intensity of vehicle use; repair costs; correlation analysis

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REPAIR COSTS AND THE INTENSITY OF VEHICLE USE

Summary. This paper presents correlation analyses of real-life data associated with the intensity of use of vehicles and the costs of replacement of operating materials and components performed in a three-year period for delivery vans, which was operated by the Poczta Polska (Polish Mail) delivery office in Lublin.

KOSZTY NAPRAW A INTENSYWNOŚĆ UŻYTKOWANIA POJAZDÓW

Streszczenie. W artykule opisano wyniki analiz korelacyjnych wykonanych dla rzeczywistych danych związanych z intensywnością użytkowania pojazdów oraz kosztami wymiany rzeczowych czynników eksploatacji w okresie trzech lat dla samochodów dostawczych należących do lubelskiego centrum logistycznego Poczty Polskiej.

1. INTRODUCTION

The possibility of predicting the repair costs to be incurred during vehicle use allows specialists to prognosticate the economic efficiency of performing particular transportation services. This is important when determining freight rates and designing business development strategies based on introduction of innovative transport technologies [1, 3, 7]. It is widely known that the economic efficiency of a transport system depends on many interacting operating factors, such as the intensity of use of vehicles, transportation service rates, personnel costs, costs of maintenance materials, taxes, insurance, etc. The most important factor that directly affects the income derived from a transportation service is the intensity of vehicle use. It is defined as the mileage (in kilometers) travelled by a car within a specified period of time (day, month or year). The value of this index affects other parameters of operation and maintenance, such as vehicle life, the driver's working time, etc. [2, 9, 10].

Another important factor in maintaining a means of transport that affects the economic efficiency of transport are the costs associated with service and repair of vehicles. Repair costs are made out of two types of cost: the costs of operating materials and components plus labor costs of the staff working at a repair station. Operating materials and components include elements, parts, systems, various sub-assemblies and assemblies, as well as fluids (engine oil, brake fluid, etc.). They do not include the costs of fuel consumed during transport [5, 8, 11].

It seems important, primarily from the utilitarian point of view, to perform a correlation analysis between the intensity of use of a means of transport and the cost of replacement of operating materials and components of the vehicle incurred during its use. The results of such a statistical analysis for an actual transport system may be useful for freight carriers when making decisions related to planning a business strategy [6, 9, 12].

This article presents the results of correlation analyses of real-life data associated with the intensity of use of vehicles and the costs of replacement of operating materials and components performed in a three-year period for delivery vans of Poczta Polska (the Polish Mail) in Lublin.

2. MATERIAL

The analysis presented in this article covered a group of 116 cars used by Poczta Polska in Lublin in the period of three years (2008–2010). This group consisted of vehicles of different makes and types, which performed a variety of transportation tasks specific to the manner of operation of postal service. The vehicles were divided into three groups, which differed primarily in cargo capacity. Subgroup I were LCV vans (e.g., the Fiat Doblo), which ran between mailboxes and carried mail in the urban area of the city of Lublin and its vicinity. This group consisted of 32 cars.

MCV vans (e.g., the VW Transporter) were sub-group II. These vehicles moved a variety of mail between post offices in the city of Lublin and the former Lublin province. This group consisted of 60 vehicles. Lorries, characterized by the highest cargo capacity (e.g., the IVECO Stralis) represented sub-group III. These vehicles transported mail mainly on routes between regional logistics centres of Poczta Polska, thus connecting Lublin with other capitals of Polish provinces. This group comprised 24 vehicles.

3. CORRELATION ANALYSIS

Statistical analyses of data related to monthly and annual intensity of use of the vehicles of Poczta Polska as well as their total mileage (travelled over three years) and the corresponding costs of replacing operating materials and components, were performed using Statistica PL software, version 7. The coefficients of linear correlation [4] between the parameters analyzed within one month of use of the three subgroups of cars are shown in Table 1.

Table 1

Coefficients of linear correlation between monthly costs of replacement of operating materials and components and the monthly intensity of vehicle use in the test subgroups along with their levels of significance

Year	Subgroup I	Subgroup II	Subgroup III
2008	−.039 *p*=.449	−.091 *p*=.015	−.017 *p*=.768
2009	−.025 *p*=.631	.002 *p*=.949	−.064 *p*=.279
2010	−.138 *p*=.007	−.079 *p*=.033	−.0975 *p*=.099

The results of the calculations of linear correlation coefficients shown in Table 1 indicate that there is no relationship between the monthly intensity of vehicle use and the costs of replacement of operating materials and components. Figures 1–3 present scatter plots of monthly intensity of vehicle use as a function of the costs of replacement of operating materials and components in the test subgroups in the successive years. A regression line was also plotted in those figures together with 95% confidence intervals for predicted mean and individual observations.

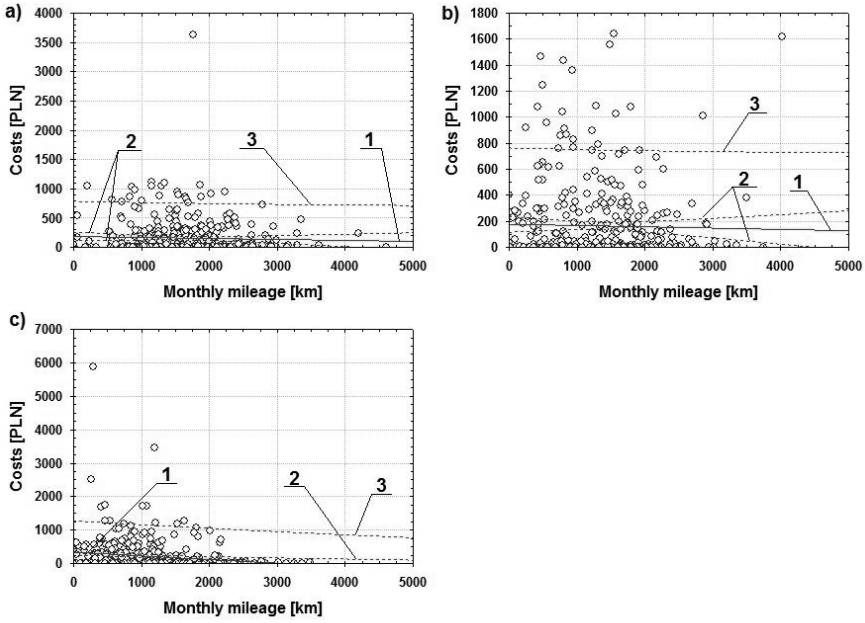

Fig. 1. Scatter plots of monthly intensity of vehicle use and the costs of replacement of operating materials and components for subgroup I vehicles; 1 – regression line, 2 – confidence interval for predicted mean observation, 3 – confidence interval for predicted observation; a) year 2008, b) year 2009, c) year 2010

Rys. 1. Wykres rozrzutu miesięcznej intensywności użytkowania oraz miesięcznych kosztów wymiany rzeczowych czynników eksploatacji dla pojazdów podgrupy nr I; 1 – prosta regresji, 2 – przedział ufności dla prognozowanej średniej obserwacji, 3 – przedział ufności dla prognozowanej obserwacji; a) rok 2008, b) rok 2009, c) rok 2010

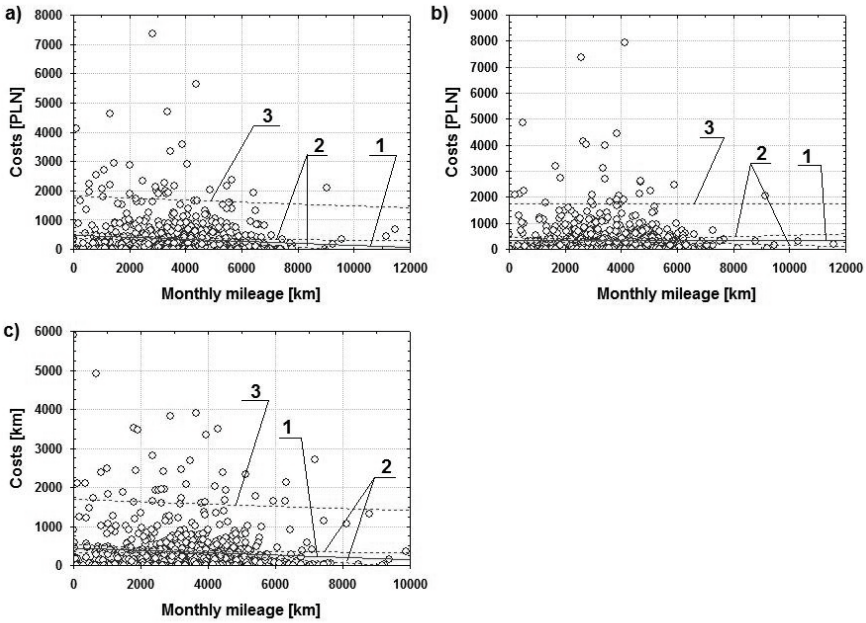

Fig. 2. Scatter plots of monthly intensity of vehicle use and the costs of replacement of operating materials and components for subgroup II vehicles; 1 – regression line, 2 – confidence interval for predicted mean observation, 3 – confidence interval for predicted observation; a) year 2008, b) year 2009, c) year 2010

Rys. 2. Wykres rozrzutu miesięcznej intensywności użytkowania oraz miesięcznych kosztów wymiany rzeczowych czynników eksploatacji dla pojazdów podgrupy nr II; 1 – prosta regresji, 2 – przedział ufności dla prognozowanej średniej obserwacji, 3 – przedział ufności dla prognozowanej obserwacji; a) rok 2008, b) rok 2009, c) rok 2010

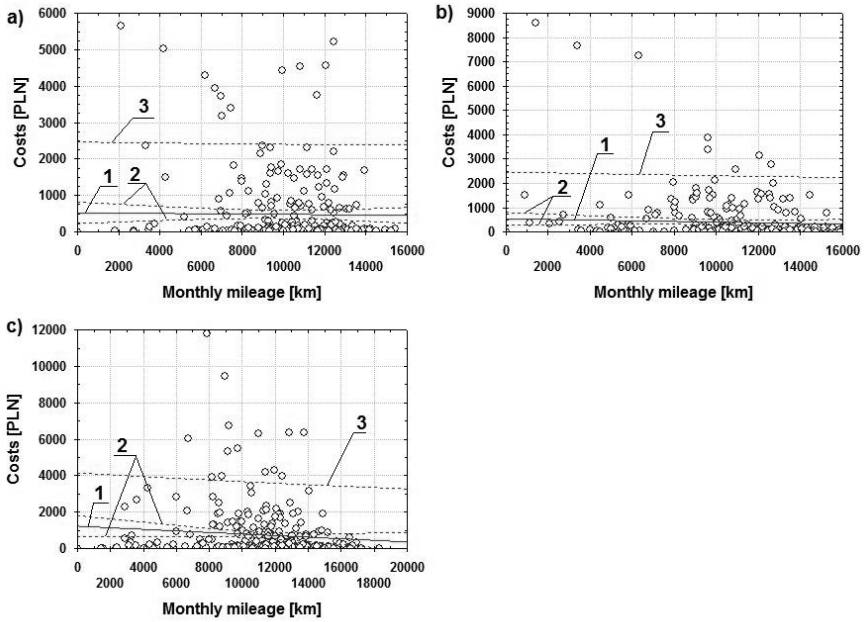

Fig. 3. Scatter plots of monthly intensity of vehicle use and the costs of replacement of operating materials and components for subgroup III vehicles; 1 – regression line, 2 – confidence interval for predicted mean observation, 3 – confidence interval for predicted observation; a) year 2008, b) year 2009, c) year 2010

Rys. 3. Wykres rozrzutu miesięcznej intensywności użytkowania oraz miesięcznych kosztów wymiany rzeczowych czynników eksploatacji dla pojazdów podgrupy nr III; 1 – prosta regresji, 2 – przedział ufności dla prognozowanej średniej obserwacji, 3 – przedział ufności dla prognozowanej obserwacji; a) rok 2008, b) rok 2009, c) rok 2010

Coefficients of linear correlation between annual intensity of vehicle use and corresponding costs of replacement of operating materials and components for the three test subgroups are shown in Table 2.

Table 2

Coefficients of linear correlation between annual costs of replacement of operating materials and components and the annual intensity of vehicle use for the test subgroups along with levels of significance

Year	Subgroup I	Subgroup II	Subgroup III
2008	.446 *p*=.01	.225 *p*=.084	.238 *p*=.262
2009	.344 *p*=.053	.371 *p*=.004	−.328 *p*=.117
2010	.336 *p*=.06	.376 *p*=.003	.134 *p*=.531

The results of the calculations of linear correlation coefficients shown in Figure 2 point to the existence of a moderate relationship between annual intensity of use of vehicles belonging to subgroups I and II and the costs of replacement of operating materials and components within a one-year period. This is reflected in the values of linear correlation coefficients along with their levels of significance. In the case of vehicles belonging to subgroup III, the relationships observed between the two parameters analyzed were weaker.

Figures 4-6 show scatter plots of annual intensity of vehicle use as a function of the costs of replacement of operating materials and components in the successive years. Also, a regression line (and its equation) was plotted in those figures together with 95% confidence intervals for predicted mean value and predicted individual observation.

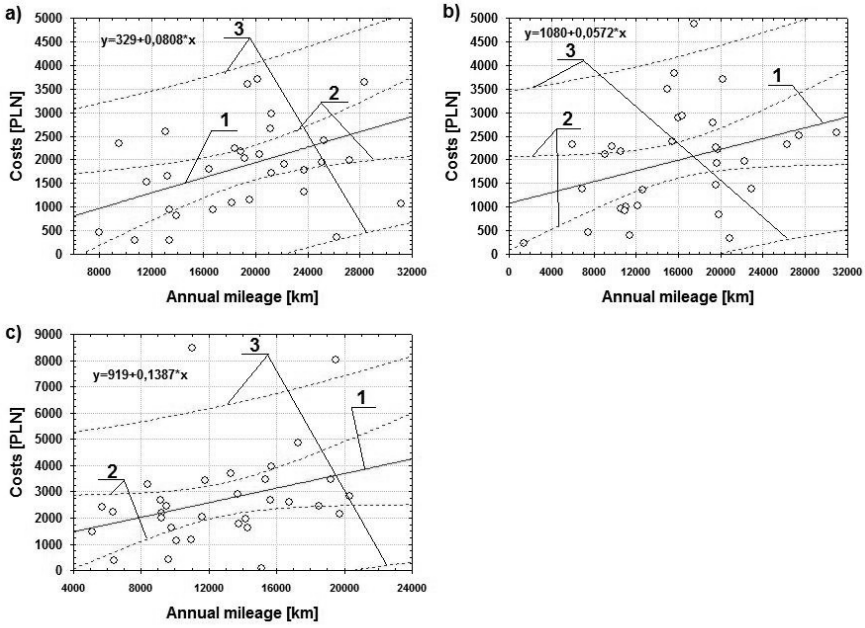

Fig. 4. Scatter plot of annual intensity of vehicle use and annual costs of replacement of operating materials and components for subgroup I vehicles; 1 – regression line, 2 – confidence interval for predicted mean observation, 3 – confidence interval for predicted observation; a) year 2008, b) year 2009, c) year 2010

Rys. 4. Wykres rozrzutu rocznej intensywności użytkowania oraz rocznych kosztów wymiany rzeczowych czynników eksploatacji dla pojazdów podgrupy nr I; 1 – prosta regresji, 2 – przedział ufności dla prognozowanej średniej obserwacji, 3 – przedział ufności dla prognozowanej obserwacji; a) rok 2008, b) rok 2009, c) rok 2010

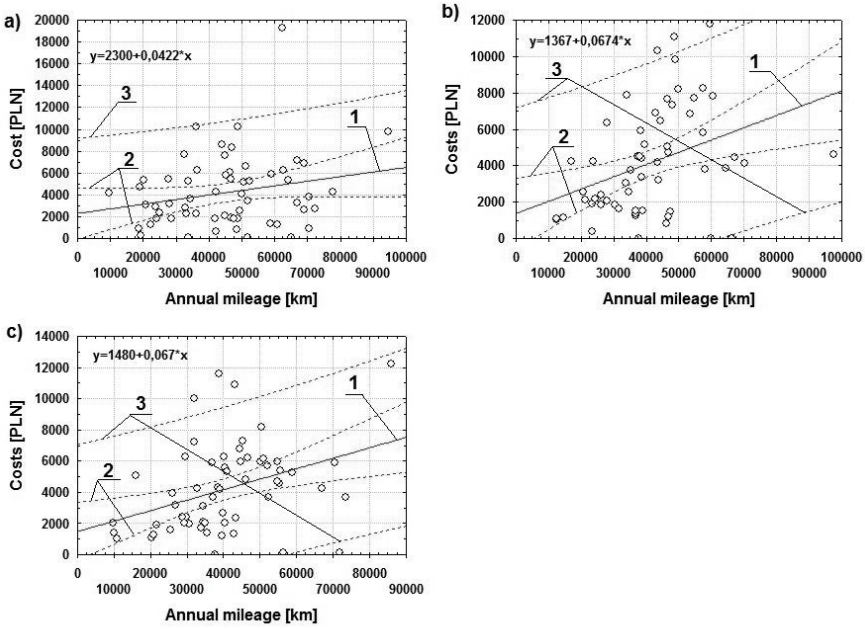

Fig. 5. Scatter plot of annual intensity of vehicle use and annual costs of replacement of operating materials and components for subgroup II vehicles; 1 – regression line, 2 – confidence interval for predicted mean observation, 3 – confidence interval for predicted observation; a) year 2008, b) year 2009, c) year 2010

Rys. 5. Wykres rozrzutu rocznej intensywności użytkowania oraz rocznych kosztów wymiany rzeczowych czynników eksploatacji dla pojazdów podgrupy nr II; 1 – prosta regresji, 2 – przedział ufności dla prognozowanej średniej obserwacji, 3 – przedział ufności dla prognozowanej obserwacji; a) rok 2008, b) rok 2009, c) rok 2010

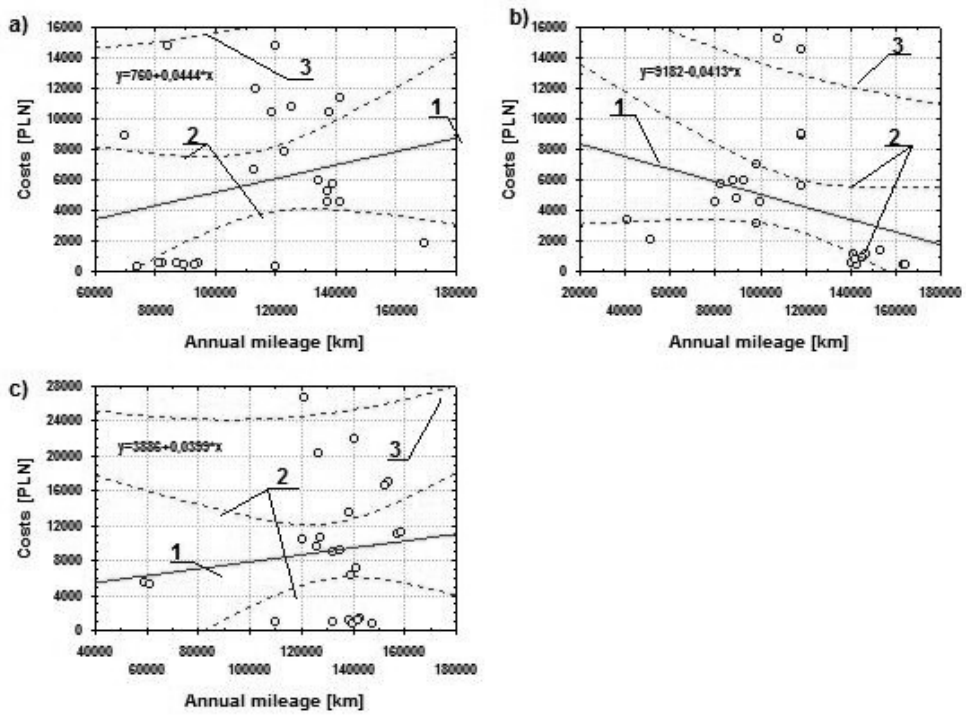

Fig. 6. Scatter plot of annual intensity of vehicle use and annual costs of replacement of operating materials and components for subgroup III vehicles; 1 – regression line, 2 – confidence interval for predicted mean observation, 3 – confidence interval for predicted observation; a) year 2008, b) year 2009, c) year 2010

Rys. 6. Wykres rozrzutu rocznej intensywności użytkowania oraz rocznych kosztów wymiany rzeczowych czynników eksploatacji dla pojazdów podgrupy nr III; 1 – prosta regresji, 2 – przedział ufności dla prognozowanej średniej obserwacji, 3 – przedział ufności dla prognozowanej obserwacji; a) rok 2008, b) rok 2009, c) rok 2010

Coefficients of linear correlation between total mileage travelled over the three years and the corresponding costs of replacement of operating materials and components for the three test subgroups are shown in Table 3.

Table 3

Coefficients of linear correlation between total costs of replacement of operating materials and components and total mileage travelled in the analyzed 3-year period for the test subgroups along with levels of significance

Subgroup I	**Subgroup II**	**Subgroup III**
.482	.416	−.060
p=.005	p=.001	p=.778

The results of the calculations of linear correlation coefficients shown in Figure 3 point to the existence of moderate statistically significant relationships between total mileage travelled by subgroup I and II vehicles of Poczta Polska in Lublin and the costs of replacement of operating materials and components in the analysed 3-year period. This is reflected in the values of linear correlation coefficients along with their levels of significance. No relationships were observed for subgroup III vehicles. This is caused by excessive scatter of the values of the costs of replacement of operating materials and components in the analysed period, which is clearly seen in Figure 7.

Figure 7 shows scatter plots of total mileage as a function of the costs of replacement of operating materials and components in the three-year period of operation of the test vehicles. Also, a regression line was plotted in this figure (with its equation) together with 95% confidence intervals for the predicted mean and the predicted individual observation.

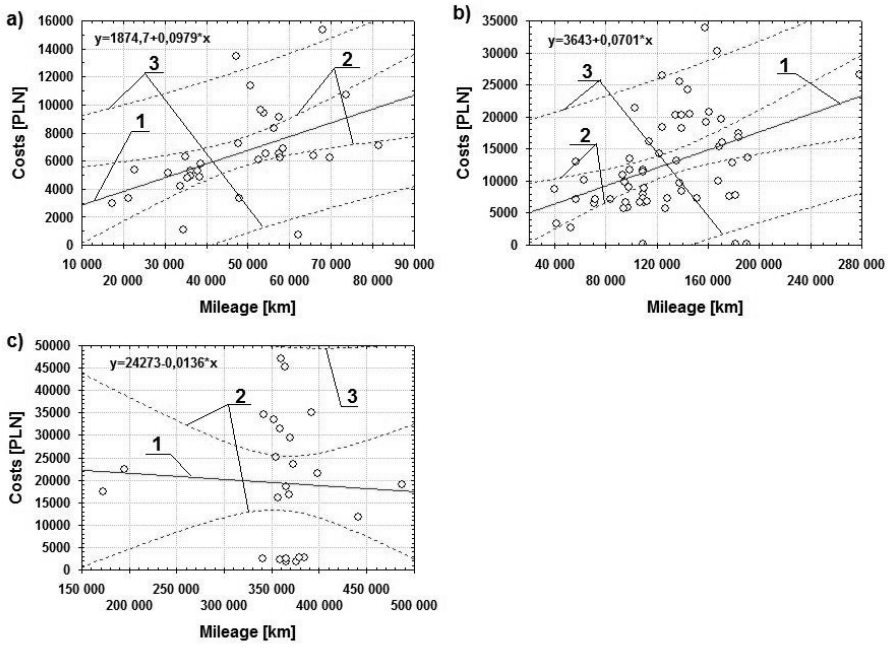

Fig. 7. Scatter plot of total mileage and the costs of replacement of operating materials and components for the three subgroups in the analyzed 3-year period; 1 – regression line, 2 – confidence interval for predicted mean observation, 3 – confidence interval for predicted observation; a) subgroup I, b) subgroup II, c) subgroup III

Rys. 7. Wykres rozrzutu sumarycznego przebiegu oraz kosztów wymiany rzeczowych czynników eksploatacji dla pojazdów w okresie 3 lat; 1 – prosta regresji, 2 – przedział ufności dla prognozowanej średniej obserwacji, 3 – przedział ufności dla prognozowanej obserwacji; a) podgrupa nr I, b) podgrupa nr II, c) podgrupa nr III

4. CONCLUSIONS

The results of the correlation analyses presented in this study for data from three-year observations related to the costs of replacement of operating materials and components and the intensity of use of vehicles in the fleet of the Polish Mail company in Lublin confirm the fact that service and repair costs grow along with increasing intensity of vehicle use.

It is observed, at the same time, that the costs of replacement of operating materials and components in LCVs, as a function of intensity of use, grow faster than in MCVs. This is reflected in higher values of direction coefficients of the regression lines defining the dependence of service and repair costs on intensity of vehicle use. This confirms the fact that cars which travel mainly in urban conditions (high load variation) are characterized by a larger number of failures and faults.

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