AN ANALYSIS OF THE INTENSITY OF VEHICLE USE USING THE EXAMPLE OF THE POLISH MAIL COMPANY

Henryk Komsta[1], Leszek Krzywonos[2] and Grzegorz Winiarski[3]

1. Introduction

There are many indices that can be used to evaluate and compare transportation systems of transport companies. These indices include profit from transportation services, mass of cargo transported and costs of personnel, fuel, lubricating oil, repairs, etc. One of the most important of those parameters is the intensity of vehicle use. It is expressed as the number of kilometres travelled by a car within a specified period of time (day, month or year). The intensity of use plays an important role because it affects many other factors and indices, such as vehicle life, the costs and the profits from transportation services, drivers' working time and other parameters of car operation [2, 3, 4, 5, 6].

For that reason, it seems that a detailed analysis of data related to intensity of vehicle use is vital and instrumental in the evaluation of a given transportation system. The paper presents and discusses results of statistical analyses of data concerning the intensity of use of delivery vans operated by Poczta Polska (the Polish Mail company) in Lublin.

2. Material

Statistical analyses were carried out using data collected for 179 vehicles operated in 2009 by the Polish Mail delivery office in Lublin. The population of the transport vehicles tested was diversified with respect to type and make. Because of this, the study population was divided into three groups characterised by different load space volumes.

Group I consisted of 47 passenger vehicles with small load space volumes (e.g., the Citroën Xsara). The cars in this group ran between post boxes and were used to deliver mail in the city of Lublin and area. Group II comprised 85 delivery vans with medium load space volumes (e.g., the Ford Transit). They moved mail between post offices in the city of Lublin and the former Lublin voivodeship. In group III, there were 47 vehicles with large load space

---

[1] prof. dr hab. inż. Henryk Komsta, Lublin University of Technology, Faculty of Mechanical Engineering, Department of Combustion Engines and Transport, Nadbystrzycka 36, 20-618 Lublin, Poland, h.komsta@pollub.pl

[2] dr inż. Leszek Krzywonos, Lublin University of Technology, Faculty of Mechanical Engineering, Department of Machine Design, Nadbystrzycka 36, 20-618 Lublin, Poland, l.krzywonos@pollub.pl

[3] Grzegorz Winiarski, student, Lublin University of Technology, Faculty of Mechanical Engineering, Department of Machine Design, Nadbystrzycka 36, 20-618 Lublin, Poland

volumes (e.g., the Volvo FM12). They carried postal packets between logistics centres of the Polish Mail outside the former Lublin voivodeship.

3. Results of statistical analyses of vehicle mileage rates

Vehicle mileage rate data provided by the Polish Mail in Lublin were analysed statistically using STATISTICA® software. Results for the entire study population and the individual groups of vehicles are shown in Tab. 1.

Group	Mean [km/year]	Median [km/year]	Min. value [km/year]	Max. value [km/year]	Standard deviation [km/year]	Standard error [km/year]
Group I	14437	12144	1248	46511	8432	1230
Group II	34762	35315	67	97707	17716	1922
Group III	83597	87771	3515	164244	48239	7036
Groups I, II, III	42248	30316	67	164244	38082	2846

Tab. 1. Location and dispersion parameters of yearly intensity of vehicle use

An analysis of the results of calculations of the statistical parameters shown in Tab. 1 indicated differences in mean yearly intensities of use among the individual groups of vehicles. To test whether the observed differences were statistically significant, an analysis of variance was carried out.

Tests were performed to see whether the classical assumptions of the analysis of variance were met [1]. The first step was to estimate whether the empirical data could be approximated by the normal distribution. An analysis using the chi-squared χ^2 test showed that the data in question, related to intensity of vehicle use, could not be approximated by the normal distribution. Additionally, heterogeneity of variances was observed in the individual groups of vehicles. Due to the unequal number of results in the analysed groups, Bartlett's **B**-test was used. The value of the test statistic was **B** = 134.48 at the level of significance $p = 0.000$.

Because the assumptions of normal distribution of the analysed variable and heterogeneity of variances were not satisfied, classical analysis of variance could not be used for the observed values of yearly intensity of vehicle use. Accordingly, further calculations were carried out using the Kruskal-Wallis test **KW**, which is a non-parametric method of analysis of variance. The calculations demonstrated that the value of the Kruskal-Wallis statistic was **KW** = 80.145 at the level of significance $p = 0.000$. This result pointed to significant differences in mean yearly intensities of vehicle use among the individual groups.
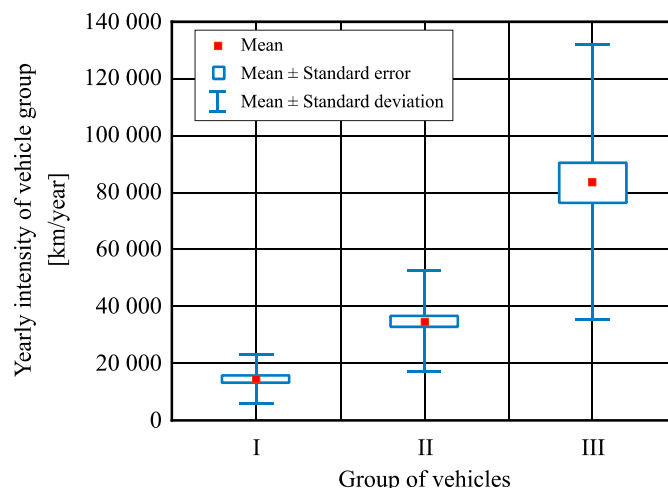
Fig. 1. A categorised box plot for the independent factor – group of vehicles, and the dependent variable – yearly intensity of vehicle use

Fig. 1 shows a categorised box plot for yearly intensity of vehicle use as a function of group of vehicles. The observed differences in mean yearly intensity of vehicle use among the groups of vehicles follow primarily from the character and range of transportation activities performed.

Further analyses were carried out to test whether the month (as a grouping factor) had a significant effect on the value of the monthly intensity of vehicle use in the particular groups. Calculations using the chi squared χ^2 test demonstrated that the distributions of monthly intensities of use of vehicles in the individual groups were consistent with the normal distribution. Also, homogeneity of variances was tested using Bartlett's **B**-test. The results are shown in Tab. 2.

Group	**B**-statistic	*p*-value
I	6.803	0.814
II	5.120	0.925
II	4.561	0.950

Tab. 2. Results of Bartlett's test of homogeneity of variances for the intensity of vehicle use with the month of operation as a grouping factor

The results shown in Tab. 2, concerning the homogeneity of variances for monthly intensity of vehicle use in the individual groups for the variable – month, indicate that the classical method of analysis of variance is applicable. Results of calculations carried out using Fisher's **F**-test are shown in Tab. 3.

Based on the results presented in Tab. 3, it can be stated that the month of operation has no significant influence on the intensity of vehicle use observed in that month. This is

confirmed by the categorised box plots shown in Fig. 2, illustrating the monthly intensities of vehicle use in the particular groups.

Group	F-statistic	p-value
I	1.567	0.104
II	1.392	0.170
II	1.698	0.071

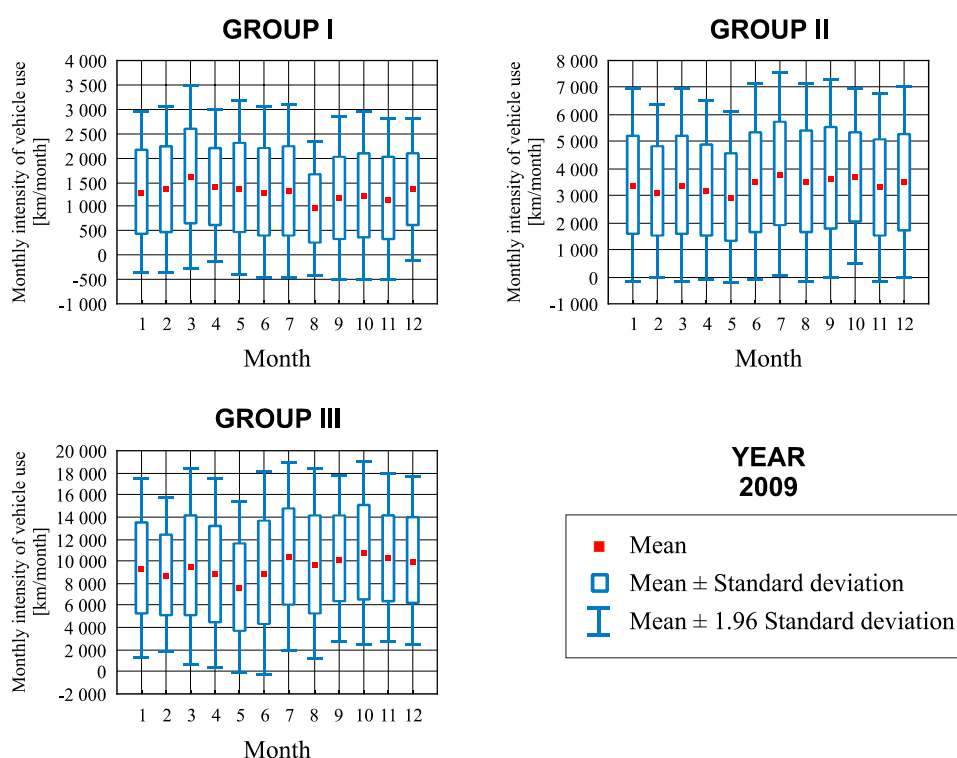Tab. 3. Results of analysis of variance for the grouping factor – month of operation of the test vehicles

Fig. 2. Categorised box plots for the independent factor – month and the dependent variable – monthly intensity of vehicle use (group I, group II and group III)

4. Conclusion

The results of the discussed statistical analyses of data related to the intensity of use of delivery vans operated by the Polish Mail company in Lublin show that

1. The division of the population of vehicles into three groups according to the criterion of load space volume is accurate. This is evidenced by the significant differences among the individual groups in yearly and monthly intensities of vehicle use.

2. In group II, the values of mean yearly intensity of vehicle use were nearly 2.5 times higher than the values observed in group I. A similar proportion obtained for intensities of vehicle use of group III relative to group II.

3. The month of operation does not have a significant effect on the observed mean values of monthly intensity of vehicle use in the individual groups.

Finally, because the analyses were conducted for data related to the process of vehicle operation spanning one year, it cannot be unequivocally determined whether the analysed intensities of vehicle use would be repeatable in different years. To establish this, calculations should be carried out for data covering at least a few years of vehicle operation in a given transport company. The authors hope to explore this issue in their future research.

References

[1] Dobosz, M.: *Wspomagana komputerowo statystyczna analiza wyników badań*, Wydawnictwo EXIT, Warszawa, 2004 (in Polish)

[2] Droździel, P.: *Widmo rozruchu silnika o zapłonie samoczynnym jako kryterium oceny warunków użytkowania samochodu*, Polskie Naukowo-Techniczne Towarzystwo Eksploatacyjne, Warszawa, 2009 (in Polish)

[3] Droździel, P., Liščák, Š.: *The Chosen Problems of Commercial Truck Maintenance*, EDIS Žilina University publisher, Žilina, 2005, ISBN 80-8070-321-3

[4] Hlavňa, V., Kukuča, P., Isteník, R., Labuda, R., Liščák, Š.: *Dopravný prostriedok jeho motor*, EDIS Žilina University publisher, Žilina, 2000, ISBN 80-7100-665-3 (in Slovak)

[5] Rydzykowski, W., Wojewódzka-Król, K.: *Transport*, PWN, Warszawa, 2009 (in Polish)

[6] Woropay, M., Landowski, B., Jaskulski, Z.: *Wybrane problemy eksploatacji i zarządzania systemami technicznymi*, Wydawnictwa Uczelniane Akademii Techniczno-Rolniczej w Bydgoszczy, Bydgoszcz, 2004 (in Polish)

Referee:

Prof. Ing. Štefan Liščák, CSc., Žilinská univerzita v Žiline

Enter to publishing: **16th September 2011**