road transport; economic effectiveness;
vehicle repair costs; statistical analysis

Paweł DROŹDZIEL*, Henryk KOMSTA, Leszek KRZYWONOS
Lublin University of Technology
ul. Nadbystrzycka 36, 20-618 Lublin, Poland
**Corresponding author*. E-mail: p.drozdziel@pollub.pl

AN ANALYSIS OF COSTS OF VEHICLE REPAIRS IN A TRANSPORTATION COMPANY. PART II

Summary. This paper presents the next results of the statistical analysis of the operating parameters of numbers of vehicle, which was operated by the Poczta Polska (Polish Mail) delivery office in Lublin. The calculations were based on data from service in the years 2008–2010.

ANALIZA KOSZTÓW NAPRAW POJAZDÓW NA PRZYKŁADZIE WYBRANEJ FIRMY TRANSPORTOWEJ. CZ. II

Streszczenie. W artykule opisano dalsze wyniki analizy statystycznej wybranych parametrów eksploatacyjnych populacji pojazdów należących do lubelskiego centrum logistycznego Poczty Polskiej. Obliczenia przeprowadzono na podstawie danych zebranych w latach 2008–2010.

1. INTRODUCTION

The most important criterion used in the assessment of a transport system is intensity of vehicle use, defined as the number of kilometers travelled by a car within a specified period of time (day, month, or year). It is this index that determines other parameters of operation and maintenance, such as vehicle life, the income from transportation services, drivers' working time, etc. [6, 8, 10].

Another important parameter is the costs related to services and repairs of the vehicles used by a transport company. Repair costs are sums of the costs of operating materials and components plus labour costs of the staff working at a repair station. The costs of operating materials and components include the costs of individual elements, parts and assemblies, and fluids (lubricating oil, brake fluid, etc.), excluding fuel costs.

It seems interesting to perform a comprehensive statistical analysis of costs of replacement of operating materials and components for a specific car transport system. An analysis like that will allow evaluation of the economic effectiveness of a given transport system [1, 2, 9, 11].

The present study is a continuation of a paper presented at the 2012 Transport Problems Conference. It presents results of the analysis of variance of the costs of replacement of operating materials and components in vehicles operated by Poczta Polska (Polish Mail) in Lublin in the years 2008–2010 with one-month observation periods.

2. A CHARACTERIZATION OF THE ANALYZED POPULATION OF VEHICLES

In part 1 of this article, an analysis was carried out of a number of 116 vehicles operated in the Lublin division of the Logistics Center of the Polish Mail. Those vehicles performed a variety of transportation tasks following from the role of the Polish Mail as the national postal operator. On the basis of earlier analyses conducted by the present authors [4, 5, 7], the cars were divided into three groups, applying the criterion of load space volume. Group I included 32 passenger cars with small load space volumes (in the class of the Citroen Berlingo), which ran between post boxes and postal mail receivers in the city of Lublin and vicinity. Group II was made up of 60 delivery trucks with medium load space volumes (in the class of the Ford Transit), which carried mail between post offices in the city of Lublin and in the former Lublin voivodeship. Group III included 24 vehicles with large load space volumes (in the class of the Iveco Stralis), which transported mail between the Lublin center and the remaining distribution and sorting centers of the Polish Mail located all over the country.

3. RESULTS OF STATISTICAL ANALYSES

In this part of the study, an analysis of variance was performed for the mean value of monthly costs of replacement of operating materials and components in vehicles operated in the Polish Mail company in Lublin over the span of three years, from 2008 to 2010.

Due to the lack of equality of the obtained empirical distributions to the normal distribution, the classical analysis of variance could not be used. Instead, a non-parametric method using the Kruskal-Wallis test **KW** was employed [3]. The results for vehicles from group I are shown in Table 1.

Table 1

Results of the Kruskal-Wallis (**KW**) test of equality of mean monthly costs of replacement of operating materials and components in group I vehicles (grouping factor – month of operation)

Group	Year	Value of the **KW**-statistic	*p*-value
I	2008	20.6779	0.0369
	2009	24.2445	0.0109
	2010	8.6289	0.6561
	2008–2010	12.3442	0.3383

The results of the calculations presented in Table 1 indicate that for vehicles from group I, at the level of significance 0.05, the hypothesis of the equality of the mean values of monthly costs of replacement of operating materials and components in the individual months of operation in the years 2008 and 2009 should be rejected. In the case of the last of the analyzed years, such hypothesis should be adopted for the sum of monthly replacement costs over the three years.

These results testify to the fact that for vehicle group I, the month of operation had no effect on the monthly costs of replacement of operating materials and components. The mean monthly value of those costs was about 200 PLN per car over the span of the three years of observation. Fig. 1 shows a categorized box-and-whisker plot for monthly costs of replacement of operating materials and components in group I vehicles.

Results of the analysis of variance carried out for group II vehicles using the Kruskal-Wallis test are shown in Table 2.

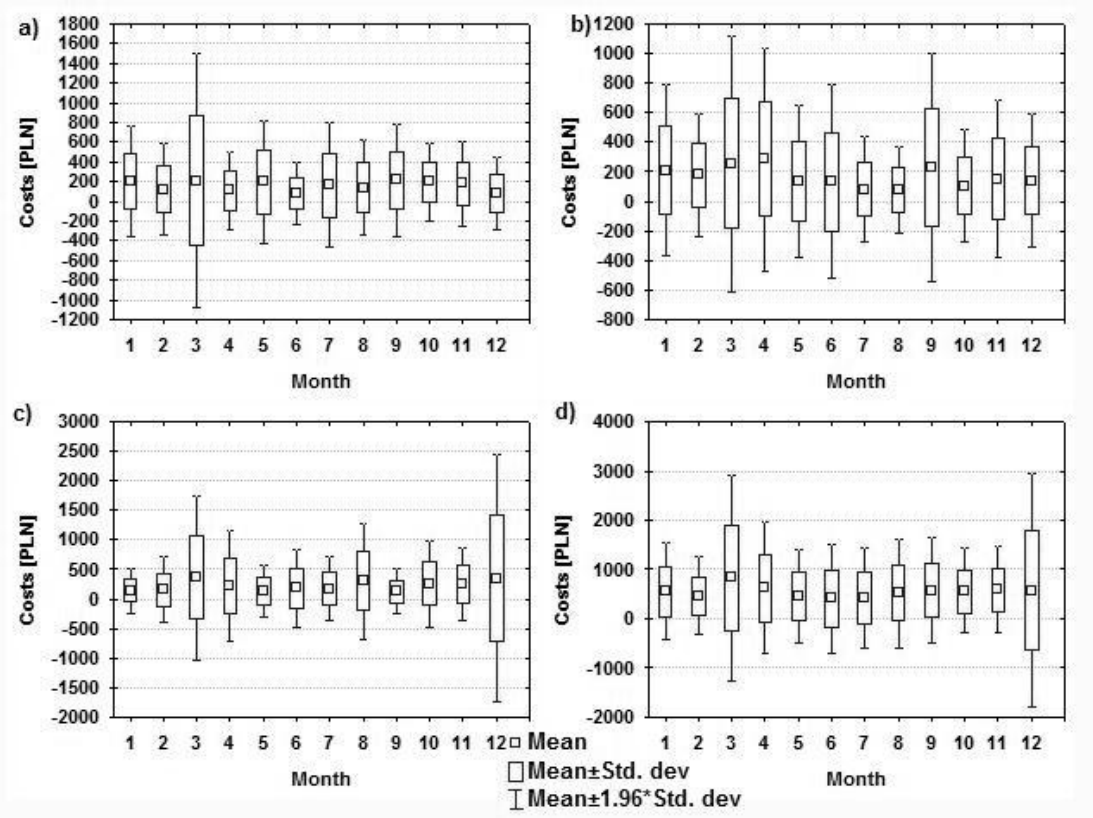

Fig. 1. A categorized box plot for the independent factor – month of operation, and the dependent variable – monthly costs of replacement of operating materials and components in group I vehicles; a) year 2008, b) year 2009, c) year 2010, d) sum of monthly costs in the period 2008-2010

Rys. 1. Skategoryzowany wykres ramkowy dla czynnika niezależnego (miesiąca eksploatacji) oraz zmiennej zależnej (miesięcznej wartości kosztów wymiany rzeczowych czynników eksploatacji pojazdów I grupy I); a) rok 2008, b) rok 2009, c) rok 2010, d) suma miesięcznych kosztów w latach 2008-2010

Table 2

Results of the Kruskal-Wallis (**KW**) test of equality of mean monthly costs of replacement of operating materials and components in group II vehicles (grouping factor – month of operation)

Group	Year	Value of the **KW**-statistic	*p*-value
II	2008	13.2882	0.2749
	2009	20.1418	0.0434
	2010	26.4579	0.005
	2008–2010	17.8852	0.0843

The results of the calculations presented in Table 2 also shows that for vehicles from group II, at the level of significance 0.05, the hypothesis of the equality of the mean values of monthly costs of replacement of operating materials and components in the individual months of operation in the years 2009 and 2010 should be rejected. The hypothesis should be adopted for the year 2008 for the sum of monthly replacement costs within the period of the three analyzed years. Fig. 2 shows a categorized box-and-whisker plot for monthly costs of replacement of operating materials and components in group II vehicles.

Next, an analysis of variance using the Kruskal-Wallis test was conducted for group III vehicles. The results are shown in Table 3.

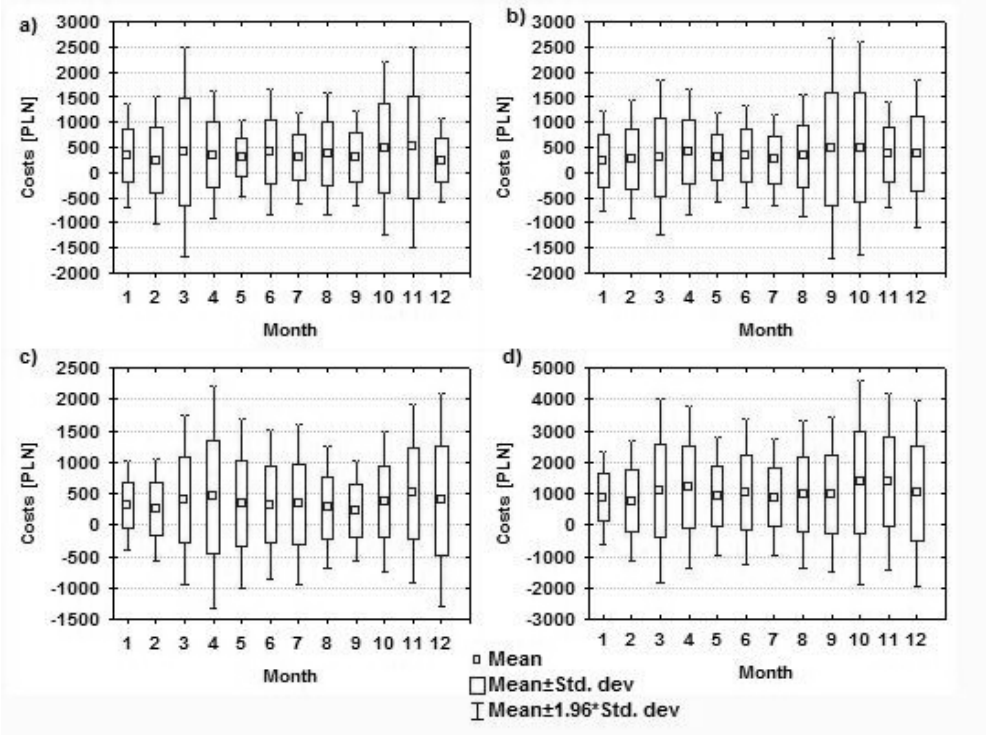

Fig. 2. A categorized box plot for the independent factor – month of operation, and the dependent variable – monthly costs of replacement of operating materials and components in group II vehicles; a) year 2008, b) year 2009, c) year 2010, d) sum of monthly costs in the period 2008-2010

Rys. 2. Skategoryzowany wykres ramkowy dla czynnika niezależnego (miesiąca eksploatacji) oraz zmiennej zależnej (miesięcznej wartości kosztów wymiany rzeczowych czynników eksploatacji pojazdów II grupy); a) rok 2008, b) rok 2009, c) rok 2010, d) suma miesięcznych kosztów w latach 2008-2010

Table 3

Results of the Kruskal-Wallis (**KW**) test of equality of mean monthly costs of replacement of operating materials and components in group III vehicles (grouping factor – month of operation)

Group	Year	Value of the **KW**-statistic	*p*-value
III	2008	8.2481	0.6909
	2009	33.1350	0.0005
	2010	21.5215	0.0284
	2008–2010	13.8870	0.2393

The results of the calculations presented in Table 3 indicates that for vehicles from group III, at the level of significance 0.05, the hypothesis of the equality of the mean values of monthly costs of replacement of operating materials and components in the individual months of operation in the years 2009 and 2010 should be rejected. In the case of the first of the analyzed years, 2008, such hypothesis should be adopted for the sum of monthly replacement costs over the three years.

The results show that for vehicle group III, the month of operation had no effect on the monthly costs of replacement of operating materials and components. The mean monthly value of those costs for vehicles in this group was about 550 PLN. Fig. 3 shows a categorized box-and-whisker plot for monthly costs of replacement of operating materials and components in group III vehicles.

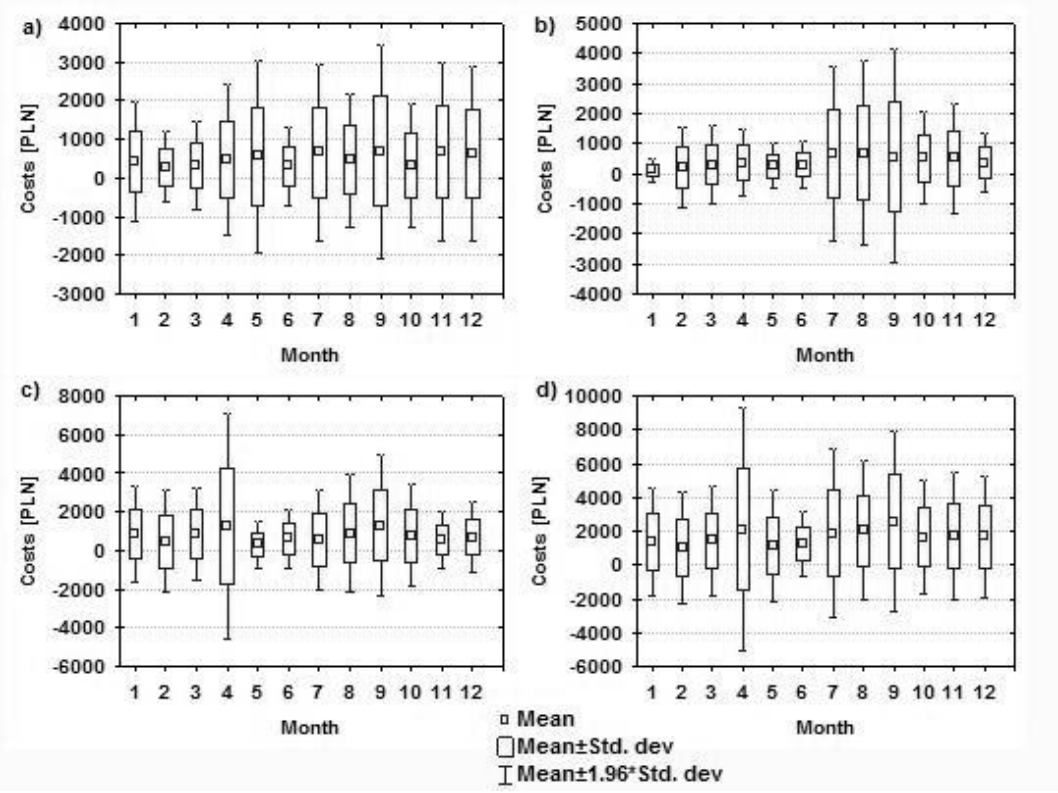

Fig. 3. A categorized box plot for the independent factor – month of operation, and the dependent variable – monthly costs of replacement of operating materials and components in group III vehicles; a) year 2008, b) year 2009, c) year 2010, d) sum of monthly costs in the period 2008-2010

Rys. 3. Skategoryzowany wykres ramkowy dla czynnika niezależnego (miesiąca eksploatacji) oraz zmiennej zależnej (miesięcznej wartości kosztów wymiany rzeczowych czynników eksploatacji pojazdów III grupy); a) rok 2008, b) rok 2009, c) rok 2010, d) suma miesięcznych kosztów w latach 2008-2010

A comparison of the mean values of monthly costs of replacement of operating materials and components for the three investigated groups of vehicles (Figs. 1–3) shows that the value of those costs increased with the volume of the load space. This indicates that the criterion of division had been appropriately adopted.

As a final step in the analyses, it was tested whether the means of monthly costs of replacement of operating materials and components in the investigated vehicles of the Polish Mail in Lublin differed significantly statistically in the individual years of observation. Again, the Kruskal-Wallis test was used for this purpose. The results are shown in Table 4.

Table 4

Results of the Kruskal-Wallis (**KW**) test of equality of mean monthly costs of replacement of operating materials and components for all vehicles (grouping factor – month of operation)

Group	Year	Value of the **KW**-statistic	*p*-value
All	2008	21.2244	0.0311
	2009	23.1242	0.0170
	2010	33.1761	0.0005
	2008–2010	22.6775	0.0196

The results of the calculations presented in Table 4 unequivocally indicates that for the investigated vehicles belonging to the fleet of the Polish Mail in Lublin, at the level of significance 0.05, the hypothesis of the equality of the mean values of monthly costs of replacement of operating materials and components in the individual months of operation in the analyzed 3-year period should be rejected.

This testifies to the fact that for these vehicles, the month of operation had a statistically significant effect on the monthly costs of replacement of operating materials and components incurred by the company. Fig. 4 shows a categorized box-and-whisker plot for monthly costs of replacement of operating materials and components in all the investigated vehicles.

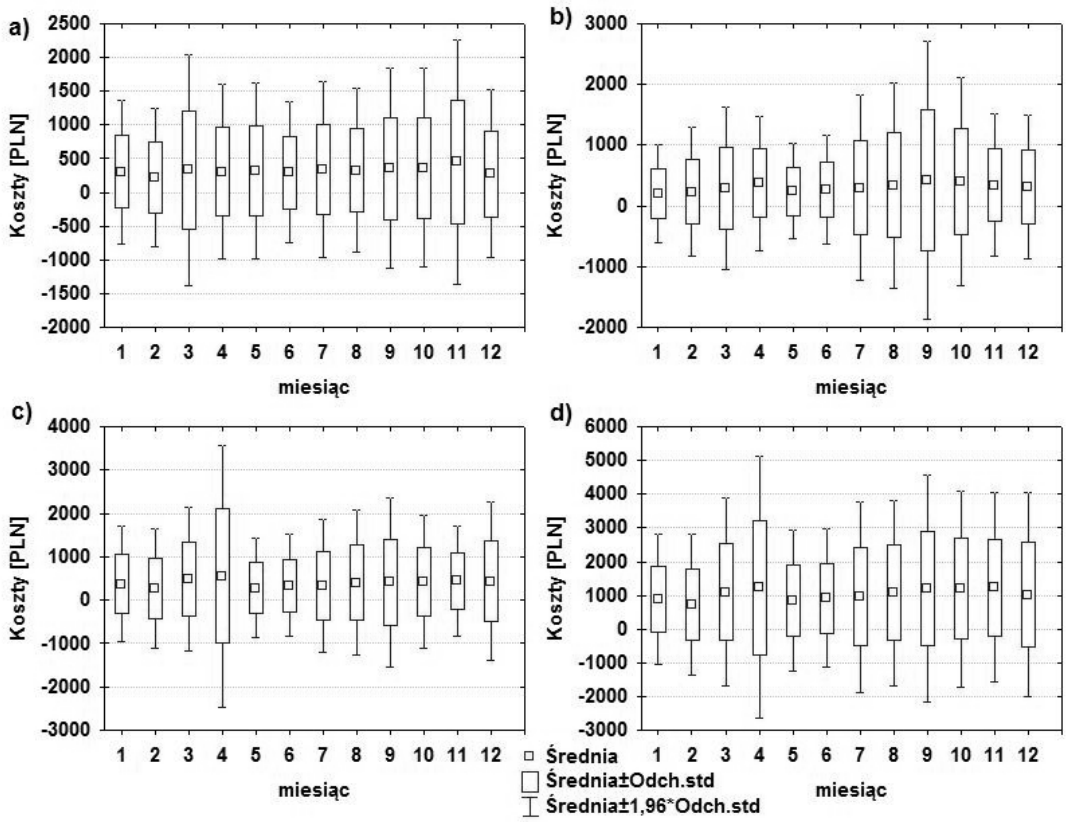

Fig. 4. A categorized box plot for the independent factor – month of operation, and the dependent variable – monthly costs of replacement of operating materials and components in the vehicles of the Polish Mail in Lublin; a) year 2008, b) year 2009, c) year 2010, d) sum of monthly costs in the period 2008-2010

Rys. 4. Skategoryzowany wykres ramkowy dla czynnika niezależnego (miesiąca eksploatacji) oraz zmiennej zależnej (miesięcznej wartości kosztów wymiany rzeczowych czynników eksploatacji wszystkich pojazdów); a) rok 2008, b) rok 2009, c) rok 2010, d) suma miesięcznych kosztów w latach 2008-2010

By analysing the box-and-whisker plots in Fig. 4 and conducting calculations using the NIR and the Duncan tests [3], we were able to demonstrate that there were two groups of months for which significant differences between the discussed mean monthly costs were observed.

A first group included 5 months: 3, 4, 9, 10 and 11. A second group included the remaining months of the year. The mean values of monthly costs of replacement of operating materials and components in the first of those groups were significantly higher than in the second group.

The higher mean values were probably a consequence of the impact of weather conditions on transport conditions (the autumn period) as well as an increase in the intensity of use of the vehicles by the Polish Mail company in the Easter period. The deterioration of transport conditions in autumn leads to more frequent failures and traffic collisions, which significantly enhance the costs of auto repairs. This also causes an increase in the amount of mail carried.

4. CONCLUSIONS

The results of the statistical analyses conducted in this paper for real-life data from three - year observations related to the monthly costs of replacement of operating materials and components in delivery vehicles of the Polish Mail company in Lublin permit the following statements to be made:

1) The differences in the mean values of monthly costs of replacement of operating materials and components for the three investigated groups of delivery vehicles shows that the criterion of division according to load space volume is accurate.
2) The observed differences in the mean values of monthly costs of replacement of operating materials and components over the span of the analyzed years 2008–2010 are the effect of weather conditions and the specific character of the business activities carried out by the Polish Mail company.

Bibliography

1. Bachmann R., Langevin A.: A vehicle cost evaluation algorithm for the strategic analysis of radial distribution networks. Transportation Research Part E, 45, 2009, pp. 50-60.
2. Buková B., Brumerčíková E.: The role of innovation in transport company, LOGI 2010 (11th International Scientific Conference LOGI 2010, Pardubice 19.11.2010), Brno (Czech Republic), Tribun EU 2010, pp.15-23.
3. Dobosz M.: Wspomagana komputerowo statystyczna analiza wyników badań [Computer-assisted Statistical Analysis of Research Results]. EXIT Publishers, Warszawa, 2004 (in Polish).
4. Droździel P., Komsta H., Krzywonos L.: Analiza intensywności użytkowania pojazdów (Część I) [An analysis of vehicle use intensity (Part I)], Logistyka, Institute of Logistics and Warehousing, Poznań, 2012 [in press].
5. Droździel P., Komsta H., Krzywonos L.: An analysis of the relationships among selected operating and maintenance parameters of vehicles used in a transportation company. Transport Problems, vol. 6, issue 4, Silesian University of Technology Publishing House, Gliwice 2011, pp. 93-99.
6. Hlavňa V., Kukuča P., Isteník R., Labuda R., Liščák Š.: Dopravný prostriedok a jeho motor. Žilina (Slovak Republic), EDIS–Žilina University Publisher, 2000 (in Slovak).
7. Komsta H., Krzywonos L., Winiarski G.: An analysis of the intensity of vehicle use using the example of the Polish Mail company; Doprava a spoje – Internetový časopis (online journal of the Faculty of Operation and Economics of Transport and Communications of the University of Zilina (Slovak Republic)), vol. 2011/2, pp. 66–70, http://fpedas.uniza.sk/dopravaaspoje.
8. Mendyk E.: Ekonomika transportu [The Economics of Transport]. Poznan School of Logistics, Poznan 2009 (in Polish).
9. Redmer A.: Optimisation of exploitation period of individual vehicles in freight transportation companies. Transportation Research Part E, 45, 2009, pp. 978-987.
10. Rydzykowski W., Wojewódzka-Król K.: Transport. PWN, Warszawa, 2009 (in Polish).
11. Sahin B., Yilmaz H., Ust Y., Guneri A. F., Gulsun B.: An approach for analyzing transportation costs and a case study. European Journal of Operational Research, 193, 2007, pp. 1-11.

Received 15.05.2011; accepted in revised form 02.09.2012