DEVELOPMENT OF PERFORMANCE EVALUATION SOFTWARE FOR ROAD FREIGHT TRANSPORT ACTIVITY

Kovács GY.[*]

Abstract: In the growing market globalization, global competitions, where the customer demands are changing continuously the enterprises have to focus on cost reduction and efficiency. The measurement of processes and activities is very important, because if we can measure the performance of processes, we can improve it in the future. The measurement of processes and activities by KPIs (Key Performance Indicators) is frequently used in general business to evaluate historic data and identify the weak areas and define improvement areas and goals of the enterprise. The goal of this study is the performance measurement and evaluations of road freight transport activity, because the transportation is one of the most expensive logistical processes. At first the structure of 4 most common used transport metrics /time utilization, transport way utilization, weight of transported freight, fuel usage relating to vehicles and transport trips/ are elaborated, then the calculation method for these transport metrics is introduced. Based on the elaborated structure of transport indicators, evaluation software was developed which is also introduced in this article. This is the reason that this research is absolutely original and unique. The developed evaluation software was implemented successfully at a forwarding company.

Key words: performance measurement, key performance indicator, transport metrics, evaluation software

DOI: 10.17512/pjms.2017.15.1.12
Article history:
Received January 23, 2017; *Revised* February 20, 2017; *Accepted* February 28, 2017

Introduction

Due to globalization, increasing global competition the carriers and forwarding agents put great emphasis on the optimization of transportation and reduction of transport costs. The research topic is very important because the 30% of the cost of the whole supply chain comes from transportation, and the volume of transport sector shows that the ratio of road transport in Europe is 78% of the total transit volume (Fraunhofer, 2015). Therefore the optimization of road transport activities can be results a significant cost saving. This research is very actual, because the cost reduction and the improvement of transport efficiency are very important goals of all of transport companies. Efficiency improvement and optimization of processes require the continuous measurement and evaluation of historic and actual transport performance. KPI is a tool for performance measurement. Key performance indicators are frequently used in business to evaluate the efficiency of activities, and the evaluation of historic data provides a real view of the actual conditions of the company.

[*] **György Kovács**, University of Miskolc, Institute of Logistics
✉ Corresponding author: altkovac@uni-miskolc.hu

Performance measurement have important role to evaluate the efficiency of the actual processes and define objectives, future improvements. Harrington states that "*If you cannot measure it, you cannot control it. If you cannot control it, you cannot manage it. If you cannot manage it, you cannot improve it"* (Harrington, 1991). Improving transport efficiency and effectiveness requires transparency of the current processes.

The goal of this study is the elaboration of a method for performance measurement and evaluation of road freight transport activity. The structure of 4 most important and common used transport metrics /time utilization, transport way utilization, weight of transported freight, fuel usage/ and calculation method for these metrics are elaborated, relating to vehicles, categories of vehicles and transport trips.

This research is absolutely original and unique, because based on the elaborated structure of transport indicators; evaluation software was developed especially for SMEs for every day application. This software is also introduced in this article. The involved KPIs are the most common used indicators which are necessary and enough to strategic decision making, further advantage of this evaluation software that absolutely fit to the user's demands and very cost effective.

Literature Review and Methodology

Performance in general terms refers to any evaluation or comparison measure. A performance measure can be considered as a quantitative or qualitative characterization of performance (Eboli and Mazzulla, 2012). The performance measurement is very important, because if we can measure the actual performance of processes we can improve it in the future (Thamrin, 2016; Stefko et al., 2016). The main goal of the process improvement is the cost reduction (Kot, 2015). There is a huge amount of literature on performance measurement systems (PMS), frameworks, and individual performance measurement. The most of the performance measurement systems are based on only financial metrics, but there are some which apply both of non-financial and financial metrics (Bendoly et al., 2007). The literature introduces several performance measurement frameworks, e.g. the Balanced Scorecard (Kaplan and Norton, 1996), the Performance Measurement Matrix (Keegan et al., 1989) or the Performance Pyramid (Cross and Lynch, 1992).

However in most cases standardised or generally accepted performance measurement systems can not be used, therefore there are lots of individual evaluation criteria, guidelines or often used KPIs (Cook and Zhu, 2005) applied in different sectors. Logistics literature often deals with description of logistics performance indicators (Schmitz and Platts, 2004; Ross, 2015). Logistics performance is included three important metrics (Ross, 2015). The first is the logistics productivity which provides information relating to productivity standards, logistics cost, quality management processes and logistics service levels. The second metric is the logistics service performance, tracks customer service goals. The third performance component is the logistics performance measurement

systems, details the content of performance metrics. In the last decade I had several Research & Development projects completed for transport companies, so I have experience in field of transportation. My theoretical experience initiated the idea of this evaluation software, which offers a prompt solution for everyday tasks. I consulted with SMEs (Small and Medium-sized Enterprises) before the software development about their requirements relating to the new evaluation software. Therefore this research topic is not only theoretical (elaboration of structure and calculation method of transport metrics), but the evaluation software was also developed which can be applied very effectively in practice. This software application is also described in this article. The evaluation software was developed especially for SMEs which can not buy expensive Business Performance Management Software. Based on the special requirements of SMEs the 4 most important transport metrics and calculation methods of these were elaborated. Based on this theory evaluation software was developed which is absolutely fit to the users demands and very cost effective.

Types and Characteristics of Transportation Metrics

The standard performance measurement frameworks, like the Balanced Scorecard, Performance Measurement Matrix, Performance Pyramid, or standardised PMSs can not be used in every sector especially at transport companies. Developing distribution and transportation metrics and key performance indicators is a challenge for any transport organization. The development of transport processes can by realized only by high transparency and continuous monitoring of the efficiency of the transport activities. Transportation Metrics are the tools for evaluating the transportation processes. Evaluation of transport metrics can provide useful information because the analysis of historic data provides a real view of the transport company's activity. Using the adequate set of metrics can result to identify opportunities for improvement and provide the latest data for making every day decisions. Traditional logistics measurement systems are related to the following five performance categories: 1) asset management, 2) cost, 3) customer service, 4) productivity and 5) logistics quality (Bowersox and Closs, 1996). Typical transportation performance measures by category type are (Bowersox et al., 1989):

- asset management: capacity utilization, return on investment;
- cost: cost per weight, transportation cost per loading unit;
- customer service: transit time, delay;
- productivity: orders delivered per vehicle, full versus partial loads;
- quality: damage in transit, etc.

KPIs vary for different types of transportation modes (Duma, 1999; Sinha and Labi, 2007). There are also a number of performance characteristics for selecting the adequate mode of transportation (road, rail, water, air, and pipeline). The most common considerations for selecting a mode of transport are 1) transit time,

2) cost, reliability, 3) capability, 4) accessibility and 5) safety. Ross (2015) wrote that there are six transport mode performance characteristics driving any transportation selection decision which are: 1) speed, 2) cost, 3) completeness, 4) dependability, 5) capability, 6) frequency. Common KPIs used in practice for Transportation Metrics are the followings (Scmwiki, 2016):

- vehicle time utilization,
- net tone kilometre,
- quantity per shipment,
- empty ways (carried no freight),
- average freight revenue per ton-kilometre,
- fuel usage / ton / km,
- fuel costs / ton / km
- fuel efficiency,
- freight cost per unit shipped,
- transit time,
- percentage of fleet time not utilised,
- truck turnaround time,
- optimize load fulfilment %,
- average number of stops per trip,
- number of handling points,
- claims as a percentage of freight cost,
- outbound freight costs as a percentage of net sales,
- shipment traceability,
- on-time pickups,
- on-time delivery,
- % of undamaged goods after shipping/transportation,
- labour productivity,
- maintenance costs,
- loading or unloading time,
- greenhouse gases emitted per kilometre travelled,
- damages as % of throughput,
- % of orders/items arrives at the right location, etc.

Elaboration of Transportation Metrics for Evaluation of Road Freight Transport Activity

It has become increasingly important goal for companies to develop performance measurement systems. At first the transportation metrics to be applied have to identify. Only 3-5 KPIs have to use per every important functional area. The management has to understand the meaning of these transportation metrics and of course the meaning behind them. Well defined KPIs show the weak areas or areas of improvement in transportation processes. Based on these improvement areas the set goals can be defined. In the frame of a Research & Development project completed for a transport company the structure of transport metrics was elaborated which can be evaluated based on the available database.

The set of transport metrics was elaborated based on the user's demands. The selected 4 indicators are the most common used metrics which are necessary and enough to strategic decision making and making every day operative decisions. Transport metrics were elaborated for vehicles, categories of vehicles and transport trips. The elaborated structure of indicators can be seen in Figure 1.

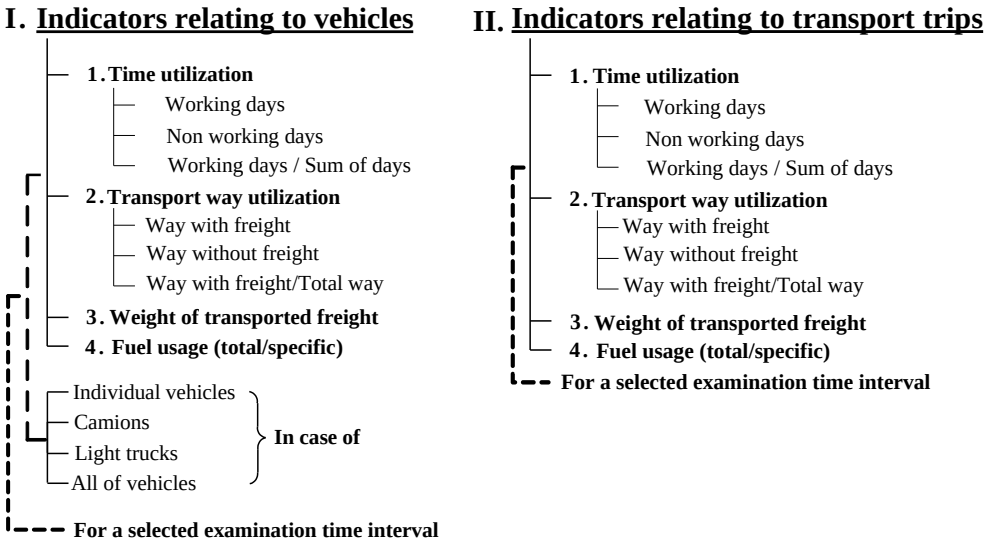

Figure 1. Structure of elaborated transport metrics

The most common form of organisation of international road freight transportation is the round trip (Gudehus and Kotzab, 2009), which is the integration of more freight transport tasks (*i*) into one round trip. The goal of round trip planning is the maximization of efficiency and minimization of length of empty ways (vehicle carried no freight).

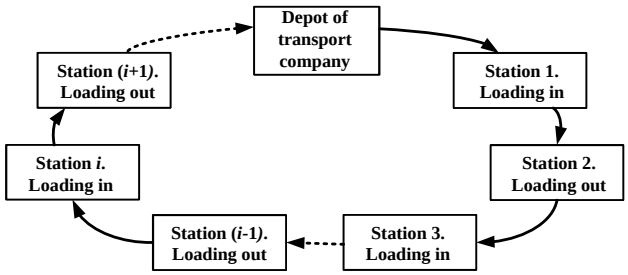

Figure 2. Structure of a road freight transport trip

Figure 2 shows the structure of a road freight round trip, in which the vehicle starts from the depot of the transport company to the first station where the goods to be transported are loading in. After it the vehicle goes to the next station where the goods are loading out and goes to the next station, etc. After the last station the vehicle goes back to the depot of the transport company.

Calculation Methods for the Elaborated Transport Metrics

Calculation methods for the different elaborated transport metrics /time utilization, transport way utilization, weight of transported freight, fuel usage relating to vehicles and transport trips/ will be described in this chapter.

Time Utilization of Vehicles

Time utilization of vehicles in a selected time interval can be calculated by the following equation:

$$\eta_{Time}^{V} = \frac{T_W^V}{T_W^V + T_{NW}^V} \cdot 100 \quad [\%] \tag{1}$$

where: η_{Time}^{V} – time utilization of vehicles,

T_W^V – working days (time that vehicles are used for transportation) of vehicles [day],

T_{NW}^V – non working days (time that vehicles are not used for transportation) of vehicles [day],

V – index is relating to vehicles, which can be: individual vehicles, categories of vehicles (e.g. camions or light trucks) or all of vehicles.

Time Utilization of Transport Trips

Time utilization of freight transport trips in a selected time interval can be calculated by the following equation:

$$\eta_{Time}^{TT} = \frac{T_W^{TT}}{T_W^{TT} + T_{NW}^{TT}} \cdot 100 \quad [\%] \tag{2}$$

where: η_{Time}^{TT} – time utilization of freight transport trips,

T_W^{TT} – working days (time that vehicles are used for transportation) of the transport trip [day],

T_{NW}^{TT} – non working days (time that vehicles are not used for transportation) of the transport trip [day],

TT – index is relating to different freight transport trips.

Transport Way Utilization of Vehicles

Transport way utilization of a vehicle is the ratio of the realised useful (with useful load) transport ways and the total transport distances in the selected time interval by a selected vehicle.

$$\eta_{TW}^{V} = \frac{L_U^V}{L_U^V + L_{NU}^V} \cdot 100 \quad [\%] \tag{3}$$

where: η_{TW}^{V} – transport way utilization of a selected vehicle,

L_U^V – length of useful (carried useful freight) transport way of a selected vehicle (V) [km],

L_{NU}^V – length of empty (carried no freight) transport way of a selected vehicle (V) [km].

Transport Way Utilization of Transport Trips

Transport way utilization of a freight transport trip is the ratio of the completed useful (with useful load) transport way and the total transport distances in the selected time interval in case of a selected transport trip.

$$\eta_{TW}^{TT} = \frac{L_U^{TT}}{L_U^{TT} + L_{NU}^{TT}} \cdot 100 \quad [\%] \tag{4}$$

where: η_{TW}^{TT} – transport way utilization of a selected transport trip,

L_U^{TT} – length of useful (completed with useful freight) transport way of a selected transport trip (*TT*) [km],

L_{NU}^{TT} – length of empty (carried no freight) transport way of a selected transport trip (*TT*) [km].

Specific Fuel Consumption of Vehicles

Specific petrol consumption of vehicles in a selected time interval can be calculated by the following equation:

$$\eta_F^V = \frac{Q_T^V}{L_T^V} \cdot 100 \quad \left[\frac{litre}{km}\right], \tag{5}$$

where: η_F^V – specific fuel consumption of a selected vehicle (*V*),

Q_T^V – total fuel consumption of a selected vehicle (*V*) in the selected evaluation time interval [litre],

L_T^V – total transport way of a selected vehicle (*V*) in the selected examination time interval [km].

Specific Fuel Consumption during Transport Trips

Specific petrol consumption during the freight transport trips in a selected time interval can be calculated:

$$\eta_F^{TT} = \frac{Q_T^{TT}}{L_T^{TT}} \cdot 100 \quad \left[\frac{litre}{km}\right], \tag{6}$$

where: η_F^{TT} – specific fuel consumption of a selected transport trip (*TT*),

Q_T^{TT} – total fuel consumption of a selected transport trip (*TT*) in the selected evaluation time interval [litre],

L_T^{TT} – total transport way of a selected transport trip (*TT*) in the selected examination time interval [km].

Development of Evaluation Software and Samples for the Evaluation of the Most Important Indicators

Based on the elaborated structure of transport metrics (Figure 1) evaluation software was developed. Analysis of data relating to the historic transport activity provides a real view of the transport company; it means that if we can measure the performance of freight transport processes we can improve it in the future. This is the most important aim of the developed evaluation software. There is lots of Business Performance Management Software on the market and transportation management software is also available for performance measurement (Kot et al., 2014). Generally this software is expensive and not easy to fit to the customer demands. Most of the complex ERP (Enterprise Resource Planning) systems also provide the opportunity for performance measurement and evaluation (in many cases hundreds of indicators are available), but the application and understanding of these indicators are very hard. This new software was developed especially for SMEs, which enterprises can not invest in expensive PMS software. Before the software development I consulted with SMEs about their requirements relating to new performance evaluation software. The developed software (Figure 3) has two menu points which are the *"**Indicators relating to vehicles**"* and *"**Indicators relating to transport trips**"*. The evaluation can be completed for vehicle and transport trips in a selected evaluation time interval.

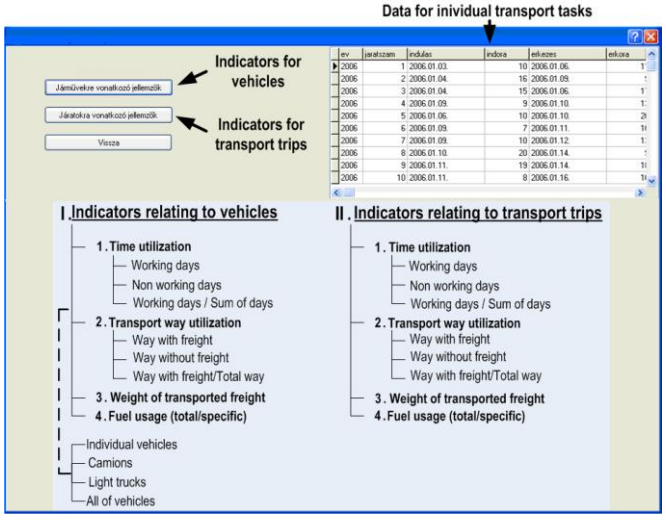

Figure 3. Main screen of the evaluation software

In the next sections the results of the evaluations completed by the developed software will be showed. The developed evaluation software provides the opportunity for a very detailed evaluation of performance measuring indicators

defined in Figure 3 for a selected evaluation time interval. Numerical and graphical evaluation of the selected indicators is also provided (see in Figures 4-8).

Time Utilization of Vehicles or Transport Trips

Time utilization of vehicles and transport trips in a selected time interval can be calculated by the equation (1-2). Figures 4-5 show the implementation of this calculation in the developed software. Graphical and numerical statistics of these indicators are also depicted on this figure.
Figure 4 shows the graphical and numerical evaluation of time utilization in case of vehicles. Figure 5 shows the numerical result of the evaluation in case of transport trips.

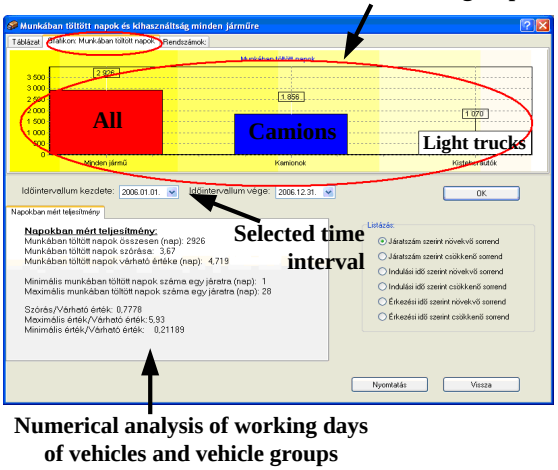

Figure 4. Working days of vehicles in a selected time interval

Transport Way Utilization of Vehicles or Transport Trips

Transport way utilization of vehicles and round trips is the ratio of the loaded transport way (with useful load) and the total transport distances in the selected time interval. These KPIs can be calculated by equations (3-4).
Figure 6 shows the evaluation of total transport distances of vehicles and transport trips in the selected time interval and the graphical and numerical statistics of these metrics.

Weight of Freight Transported by Vehicles or in the Transport Trips

The weight of freight transported by vehicles or in the transport trips is one of the most important and often used KPI in the transport sector. The software is also providing the opportunity for evaluation of these metrics for a selected vehicle, vehicle group or transport trip in a selected time interval (Figure 7).

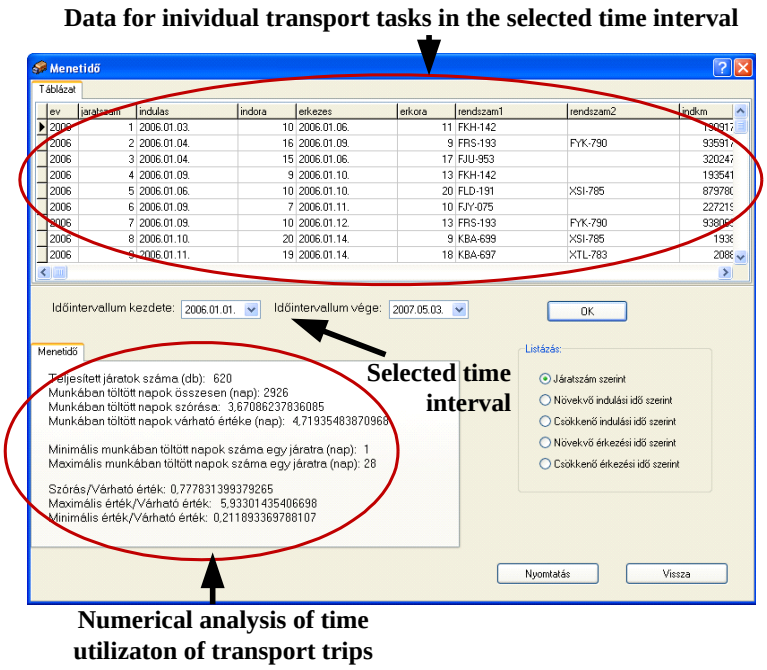

Figure 5. Numerical analysis of working days of 620 transport trips in a selected time interval

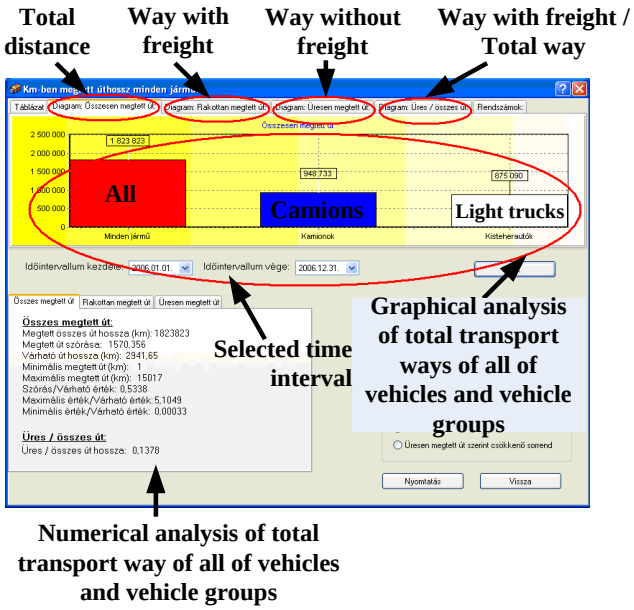

Figure 6. Evaluation of total transport distances of vehicles in a selected time interval

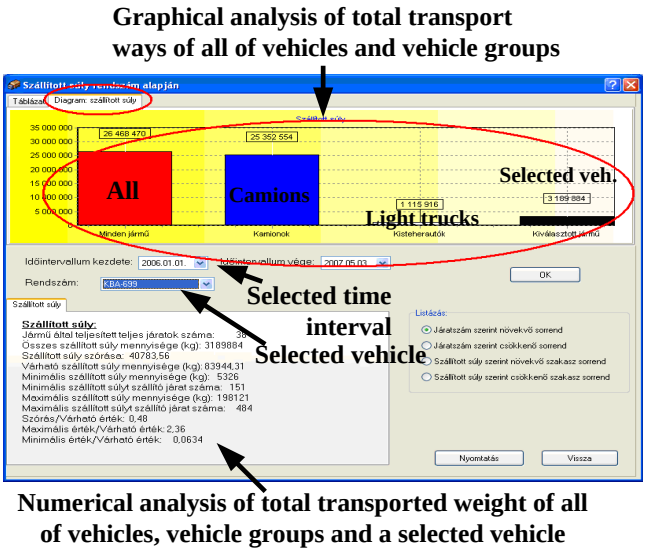

Figure 7. Weight of freight transported by a selected vehicle in a selected time interval

Total and Specific Fuel Usage of Vehicles or in the Transport Trips

Specific usage of vehicles or in the transport trips in a selected time interval can be calculated by the equations (5-6). Figure 8 shows the total- and specific fuel usage of vehicles in a selected time interval.

The evaluation software was developed especially for SMEs which can not buy expensive Business Performance Management Software. Based on the special requirements of SMEs the 4 most important and most common used transport metrics /time utilization, transport way utilization, weight of transported freight, fuel usage relating to vehicles and transport trips/ and calculation methods of these were elaborated. Based on this theory evaluation software was developed which is absolutely fit to the users demands and very cost effective. Indicators of the software are necessary and enough for evaluation of historic transport activities and for the future strategic decision making of general management. The developed software was successfully implemented at a Hungarian forwarding company. The feedback about the applicability of the developed evaluation software is absolutely positive and other enterprises are interesting in this software.

Summary

This research is very actual, because the cost reduction and the improvement of transport efficiency are very important goals of all of transport companies because the transportation is one of the most expensive logistical activities.

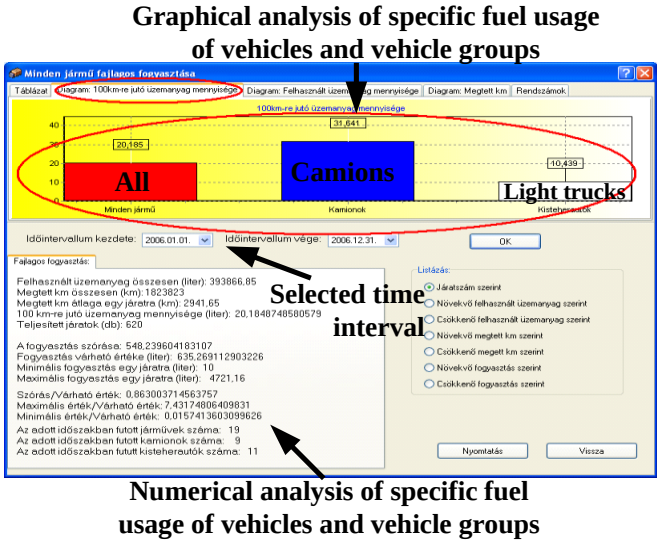

Figure 8. Specific fuel usage of vehicles in a selected time interval

The continuous measurement, high transparency and evaluation of transport performance and efficiency are the requirements of the efficiency improvement and optimisation. The goal of this study was the performance measurement and evaluation of road freight transport activity by key performance indicators. If we can measure the historical and actual performance of processes we can improve it in the future and define objectives and future improvement opportunities. The study is original and unique, because the structure of the 4 most important and common used transport metrics /time utilization, transport way utilization, weight of transported freight, fuel usage/, and the calculation method for these transport metrics were elaborated, relating to vehicles, categories of vehicles and transport trips.

Based on the elaborated structure of transport indicators, evaluation software was developed especially for SMEs for every day application. The involved KPIs are the most common used indicators which are necessary and enough to strategic decision making, therefore the advantage of this evaluation software that absolutely fit to the SME's demands and very cost effective. The developed evaluation software was implemented at a transport company; further companies are also interesting in this new software.

Recently I'm working on the development of a new module of this evaluation software. This module will be an "expert system", which can make suggestions automatically for optimisation of the transport activity based on the results of the evaluations.

References

Bendoly E., Rosenzweig E., Stratman J., 2007. *Performance metric portfolios: a framework and empirical analysis*, "Production Operation Management", 16(2).

Bowersox D., Daugherty P., Droge C., Rogers D., Wradlow D., 1989, *Leading edge logistics competitive positioning for the 1990's*, Council of Logistics Management, Oakbrook.

Bowersox D.J., Closs D.J., 1996, *Logistical management, the integrated supply chain process*, New York: McGraw-Hill.

Cook W.D., Zhu J., 2005, *Modelling performance measurement*, Springer.

Cross K.F., Lynch R.L., 1992, *For good measure*, "CMA Magazine", 66.

Duma L., 1999, *The measurement of the performance of freight transportation*, "Periodica Polytechnica Transportation Engineering", 27(1-2).

Eboli L., Mazzulla G., 2012, *Performance indicators for an objective measure of public transport service quality European Transport*, "Trasporti Europei", 51(3).

Fraunhofer Institute, 2015, *Executive summary*. Available at: http://www.scs.fraunhofer.de/content/dam/ scs/de/dokumente/studien/Top%20100%20EU%202015%20Executive%20Summary.pdf, Access on: 15.09.2016.

Gudehus T., Kotzab H., 2009, *Comprehensive Logistics*, Springer.

Harrington H.J., 1991, *Business process improvement: the breakthrough strategy for total quality, productivity, and competitiveness*, New York: McGraw-Hill.

Kaplan R.S., Norton D.P., 1996, *The Balanced Scorecard - Translating strategy into action*, MA Boston: HBS Press.

Keegan D.P., Eiler R.G., Jones C.R., 1989, *Are your performance measures obsolete?* "Management Accounting", 70(12).

Kot S., Marczyk B., Ślusarczyk B., 2014, *Identification of information systems application in road transport companies in Silesia Region*, "Communications in Computer and Information Science", 471.

Kot S., 2015, *Cost structure in relation to the size of road transport enterprises*, "Promet - Traffic – Traffico", 27(5).

Ross D.F., 2015, *Distribution Planning and Control*, Springer.

Schmitz J., Platts K.W., 2004, *Supplier logistics performance measurement: Indications from a study in the automotive industry*, "International Journal of Production Economics", 89.

Scmwiki 2016, *Transportation metrics*, Available at: https://scmwiki2012.wordpress.com/r/transportation-metrics. Access on: 15.07.2016.

Sinha K.C., Labi S., 2007, *Transportation decision making*, John Wiley&Sons Inc.

Stefko R., Gavurova B., Korony S., 2016. *Efficiency measurement in healthcare work management using Malmquist indices*, "Polish Journal of Management Studies", 13(1).

Thamrin H.M., 2016, *From goal orientation to manager performance: A case on managers of shipping company in Indonesia*, "Polish Journal of Management Studies", 13(2).

ROZWÓJ OPROGRAMOWANIA DO OCENY WYDAJNOŚCI DLA DZIAŁALNOŚCI TRANSPORTU DROGOWEGO

Streszczenie: W rosnącej globalizacji rynku, globalnej konkurencji, w której wymagania klientów stale się zmieniają, przedsiębiorstwa muszą koncentrować się na redukcji kosztów i efektywności. Pomiar procesów i działań jest bardzo ważny, ponieważ jeśli możemy

zmierzyć wydajność procesu, to możemy go w przyszłości poprawić. Pomiar procesów i działań według kluczowych wskaźników efektywności (ang. Key Performance Indicators, KPI) jest często stosowany w przemyśle ogólnym w celu oceny danych historycznych, zidentyfikowania słabych obszarów, określenia obszarów i celów przedsiębiorstwa. Celem tego badania jest pomiar i ocena działalności w zakresie transportu drogowego, ponieważ transport jest jednym z najbardziej kosztownych procesów logistycznych. Początkowo opracowano strukturę 4 najczęściej stosowanych metryk transportu (wykorzystania czasu, wykorzystania środków transportu, ciężaru przewożonego ładunku, zużycia paliwa w pojazdach podczas transportu). Następnie opracowano metodę obliczania tych parametrów transportu. Opierając się na opracowanej strukturze wskaźników transportowych, opracowano oprogramowanie oceniające, które zostało również wprowadzone w tym artykule. Z tego powodu badania są absolutnie oryginalne i niepowtarzalne. Opracowane oprogramowanie oceniające zostało zrealizowane z powodzeniem w firmie spedycyjnej.
Słowa kluczowe: pomiar wydajności, kluczowe wskaźniki wydajności, metryki transportu, oprogramowanie do oceny wydajności

開展道路交通活動性能評估軟件

摘要：在不斷增長的市場全球化，全球競爭中，客戶需求不斷變化，企業必須注重成本降低和效率。過程和活動的測量非常重要，因為如果我們可以衡量過程的性能，我們可以在將來改進。
KPI（關鍵績效指標）的流程和活動測量經常用於一般業務，以評估歷史數據，確定薄弱環節，確定企業的改進領域和目標。
這項研究的目標是對道路貨運活動的績效評估和評估，因為交通運輸是最昂貴的物流過程之一。首先介紹了4種最常用的運輸指標/時間利用率，運輸方式利用率，運輸貨物的重量，與車輛的燃料使用量和運輸行程的結構，然後介紹了這些運輸指標的計算方法。基於運輸指標的詳細結構，本文還介紹了評估軟件。這就是這個研究是絕對原創和獨特的原因。開發的評估軟件在轉發公司成功實施。
關鍵詞：績效評估，關鍵績效指標，運輸指標，評估軟件