

Life Cycle Cost Calculation and its Importance in Vehicle Acquisition Process for Truck Transport

Kalkulacija troška životnog ciklusa i njegova važnost u procesu nabavke vozila za prijevoz kamiona

Rudolf Kampf

Institute of Technology and Business in
České Budějovice
Faculty of Technology, Czech Republic
e-mail: Kampf@mail.vstecb.cz

Marek Potkány

Department of Business Economics
Faculty of Wood Sciences and Technology
Technical University in Zvolen, Slovak Republic
e-mail: potkany@tuzvo.sk

Lucia Krajčírová

Department of Business Economics
Faculty of Wood Sciences and Technology
Technical University in Zvolen, Slovak Republic
e-mail: krajcirova@tuzvo.sk

Katarína Marcinekóv

Department of Business Economics
Faculty of Wood Sciences and Technology
Technical University in Zvolen, Slovak Republic
e-mail: xmarcinekova@tuzvo.sk

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Summary

Life Cycle Costing is a strategic managerial tool supporting decision making process even in the beginning phase. This calculation in its own base takes into account costs during the whole life cycle and creates a precondition for precise information database for decision making. The utilization of this calculation is often connected with the issue of the Environment. The aim of the paper is to propose LCC utilization in condition of goods transport by truck. Case-Based-Methodology for cost estimation as well as the time factor of discount rate for expected payments calculation of two vehicle acquisition cases with Net Present Value determination are used in this paper.

KEY WORDS

LCC calculation
cost
truck transport
vehicle

Sažetak

Trošak životnog ciklusa je strateški i menađerski alat procesa podrške donošenja odluka čak i na početku stadija. Ova kalkulacija u svojoj osnovi uzima u obzir troškove za vrijeme cijelog ciklusa i stvara preduvjete za preciznu bazu podataka za donošenje odluka. Korištenje kalkulacije je često povezano s problemom okoliša. Cilj ovog članka je predložiti LCC korištenje u uvjetima transporta robe kamionom. Metodologija temeljena na slučajevima za procjenu troška kao i vremenski faktor stope diskonta za kalkulaciju očekivanih plaćanja za nabavku dvaju vozila s određivanjem neto aktualne vrijednosti koristi se u ovom članku.

KLJUČNE RIJEČI

kalkulacija LCC
trošak
prijevoz kamionom
vozilo

1. INTRODUCTION

Life Cycle Cost calculation also called process of economic analysis is a result of managers' effort to minimize costs in decision making process of technical and economic side of future transformation process. It is possible to make decision about potential investment according to two approaches. The first one consists of acquisition price determination and it is more preferred in practice, but on the other hand it is a less precise approach. It poses a risk that the operating costs and additional costs for revitalization will not be taken into account. The second one takes into account the aforementioned costs and other decision factors, and so it is a base for utilization of Life Cycle Cost calculation. This technique allows quantifying of comparable costs of decision alternatives. Costs are allocated in certain time period taking into account all relevant economic factors. Factors are analyzed in terms of initial costs of acquisition as well as from the point of view of future operating and disposal costs. The paper deals with the theoretical bases for LCC calculation and its practical application within the decision making process of the transport company.

2. THEORETICAL BACKGROUND

Narrow view or traditional calculations aiming at accounting period could be eliminated by utilization of LCC calculation. The importance of LCC calculation is that the product costs created during its assumed lifetime in the market are estimated. The author [1] states that LCC calculation includes costs that are usually excluded by using traditional operating and planning calculation. These are costs referring to purchase and implement the assets also known as acquisition costs, operating costs, product recall costs and disposal costs. Another author [2] states that LCC calculation spreads the view to product costs. Research and development costs are considered as well as costs created in the preproduction phase and production process stopping costs. Author of the publication [3] highlights the advantage of the calculation particularly in coherent costs implementation to decision making process throughout discount techniques. The Czech Association for financial managing (CAFIN) [4] declares that this term has three different meanings:

- The first one means the maintenance of physical asset cost records over the entire asset live, so that decisions

concerning the acquisition, use or disposal of the asset may be made in a way that achieves the optimum asset usage at the lowest possible cost to the entity.

- The second one means profiling of cost during the entire life cycle of a company or even industry.
- The third one – and the most usual one – means profiling of cost over a product's life cycle, including the pre-production stage.

The calculation is used in conditions of industrial manufacturing, particularly. Publications [5-8] deal with this issue. Utilization of LCC calculation is frequent particularly in the building industry. This is discussed in publications [9-11]. The calculation is most commonly used in connection with the issue of the environment and the ecology as it is evidenced in papers [12-15]. Occasionally, it is possible to find publications dealing with application of this calculation in rail transport [16], in maritime transport [17] and in road transport [18-23].

According to [24], this term includes also certain process for planning, assessment and comparison of investment alternatives, moreover it is used for analysis of system and product effectiveness [25]. It is applied to planning and development of systems and products as well as to decision making process about vehicle purchase.

Following the aforementioned information the selection of cost estimation method is the main issue. The cost estimation is a complex process because it depends on the amount of information. In the scientific paper [26] a classification of some cost estimation methods is illustrated:

- Qualitative methods of cost estimation: intuitive methods are based on the expert estimation and information from previous periods (CBM Case-Based-Methodology, DSS Decision Support Systems), analogous methods are based on the utilization of similar criteria used in similar conditions (correlation analyses and models, BPNN Back Propagation Neural Network)
- Quantitative methods of cost estimation: parametric methods are based on statistical dependencies between costs and certain variable, analytical methods use a procedure of identification of activities and sources for product creation (OBA Operation Based Approach, BA Breakdown Approach, FBCE Feature Based Cost Estimation, TBCM Tolerance Based Cost Models)

The success of the calculation is influenced not only by the total cost estimation but also by other factors such as the duration of the product life cycle, assumed amount of outputs during its life cycle and expected trend of the product prices. The main function is optimizing the life cycle cost of the asset or investment project without a total performance reduction. The total interaction between all types of cost and revenue of project under consideration is presumption of life cycle cost optimization. Human resources are an important factor influencing accomplished expert estimations [27], [28]. Time and the used method of economic assessment are the key parameters of appraisal (calculation of Nett Present Value, utilization of discount rate, inclusion of inflation and interest rate) [29].

3. METHODOLOGY

Authors of publication [30] state that the application of LCC calculation could cause problems within the unification of

practiced accounting periods and life cycle phases or with the investment project phases. The problem solution consists in necessity of transformation of all financial data within the product life cycle to real cash flow in case of project assessment by discount rate [31-36]. The author of the paper [6] also deals with this issue.

There are several approaches to application of LCC calculation as it is presented in the paper [29].

- Approach to the LCC calculation on the base of Nett Present Value (NPV) – Nett Present Value is the difference between the present value of cash inflows and the present value of cash outflows. It is necessary to quantify the initial cost of acquisition (IN) if this method is used. Following formula represents the determination of Nett Present Value (1).

$$NPV = -IN + \sum_{t=1}^T \frac{CF_t}{(1+r)^t} \quad (1)$$

NPV – Nett Present Value

IN – Initial Cost of Acquisition

CF – Cash Flow

r – Discount Rate

t – Analysed Period (Time)

T – Life Cycle (Tenure)

It is possible to quantify Nett Present Value for Cost of Life Cycle on the basis of previous approach (2):

$$NVP_{LCC} = \sum_{t=0}^T \frac{C_t}{(1+r)^t} \quad (2)$$

NPV_{LCC} – Nett Present Value of LCC

C_t – sum of all relevant cost after deducting revenues arising in the period t

Stochastic approach to the LCC calculation represents the inputs as random variables with assigned probability density functions. Currently, probability distribution function LCC – f(LCC) is determined by the following formula (3):

$$f(LCC) = f(C_p) + \sum_{t=0}^{LC} \frac{f(C_{it})}{(1+f(r))^t} \quad (3)$$

f(C_p) – Probability Distribution Function for Acquisition Cost

f(r) – Probability Distribution Function for Discount Rate

f(C_{tj}) – Probability Distribution Function for every relevant cost item during the whole life cycle (LC) of the property after deducting the positive cash flow

LC – Life Cycle

Deterministic approach to the LCC calculation is based on the expert assessment of input values from previous periods while sensitivity analysis is added. Life Cycle Cost in the present value could be calculated by the following formula (4):

$$LCC = C_A + \sum_{t=0}^{LC} \frac{C_t}{(1+r)^t} \quad (4)$$

LCC – Current Value of Total Life Cycle Cost

C_A – Acquisition Cost

r – Discount Rate (time value of money)

LC – Life Cycle

C_T – sum of relevant Life Cycle Cost of property after deducting the positive cash flow

The paper [37] is based on the deterministic approach. The formula for calculation of the current value of the total life cycle cost was determined as follows (5):

$$LCC = C_A + \sum_{t=1}^{LC} C_t \times \frac{(1+r)^n - 1}{(1+r)^n \times r} \pm \left(\frac{1}{(1+r)^n} \times NBV \right) \quad (5)$$

NBV – Net Book Value

Petřík T. [1] states that it is necessary to modify the discount rate if the cash flows are displayed in the constant price and the inflation rate is low and stable. Authors of the publication [24] also modify the discount rate by using the inflation rate, and therefore the discount rate would be quantified by the following formula (6):

$$\text{discount rate } (r) = \frac{\emptyset \text{ interest rate} \times 100}{\emptyset \text{ inflation rate} \times 100} \quad (6)$$

4. APPLICATION OF LIFE CYCLE COST CALCULATION IN TRANSPORT COMPANY

The transport company provides services to customers of several industries.

- 1st alternative: acquisition of a new semi-trailer unit at acquisition cost of 129,000 €,
- 2nd alternative: acquisition of a used semi-trailer unit at acquisition cost of 39,000 €.

Tenure of semi-trailer is 6 years and the time resources are 250 working days per year.

The cost analysis consists in the utilization of Case-Based-Methodology for the cost estimation (see Table 1 for comprehensive presentation). The costs were divided into these groups:

- a) Fuel costs were quantified based on the price of diesel in the current period and the average fuel consumption of every vehicle in the previous period.

$$\text{Fuel costs} = (\emptyset \text{ fuel consumption per } 100 \text{ km} \times \text{driven km}) \times \text{diesel price} \quad (7)$$

1st alternative:

$$\text{fuel costs} = \frac{(40.5 \times 115,000)}{100} \times 0.956 = 44,525.70 \text{ €}$$

2nd alternative: Average fuel consumption per 100km is 45 liters, therefore fuel costs are 49,473 €.

$$\text{engine oil costs} = \frac{(38 \times 4)}{50,000} \times 115,000 = 349.60 \text{ €}$$

- b) Prerequisites for calculation of engine oil costs are calculated by the quantification of oil change interval (50,000 km), oil tank volume (38 l) and engine oil price (4 € per liter). The costs are equal for both alternatives.

$$\frac{\emptyset \text{ interest rate} \times 100}{\emptyset \text{ inflation rate} \times 100} = \frac{101.8}{100.7} = 1.01 \%$$

$$\text{transmission fluid costs} = \frac{(24 \times 9) + (12 \times 9)}{400,000} \times 115,000 = 93.15 \text{ €}$$

- c) Every semi-trailer unit needs 2 tires on the steering axle, 4 tires on the driving axle and 6 tires on the spread axles. It is necessary to use both types of tires (summer and winter) on the steering axle. Therefore, the storage costs and costs for tire changing were added to the total costs. The costs are equal for both alternatives. Practical calculation is too complex, therefore only final amount is listed below [16-18], [28-31]:

- cost of steering axle tires = 1,684.75 €,
- cost of spread axle tires = 1,926.25 €,
- cost of driving axle tires = 991.57 €.

- d) Toll costs were quantified based on the valid tariffs and estimation of driven kilometers in the monitored period.

- e) Operating costs consist of drivers earnings. The current rate is 0.20 € per kilometer. Therefore, wage payments are 23,000 € in the monitored period if average driving performance is 115,000 km.

- f) Repair and maintenance costs are affected by the tenure. A new semi-trailer unit needs a lower value of the operating cost items and a used semi-trailer unit needs a higher value of operating cost items.

- g) Costing depreciations were evenly distributed within the life cycle (6 years) and the straight-line method was used.

- h) Motor insurance costs (tractor = 780 €, semi-trailer = 165 €), accident insurance costs (tractor = 3,100 €, semi-trailer = 520 €) and road tax (tractor = 740 €, semi-trailer = 1,650 €)

- i) Costs of technical inspection (tractor = 44.50 €, semi-trailer = 27.50 €) and emission control (semi-trailer = 33 €) are spent once a year.

- j) Other costs are overhead costs and those are independent from the driving performance of the vehicles used, but on the other hand these costs are necessary (e.g. bank charges, accounting maintaining fees, charges for economic agenda maintaining, parking fees).

If the life cycle costs are calculated, it is necessary to take into account the disposal costs of the considered vehicles. The semi-trailer unit will be sold at net book value (15,000 €) if the 1st alternative is used. It has a positive impact on the costs within LCC calculation in our case study. On the other hand the added cost of vehicle disposal (1,000 €) related to the 2nd alternative has a negative impact on costs within the LCC calculation.

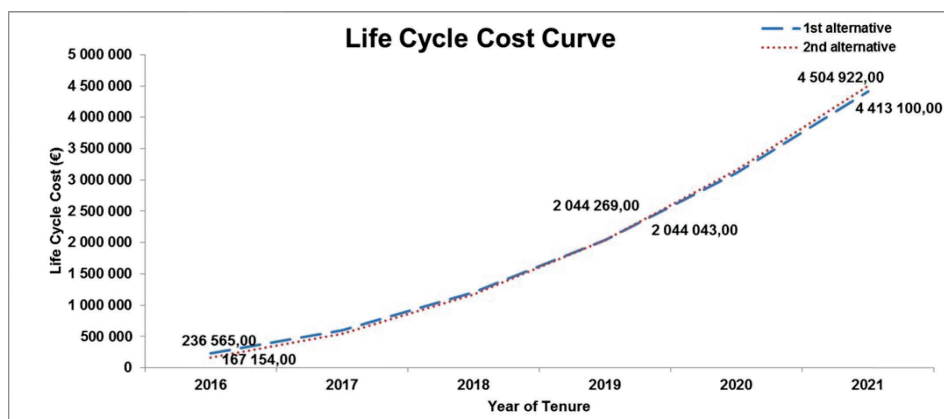
Table 1 Semi-trailer unit data (€)

	1 st alternative	2 nd alternative
Acquisition cost	95,000 + 34,000 = 129,000.00	22,000 + 17,000 = 39,000.00
Operating cost (annual):	123,651.02	128,448.32
Fuels	44,525.70	49,473.00
Engine oil	349.60	349.60
Transmission fluid	93.15	93.15
Tires costs: - steering axle	1,684.75	1,684.75
- driving axle	1,991.57	1,991.57
- spread axle	1,926.25	1,926.25
Toll	7,800.00	7,800.00
Drivers wages	23,000.00	23,000.00
Repair and Maintenance	650.00	15,500.00
Depreciation	21,500.00	6,500.00
Motor insurance	945.00	945.00
Accident insurance	3,620.00	3,620.00
Road tax	2,390.00	2,390.00
Technical inspection cost	105.00	105.00
Vehicle monitoring	20.00	20.00
Other costs	13,050.00	13,050.00
Disposal costs	-	1,000.00
Resale value	15,000.00	-

Source: own calculation

Inflation rate is 0.7 % and the annual interest rate is 1.8 % therefore the discount rate could be calculated by the formula (6):

Deterministic approach was used for LCC calculation (5). The input cost items are presented in Table 2. The life cycle costs of both alternatives are calculated:



Source: authors

Figure 1 Life Cycle Cost Curve (€)

1st alternative:

$$LCC = 129,000 + (123,651.02 \times 6) \times 5.793 - 15,000 \times (1.0101)^{-6} \doteq 4,413,100 \text{ €}$$

2nd alternative:

$$LCC = 39,000 + (128,448.32 \times 6) \times 5.793 + 1,000 \times (1.0101)^{-6} \doteq 4,504,922 \text{ €}$$

Table 2 Trend of the life cycle costs

	tenure year					
	2016	2017	2018	2019	2020	2021
1 st alternative	236,565	601,509	1,205,197	2,044,043	3,114,509	4,413,100
2 nd alternative	167,154	546,093	1,173,040	2,044,269	3,156,107	4,504,922

Source: own calculation

LCC analysis resulted into the statement that the total life cycle costs are higher if the 2nd alternative is used (acquisition of a used semi-trailer unit) as it is illustrated in Figure 1. There is a pictorial representation of the life cycle costs curves for both alternatives in Figure 1. If enterprise uses the 2nd alternative the difference of life cycle costs between alternatives exceeds the sum of 91,822 € (see Table 2).

Comparison of the life cycle costs in tenure of motor vehicles shows that used semi-trailer unit is more profitable only as a short-term decision. Life cycle costs of both alternatives will be at same level in the 4th year of tenure and reach the value of 2,044,000 € (see Figure 1). That is a break-even-time point and after this point the 2nd alternative is more effective. Truck tenure is 6 years therefore the 2nd alternative is profitable for the enterprise. Despite the fact that the acquisition costs of a new semi-trailer unit are higher, it is preferable than the acquisition of a used semi-trailer unit.

5. CONCLUSION

Currently, managerial accounting is focused on providing information for strategic management and long-term decision. Life cycle cost calculation throughout consideration time value of money (discount rate) controls cash flows within assumed product life cycle as well as provide important information for investment decision. Uncertainty of input data utilization represents a risk of this calculation because the inputs are based on expert estimation of initial acquisition costs, future operating costs and disposal costs. Deterministic approach was used for

the total life cycle costs determination and inflation and interest rate were taken into account, too. Our case study was focused on the utilization of LCC calculation in a transport company. It was necessary to highlight uncertainty in decision making process only according to the acquisition price. It is possible to lead up future utilization of this calculation to area of enquiry impact of vehicle operating costs to the environment.

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REFERENCES

- [1] Petřík, T. Procesní a hodnotové řízení firem v organizaci – nákladová technika a komplexní manažerská metoda:ABC/ABM (Activity Based Costing/Activity Based Management). Praha: Linde, 2007, 911 p. ISBN 978-80-7201-648-8.
- [2] Šoljaková, L. Strategicky zaměřené manažerské účetnictví. Praha: Management Press, 2009, 206 p. ISBN 978-80-7261-199-7.
- [3] Foltínová, A. a kol. Nákladový controlling. Bratislava: Sprint, 2007, 450 s. ISBN 978-80-89085-70-5.
- [4] CAFINews. Kalkulace životního cyklu, 2013, [online]. [cit. 2016.02.15]. Available online: <http://news.cafin.cz/slovník/kalkulace-zivotniho-cyklu>.
- [5] Kunttu, S., M. Reunanen, J. Raukola, K. Frankenhaeuser, K. Frankenhaeuser. Executing sustainable business in practice a case study on how to support sustainable investment decisions. Lecture Notes in Mechanical Engineering, 2015, Vol. 19, pp. 1095-1107. ISSN 2195-4356.
- [6] Langdon, D. Life Cycle Costing as a Contribution to Sustainable Construction: a Common Methodology. London: Davis Langdon Management consulting, 2007, pp. 29.
- [7] Seif, J., Rabbani, M. Component based life cycle costing in replacement decisions. Journal of Quality in Maintenance Engineering, 2014, Vol. 20, Issue 4, pp. 436-452. ISSN: 1355-2511.
- [8] Vojtekova, M., Blazekova, O. Application of Markov chains in the calculation of provisions for loan portfolio. Ekonomicko-manazerske spectrum, 2012, Vol. 6, No 1, pp. 52-55.
- [9] Hunkeler, D. Societal LCA methodology and case study. International Journal of Life Cycle Assessment, 2006, Vol. 11, Issue 6, pp.371-382. ISSN 0948-3349.
- [10] Brown, N.W.O., T. Malmqvist, W. Bai, M. Molinari. Sustainability assessment of renovation packages for increased energy efficiency for multi-family buildings in Sweden. Building and Environment, 2013, Vol. 61, pp. 140-148. ISSN 0360-1323.
- [11] Stephan, A., L. Stephan. Life cycle energy and cost analysis of embodied, operational and user-transport energy reduction measures for residential buildings. Applied Energy, 2016, Vol. 161, Issue 1, pp. 445-464. ISSN 0306-2619.
- [12] Tanaka, K., H. Yamada, N. Koshiishi, M. Tanabe, Y. Nakazawa, H. Kajita. Concept and feasibility study of specification for future waterproofing systems. Journal of Structural and Construction Engineering, 2014, Vol. 79, Issue 700, pp. 681-687. ISSN 1340-4202.
- [13] Rigamonti, L., Sterpi, I., Grosso, M. Integrated municipal waste management systems: An indicator to assess their environmental and economic sustainability. Ecological Indicators, 2016, Vol. 60. pp. 1-7. ISSN 1470-160X.

- [14] Schmidt Rivera, X., C., A. Azapagic. Life cycle costs and environmental impacts of production and consumption of ready and home-made meals. *Journal of Cleaner Production*, 2016, Vol. 112, Issue 1, pp. 214-228. ISSN 0959-6526.
- [15] Qiao, Y., A. Dawson, G. Flintsch. Evaluating the effects of climate change on road maintenance intervention strategies and Life-Cycle Costs. *Transportation Research Part D: Transport and Environment*, 2015, Vol. 41, pp 492-503. ISSN 1361-9209.
- [16] Babel, M., M. Szkoła. Diesel locomotive efficiency and reliability improvement as a result of power unit load control system modernisation. *Eksplotacja i Niezawodność*. 2016, Vol. 18, Issue 1, pp. 38-49. ISSN 1507-2711.
- [17] Simkova, I., Konecny, V. Key performance indicators in logistics and road transport. In: *Logi - Scientific Journal on Transport and Logistics*, 2014, Vol. 5, No. 2, pp. 87-96, ISSN 1804-3216.
- [18] Luttenberger, A., R. L. Luttenberger. Environmental Life Cycle Costing in Maritime Transport. *Proceedings 16th IAUMU Annual General Assembly Opatija, Croatia*, 2015, Available on: https://www.researchgate.net/publication/283302664_Environmental_life-cycle_costing_in_maritime_transport.
- [19] Zhang, J., Wnag, J.J. Liu, K. Highway life – cycle cost analysis with environment impact considered. *Journal of Chang'an University (Natural Science Edition)*, 2014, Vol. 34, Issue 3, pp. 128-132. ISSN 1671-8879.
- [20] Gasparik, J., Stopka, O., Peceny, L. Quality evaluation in regional passenger rail transport. In: *Nase More, Dubrovnik: University of Dubrovnik*, 2015, Vol. 62, No. 3, pp. 114-118. ISSN 0469-6255. <http://dx.doi.org/10.17818/NM/2015/S15>
- [21] Mitropoulos, L.K., Prevedouros, P.D. Life cycle emissions and cost model for urban light duty vehicles. *Transportation Research Part D: Transport and Environment*. 2015, Vol. 41, pp 147–159. ISSN 1361-9209.
- [22] Drożdżel, P., Komsta, H., Krzywonos, L. An analysis of costs of vehicle repairs in a transportation company. Part I. *Problemy Transportu/Transport Problems*, 2012, Vol. 7, Issue 3, pp. 67-75. ISSN 1896-0596.
- [23] Krile, S., Peraković, D., Remenar, V. Possible Collision Avoidance with Off-Line Route Selection. *Promet & Transportation, Portorož, Trieste, Zagreb*, 2009, Vol. 21, No. 6, pp. 415-423. ISSN 0353-5320.
- [24] Baum, H.G., Coenenberg, A.G. Günther, E. *Betriebliche Umweltökonomie in Fällen. Band I: Anwendung betriebswirtschaftlicher Instrumente*. [online]. München, 1999, ISBN 3-486-24675-5. [cit. 2016.02.15.]. Available online: <https://books.google.sk/books?id=hNedCgAAQBAJ&pg=PA256&lpg=PA256&dq=Lebenszykluskosten+Break-Even-Time&source=bl&ots=y6ondKquN0&sig=2P5CUGpRacBFoxJQjSATTiNY8Ds&hl=sk&sa=X&ved=0ahUKewjtq6KHsfKAhVlw3IKHfGacQwQ6AEIGAA#v=onepage&q=LCC&f=false>.
- [25] Hitka, M., A. Hajduková, Ž. Balážová. Impact of economic crisis on changes in motivation of employees in woodworking industry. *Drvna industrija*, 2014, Vol. 65, Issue 1, pp. 21-26. ISSN 0012-6772.
- [26] Prajer, M. Model hodnocení výrobní fáze životního cyklu produktu v podniku. 2007. Available online: <http://stc.fs.cvut.cz/pdf14/4542.pdf>.
- [27] Stacho, Z., H. Urbancová, K. Stachová. Organisational arrangement of human resources management in organisations operating in Slovakia and Czech Republic. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, 2013, Vol. 61, Issue 7, pp.2787-2799. ISSN 1211-8516.
- [28] Urbancová, H., K. Stachová. Importance of organisational culture of knowledge continuity ensuring in organisations (in Czech). *Scientific Papers of the University of Pardubice*, 2013, Vol. 27, Issue 2, pp. 140–149. ISSN 1211-555X.
- [29] Heralová, R.S. Life Cycle Cost optimization within decision making on alternative designs of public buildings. *Procedia Engineering*, 2014, Vol. 85, pp 454-463. ISSN 1877-7058.
- [30] Král, B. a kol.. *Manažerské účetnictví*. 3. Ed., Praha: Management Press, 2012, 660 p. ISBN 978-80-7261-217-8.
- [31] Bartuska, L., Stopka, O., Lizbetin, J. Methodology for Determining the Traffic Volumes on Urban Roads in the Czech Republic. In: *Transport Means - Proceedings of the 19th International Scientific Conference on Transport Means*. Kaunas (Lithuania): Kaunas University of Technology, 2015, pp. 215-218. ISSN 1822-296X.
- [32] Urbanek, A. Risk sharing in the paper ticket distribution system on the example of Municipal Transport Union of the Upper Silesian Industrial District in Katowice. *Transport Problems*, 2015, Vol. 10, Issue 1, pp. 45-54. ISSN 1896-0596.
- [33] Pavlíčková, M., K. Teplíková. Application of operational analysis methods in alternative energy sources. *Acta Montanistica Slovaca*, 2014, Vol. 19, Issue 2, pp. 59-64. ISSN 1335-1788.
- [34] Drożdżel, P., Komsta, H., Krzywonos, L. An analysis of costs of vehicle repairs in a transportation company. Part II. *Problemy Transportu/Transport Problems*, 2012, Vol. 7, Issue 4, pp. 7-11. ISSN 1896-0596.
- [35] Kubasakova, I., Simkova, I., Krzywonos, L., Nieoczym, A. The national strategy of logistics and transport in Slovakia. In: *Logi - Scientific Journal on Transport and Logistics*, 2015, Vol. 6, No. 1, pp. 67-79, ISSN 1804-3216.
- [36] *Lebenszykluskostenrechnung*. [cit. 2016.02.15.]. Available online: https://www.f08.th-koeln.de/imperia/md/content/personen/professoren/schmieder_matthias/controlling/loesung_lebenszykluskostenrechnung.pdf.