900 CZK	109 €
Security				2 000 CZK	75 €
Facility management				17 000 CZK	642 €
(warehousing cleaning, road marking, rack and other inspections)					
Consumables (office equipment consumption)				15 000 CZK	566 €
Q - system (recertification)				2 500 CZK	94 €
Other (waste)				8 500 CZK	321 €
Subtotal numb. 7 – Other:				47 900 CZK	1 808 €
Hardware and software				45 000 CZK	1 698 €
Electronic data interchange				11 320 CZK	427 €
Phone, Internet connection				5 000 CZK	189 €
Other				10 000 CZK	377 €
Subtotal numb. 8 – Hardware and software:				71 320 CZK	2 691 €
Total costs				1 879 148 CZK	70 911 €
Overheads costs		2%		37 583 CZK	1 418 €
Subtotal + Overheads costs				1 916 731 CZK	72 329 €
Operation profit		6%		115 004 CZK	4 340 €
Total budget				2 031 735 CZK	76 669 €

Source: Kučera (2019) based on real company data

Area, energy and racking systems are negligible in this particular calculation of logistics costs of warehousing in the automotive industry. This is already a leased warehouse area equipped with a racking system, including all energy consumption.

The allocation of handling equipment costs is based on the customer's requirements for product warehousing and the necessary handling equipment for product handling. These are various types of forklift trucks, pallet trucks and other picking and hand pallet trucks. Transport costs are calculated per km for a specific vehicle, which is used for transport within the shuttle service. Furthermore, transport costs include a car, costs of other possible transports. The logistics service provider calculates the warehouse's personnel costs per employee in a specific order (white collars – administrators, blue collars – warehouse workers). The total personnel costs per employee are calculated. The costs include, in addition to labour costs, social costs, statutory insurance and liability insurance, protective work aids, training, contributions to cultural and sporting events and other bonuses (benefits) of logistics service providers. Other costs include insurance, security, facility management, consumables, recertification and waste costs. Other costs include unexpected costs, which may be costs associated with delays in the start of production or unexpected situations that may arise. Costs associated with information technology (hardware and software) are focused on equipping the warehouse with all information technology, electronic data interchange, telephone, internet connection and other costs related to information technology. The last part of the calculation of logistics costs of warehousing are overhead costs (2% of total costs), which include the costs of management, accounting, controlling, auditing and administration of passenger cars. The calculation also includes an operation profit of 6%.

5.2 Case study number two

In case study number two, the use of activity-based costing calculation can be highlighted as the calculation method for the logistics service provider with regard to cost management. The basic advantages of qualitative research are a detailed description and insight into the study of the issue, in addition it responds well to the local situation and conditions and can look for local causal links. The use of the activity-based costing method is presented on the real case study based on the processes used in the decision-making process of the particular logistics service provider. The selected logistics service provider provides transport services for many customers. In addition to transport, it also provides other logistics services, such as activities related to warehousing, receipt of goods, including its control, warehousing according to the customer's required systems or delivery of material and its transport directly to the customer's production lines. Based on the author's recommendation, the logistics service provider can use a new approach to the calculation of logistics costs of warehousing (the use of the activity-based costing method) in connection

with increased competition in the provision of logistics services. From the entire calculation system, the logistics service provider uses only preliminary calculations and within the calculations it serves to support price decisions (for price negotiations, for price defence, for deciding whether the logistics service provider is interested in accepting the order, either due to limited warehouse capacity or whether the requirement is interesting for logistics service providers). Calculations always take into account the customer's requirements (specific type and scope of service provided). There is a uniform cost structure in the calculation of logistics costs of warehousing (see Table 2). The calculation unit is always one product that the customer requests to stock. The costs in the calculation are structured to meet all customer requirements for the service provided. The calculation includes elements such as:

- personnel costs,
- handling equipment costs,
- transport costs,
- facilities costs (warehousing area),
- information technology costs,
- other costs,
- overtime costs.

The logistics service provider has monthly personnel costs calculated for employees in a specific job position. Costs include, in addition to labour costs, social costs, statutory insurance and liability insurance, protective work aids, training, contributions to cultural and sporting events and other company benefits. The allocation of handling equipment costs is based on the customer's requirements for product warehousing and the necessary handling equipment that needs to be handled with the product. The distribution of transport costs to order is based on the fact that the logistics service provider is assigned costs per km and number of kilometres travelled by different means of transport per month. The allocation of costs per warehouse area is based on the price per square meter and adequate warehouse equipment. Information technology (IT) costs are focused on label printing, printer operation, printer cartridge costs, IT connection costs, IT maintenance costs, and communication costs. Other costs comprise 100% external maintenance of the warehouse, and other costs include unexpected costs, which may be costs associated with delays in the start of production or unexpected situations that may arise. The allocation of other costs is based on floor tape

marking in the warehouse, an operational profit of 1% and a corporate profit of 10%, the last item being liability insurance.

Table 2 Calculation of logistics costs of warehousing and other logistics services

Volume of the Product 120000 / Year	Unit #	Unit €	Price/Month	Price/Year	Price/Product/Year
PERSONNEL COST					
Sequencing operators	1	6,50 €	3 978 €	47 736 €	0,398 €
Forklift truck drivers	1	7,20 €	4 406 €	52 877 €	0,441 €
Warehousing operators	1	6,10 €	3 733 €	44 798 €	0,373 €
Team leader	1	9,00 €	1 377 €	16 524 €	0,138 €
Social resources, Food vouchers	1	100,00 €	100 €	1 200 €	**0,010 €**
TOTAL PERSONNEL COST			**13 595 €**	**163 135 €**	**1,3595 €**
HANDLING EQUIPMENT					
Forklift rent/month	1	820,00 €	820 €	9 840 €	0,082 €
Others movement equipment	1	300,00 €	300 €	3 600 €	0,030 €
Maintenance - equipment	70%	1120,00 €	784,00 €	9 408,00 €	**0,078 €**
TOTAL HANDLING EQUIPMENT			**1 904 €**	**22 848 €**	**0,1904 €**
TRANSPORT					
Stuttle extern warehousing - (one day)	1	55,00 €	1 650 €	17 325 €	**0,144 €**
Truck drivers	1	8,00 €	4 896 €	58 752 €	**0,490 €**
Maintenance - transport - truck	8%	55,00 €	4,40 €	52,80 €	**0,000 €**
TOTAL TRANSPORT			**6 550 €**	**76 130 €**	**0,6344 €**
FACILITIES					
JIS Warehousing	2050 m2	2,70 €	5 535 €	66 420 €	**0,554 €**
Sequence area preparation	180 m2		486 €	5 832 €	**0,049 €**
Empty	450 m2		1 215 €	14 580 €	**0,122 €**
Full	250 m2		675 €	8 100 €	**0,068 €**
Office	120 m2	3,70 €	444 €	5 328 €	**0,044 €**
Building maintenance	-	40,00 €	40 €	480 €	**0,004 €**
Facilities cleaning	-	850,00 €	850 €	10 200 €	**0,085 €**
TOTAL FACILITIES			**9 245 €**	**110 940 €**	**0,9245 €**
INFORMATION TECHNOLOGY (IT)					
IT - Labeles - container	1	295,00 €	295 €	3 540 €	**0,030 €**
IT - Labeles - small	1	185,00 €	185 €	2 220 €	**0,019 €**
Printer Zebra	2	255,00 €	510 €	6 120 €	**0,051 €**
Cartridge	1	105,00 €	105 €	1 260 €	**0,011 €**
Print out	1	120,00 €	120 €	1 440 €	**0,012 €**
Comunication equipment - mobile telephone	2	39,00 €	78 €	936 €	**0,008 €**
IT - connection	1	711,00 €	711 €	8 532 €	**0,071 €**
Maintenance - IT	100%	294,00 €	294,000 €	3 528,000 €	**0,029 €**
TOTAL INFORMATION TECHNOLOGY			**2 298 €**	**27 576 €**	**0,2298 €**
OTHERS					
Maintenance - external warehouse	100%	95,00 €	95,00 €	1 140,00 €	**0,010 €**
Unexpectedly cost	1	500,00 €	500 €	6 000 €	**0,050 €**
TOTAL OTHERS			**595 €**	**7 140 €**	**0,0595 €**
OPERATING COST					
Rack labelling, floor layout - floor tape, labelling	-	500,00 €	0 €	0 €	**0,000 €**
Operational margin in %	1%	100,00 €	1,00 €	12,00 €	**0,000 €**
Corporate margin in %	10%	100,00 €	10,00 €	120,00 €	**0,001 €**
Insurance/liability	1	225,00 €	225 €	2 700 €	**0,023 €**
TOTAL OPERATING COST			**236 €**	**2 832 €**	**0,0236 €**
OVERTIME COST					
Overtime - daily	1	9,50 €	10 €	114 €	**0,001 €**
Overtime - afternoon	1	11,00 €	11 €	132 €	**0,001 €**
Overtime - night	1	12,00 €	12 €	144 €	**0,001 €**
Overtime - holiday	1	13,00 €	13 €	156 €	**0,001 €**
TOTAL COSTS			**34 423 €**	**410 601 €**	**3,422 €**

Source: Kučera (2018) based on real company data

The chain of logistics activities ensures the smooth running of the production process and there are logistics costs associated with each logistics activity. These costs are not negligible items that significantly affect the company's overall profit or loss. The need to monitor costs in terms of logistics activities is a prerequisite for identifying rationalization

measures in logistics activities and optimizing the logistics costs of the logistics service provider. In today's competitive environment, it is necessary to provide the required information to users, i.e. top management, in order to ensure the synchronization of individual logistics processes, the availability of information needed for different levels of management, employee evaluation, customer feedback and flexible operation in case of deviations from the financial plan.

5.3 Calculation of personnel warehousing costs

The activity-based costing method is used each time, all personnel costs that apply to each employee must be analysed in detail.

Table 3 provides an analysis of the time required to occupy the warehouse, according to which the personnel costs of employees are determined. Hourly wage costs are determined according to the wage regulation of the selected logistics service provider. These costs include basic salary, afternoon and night shift supplements, variable salary, share of the 13th salary, meals, tax levies and other items. Table 3 provides for three shift managers and one warehouse manager. No time analysis is performed for these positions. For other positions, i.e. forklift driver, administrator and warehouse operator (worker), time analysis is performed (blue fields show hourly labour costs – forklift driver CZK 193.35/hour, administrator CZK 197.48/hours and warehouseman 168.57 CZK/hour). 21 working days are considered, which means a total of 63 shifts per month in three-shift operation. The monthly time-lapse image found that the number of pallets stored and exported was 39,500 per month, which means that after 63 shifts, the number of pallets processed per shift, i.e. 627, can be obtained. The time analysis was performed at the selected logistics provider as follows:

- detection of all activities to ensure operation,
- identification of the employee performing the activity,
- measured time required to perform the activity (per pallet),
- multiplying this time by the number of pallets per shift gives the duration of the activity per shift,
- the sum of these times is equal to the number of minutes needed to ensure the shift operation,
- dividing by 60 determines the number of hours.

This number divided by seven (number of hours of active work of the employee – expert estimate) is the required result, i.e. the number of employees needed

per shift (multiplying by three gives the total number of employees in three shifts without management).

Wage costs are determined on the basis of the number of employees as the product of hourly wage costs, the number of employees and the working time fund (21 working days and 8 working hours, i.e. 168 hours per month). Administrative costs are added to these costs.

Table 3 Analysis and calculation of personnel warehousing costs at the selected logistics service provider

	Income - Warehousing - Expedition	Shift Manager	Warehouse Manager				
	Management Costs [CZK]	107,031	45,190		**39,500** pallets/month		
	Number of Working Days	**21**					
	Number of Shifts/Day	**3**			**627 pallets/shift**		
	Number of Shifts/Month	**63**			193.35	197.48	168.57
N.	Activities	Forklift Driver	Administrator	Worker	Forklift Driver	Administrator	Worker
1	Unloading of pallets	0.50	0.00	0.00	313.49206	0.00000	0.00000
2	Administrative activities related to unloading	0.00	0.10	0.00	0.00000	62.69841	0.00000
3	Goods receipt - quantity control	0.00	0.10	0.50	0.00000	62.69841	313.49206
4	Software entry of material into stock state	0.00	0.10	0.00	0.00000	62.69841	0.00000
5	Repackaging	0.00	0.00	0.00	0.00000	0.00000	0.00000
6	Pallets warehousing	0.70	0.00	0.00	438.88889	0.00000	0.00000
7	Order receipt - find material	0.00	0.10	0.50	0.00000	62.69841	313.49206
8	Picking at the dispensing point	1.00	0.00	0.00	626.98413	0.00000	0.00000
9	Delivery completion - dispatch control	0.00	0.50	0.50	0.00000	313.49206	313.49206
10	Depreciation from warehouse	0.00	0.30	0.00	0.00000	188.09524	0.00000
11	Issue of delivery note, packing note	0.00	0.30	0.50	0.00000	188.09524	313.49206
12	Loading of pallets	0.50	0.50	0.00	313.49206	313.49206	0.00000
13	Receiving empty packages - cargo control	0.00	0.00	0.00	0.00000	0.00000	0.00000
14	Warehousing of empty containers	0.00	0.00	0.00	0.00000	0.00000	0.00000
15	Removal of empty packaging	0.00	0.00	0.00	0.00000	0.00000	0.00000
16	Evidence of packaging	0.00	0.00	0.00	0.00000	0.00000	0.00000
	Minutes/pallet (In-Out)	0.00	0.00	0.00			
	Minutes/shift	2.70	2.00	2.00	1692.85714	1253.96825	1253.96825
	Hours/shift	0.05	0.03	0.03	28.21000	20.90000	20.90000
	Employees/shift	0.01	0.00	0.00	4.03000	2.99000	2.99000
	Employees/day	0.02	0.01	0.01	12.09000	8.96000	8.96000
	Total number of employees without management			30	12	9	9
					389,796	298,593	254,871
	Total personnel costs without management costs				**943,260 CZK**		
	Total number of employees including 3 shift managers and a warehouse manager				**34 Persons**		
	Total personnel costs including management costs				**1,095,481 CZK**		

Source: Kučera (2020) based on real company data

The analysis and calculation show that a total of 34 employees are needed to ensure operation, which represents a total of CZK 1,095,481 (approximately euro 41,339) per month. The euro exchange rate for CZK is: 1 euro is CZK 26.50 (General Finance Directorate, 2021).

5.4 Application of case-based reasoning method

With the use of in-depth interviews and consultations with selected logistics service providers, the practical use of the case-based reasoning method with a focus on the calculation of logistics costs of warehousing was chosen. These are activities that most

logistics service providers offer to their customers. Individual attributes are selected on the basis of already applied case studies using the activity-based costing method. Based on the above case studies and expert assessment, six attributes important in price decisions were selected. Selected attributes include:

- personnel costs (A1),
- handling equipment costs (A2),
- transport costs (A3),
- warehousing area costs (A4),
- information technology costs (A5),
- other costs (A6).

The new application of the case-based reasoning method in the area of calculation of logistics costs of warehousing brings simpler price decisions for the top management of the logistics service provider. After processing all three variants of distribution of individual attributes (A1-A6) according to experts, equidistantly and equivalently, after discussion with experts for logistics service providers, the best option is to divide the range (scaling) of individual attributes (A1-A6) according to the opinions and views of experts from companies engaged in logistics services.

6 EVALUATION OF RESULTS AND DISCUSSION

The doctoral thesis was focused on the issue of calculations of logistics costs of warehousing. The calculation system of logistics costs of warehousing at logistics service providers was created. This system was created on the basis of the results of the analysis of the current state of the researched issue, which resulted in the specifics of calculations of logistics costs. The new proposed calculation system in the area of calculations of logistics costs of warehousing using the activity-based costing method was presented and verified on the basis of two case studies at selected logistics service providers.

6.1 Evaluation of results and discussion of doctoral thesis

The new proposed calculation system in case study number one using the activity-based costing method includes elements:

- area,
- racking system,
- energy,

- handling equipment,
- transport,
- warehouse staff,
- other costs,
- hardware and software.

The new proposed calculation system in case study number two using the activity-based costing method includes elements:

- personnel costs,
- handling equipment costs,
- transport costs,
- facilities costs (warehousing area),
- information technology costs,
- other costs,
- overtime costs.

The case studies confirmed the usefulness of using the activity-based costing method as a new tool to better support price decisions in the calculation of logistics costs of warehousing at two selected logistics service providers.

The proposed calculation system was further focused in the doctoral thesis on the calculation of personnel costs of warehousing. An analysis of the time required to occupy the warehouse was performed, according to which personnel costs of employees are determined. In the next part, the cost calculation for racking systems was analysed and specified. The calculation of costs for racking systems includes the costs of acquiring racks, service, insurance, including the profit of the logistics service provider. The doctoral thesis also presented the calculation of forklift trucks costs and was presented in a case study focusing on the current situation and a possible change in forklift trucks financing. Furthermore, the warehouse area or warehouse capacity was determined. The size or capacity of the warehouse is related to several factors, such as the level of customer service, the amount of warehouse products, the handling system and the method of warehousing. In the warehouses, it is necessary to take into account, in addition to the warehousing area, also the area for receiving material, material handling or mobility of employees in the warehouse area. The theoretical layout of the warehouse was presented at a specific logistics service provider. In this layout, the required size of the warehouse in m^2 is determined, including the space for receiving, picking and dispensing. Another part

of the doctoral thesis was to create a controlling approach to the calculations of logistics costs. The controlling approach can help successfully manage critical business processes and enable the company as a whole to build a concept of continuous improvement to reduce logistics costs. The case-based reasoning approach was chosen as another appropriate method with regard to decision support. New application of this method in the field of calculation of logistics costs of warehousing brings simplification of price decisions for top management. Its further possible modification to the method of soft case-based reasoning may provide deeper information on individual calculations of logistics costs of warehousing in future research.

6.2 Benefits of doctoral thesis

Based on the analysis of the current situation, the activity-based costing method was newly chosen as a suitable tool for calculating logistics costs of warehousing within the calculation system for the needs of logistics service providers.

The following was also performed in the calculation system:

- defining the subject of calculation (i.e. calculation unit and calculated quantity) of logistics costs of warehousing,
- determining the method of assigning costs to the subject of calculation,
- definition of the cost structure in the individual calculations forming the calculation system.

The proposed calculation system was applied and verified using case studies in the conditions of two selected logistics service providers.

A usable method of case-based reasoning was newly chosen. The new application of this method in the field of calculations of logistics costs of warehousing brings simplification of price decision support for the top management of a logistics service provider based on real historical data.

The doctoral thesis is also usable in the field of scientific work or as a basis for further research in the field. The warehousing logistics cost calculation system is applicable to logistics service providers when deciding on a price at the top management level in practical use.

The benefits of the doctoral thesis for the development of the field of science can be summarized in the following areas:

- use of the search of world literature for the critical analysis of the current state in the field of calculations of logistics costs of warehousing,

- identification and specification of existing approaches to the calculation of logistics costs of warehousing at selected logistics service providers,
- create of the calculation system of logistics costs of warehousing at logistics service providers,
- verification of the calculation system based on case studies in the field of calculations of logistics costs of warehousing at selected logistics service providers,
- the use of the case-based reasoning method in the area of calculation of logistics costs of warehousing and its possible modifications in future research using the soft case-based reasoning method,
- development of the topic in connection with other possible doctoral theses, which may deal in more detail with the development of calculations of logistics costs of warehousing for other companies than logistics service providers.

The benefits of the doctoral thesis for the development in practice can be summarized in the following areas:

- new application of the activity-based costing method and the case-based reasoning method in the area of calculations of logistics costs of warehousing in practice,
- usability of the topic of calculation of logistics costs of warehousing in the pedagogical environment of the author in the bachelor's study program in the subject Logistics and Transport Technologies and in the master's study program in the subject Theory of Logistics Technologies and in the subject Calculation of Transport Costs.

7 CONCLUSION

Logistics is currently an area that has an irreplaceable function in the company. The chain of logistics activities ensures the smooth running of the production process, and each logistics activity is associated with the incurrence of logistics costs. These costs represent significant items that greatly affect the company's overall results of operations. The need to monitor costs in terms of logistics activities is a prerequisite for identifying rationalization measures in the field of logistics activities and reducing the company's logistics costs. The analysis of the current state of the issue shows that the topic of the doctoral thesis is very current, and this topic has recently received increased attention. Based on the analysis of the current situation, it is also possible to state that the theory does not currently offer a systematic approach to the calculation of logistics costs of warehousing

at the logistics service provider. An important starting point for the doctoral thesis was a comparison of existing calculation approaches at logistics service providers with an emphasis on warehousing. In the doctoral thesis, a calculation system of logistics costs was created with regard to the area of warehousing at the logistics service provider. The work also evaluated the results and discussed the limits of the created calculation system of logistics costs of warehousing at the logistics service provider. The main goal of this doctoral thesis was to create the calculation system of logistics costs at the logistics service provider based on an analysis of the current state of logistics cost calculations with an emphasis on warehousing. Based on the analysis of the current state, the actual results of the doctoral thesis using the method of activity-based costing in case studies and the method of case-based reasoning, evaluation and discussion of the obtained results, it can be stated that the goal of the doctoral thesis was met.

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