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Influence parameters of transportation process on own/hired fleet selection

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Abstract

Increased competition between enterprises is a characteristic feature of the modern market globally as well as in Ukraine. The growth of the number of trading, transport, forwarding, warehousing and other enterprises leads to an increase in the complexity of the collaboration between them. The use of logistics management in the process of transport services in the conditions of increase of the range of goods and the amount of material flows, uneven volumes of transportation can improve the efficiency of the operation of the logistics system. The article is devoted to investigation of the rational sphere of using own and hired fleet issue and discovers influence technological parameters and demand on efficiency of transportation services. The approach for own/hired fleet estimation and their ratio for transportation services is based on the use of the project analysis methodology. The created economic-mathematical model allows modeling the technological and economic results of the transport service system. The article presents the results of research of the influence of transportation process parameters on the choice of own / hired fleet.

Keywords: transportation, demand, investments

1. Introduction

Constant aggravation of competition forces market participants to find ways to reduce the cost of goods and services while maintaining their quality and service level. Logistics cost represents a significant share in the value of the goods. One of the components of these costs is the costs associated with the delivery. The transportation costs depend on a wide range of indicators and conditions, in particular the strategy of transportation service (TS): using own fleet (the creation of a functional unit), outsourcing, or a certain ratio of both. The question of the formation of a

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fleet, its updating and maintenance, belongs to the range of issues of technical support of the logistics system. These issues do not misplace their relevance as they are crucial for the development and economic performance of the vehicle and logistics system. (Makarova, Shubenkova & Pashkevich, 2017).

A fair amount of papers are devoted to the issue of the forming rational structure of fleet. Multiple objective optimization of the fleet size planning (FSP) problem for road freight transportation was made by Żak, Redmer, Sawicki (2011). This research work provides a good theoretical background and a methodological framework for FSP determination. The two stage simulating model was used in the FSP presented by Imai & Rivera IV (2001). An analytical model is first discussed to estimate the optimal FSP. Then, the various scenarios are analysed to determine the hired fleet in extremely unbalanced trade periods. The optimal fleet configuration model was presented by Van Duin, Tavasszy & Quak (2013). They used performance of alternative fleet scenarios, to assess their robustness. Transport fleet sizing by using make and buy decision-making was explored according to the impact of time demand characteristics in supply chain (Stojanović, Nikoličić & Miličić, 2011). Results of this paper showed influence of demand variability and uncertainty directly impact on the optimal quantity of vehicles in own fleet. The variation of cargo volumes, time windows, and size of distribution area in FSP were developed in (Cruijssen, et. al., 2007). Thus, the possible options of TS are presented, Fig. 1.

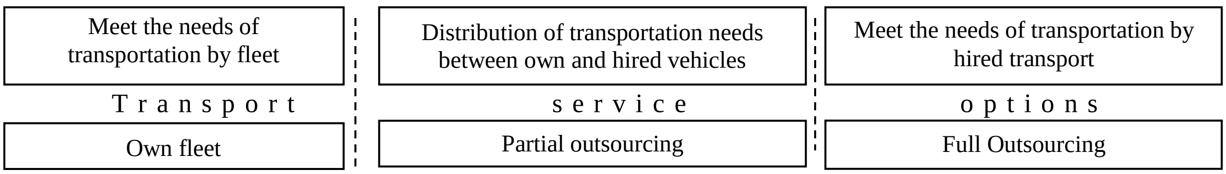

Fig. 1. Transport service options (by road)

Following are the options for the use own or hired vehicles (Schiffer, Walther, 2018): allocate the demand via own fleet; allocate the demand via hired vehicles; allocate the demand between own fleet and hired vehicles. When using first two options, there is no necessary to solve task, which customer served by own, and which by hired vehicles. Using the combined version, required to determine Transportation Company (TC) effectiveness, with varying amounts of own and hired vehicles. Own and hired vehicles redistribution between different MF leads to changes their efficiency usage and consequently profits. Therefore, hiring vehicles to fulfil contractual obligations reduces costs: maintenance, loans and lease payments for own vehicles, but, systematic usage of the hired vehicle cost more than own (Haugen, Musser and Lovelace, 2009). Vehicles absence in greatest demand TS periods leads to losses (penalties) for TC (Olkhova, et. al., 2017). Large own vehicles number for TS MF volumes peaks in some periods, not appropriate from an economic point of view (Krajewska, et. al., 2008). This is especially important in long-term TS contracts with seasonal material flows (MF) changing value of parameters. Analysis showed less contribution is been made in using project investment indicators to assessing efficiency of FSP problem. The problem of using own and hired fleet for joint TS the MF requires further research. Existing approaches to TS not estimate specification influence of technological parameters of TS on own/hired fleet selection. The purpose: To evaluate the influence of technological parameters of TS on own/hired fleet selection.

2. Materials and methods

2.1 Compatible transport services

The MF intensity consumption indicated seasonal goods movement. In the long-term TS implementation is important to optimize load distribution at different orders stages for transportation. This will avoid seasonal excess capacity underutilization or lack of it. In this case, the TC can redistribute vehicles between various clients MF for them TS in different time periods. Vehicles estimated quantity (*A*) for the entire period (τ) of TS (the contract period) can find as vehicles maximum amount from every time period (*t*) and every MF (*M*), including all periods *t*:

$$A'_t = \max\left[(A_{11} + A_{21} + ... + A_{m1});...;(A_{1t} + A_{2t} + ... + A_{mt})\right] = \max\left[\sum_{i=1}^{m} A'_{m1},...,\sum_{i=1}^{m} A'_{mt}\right], \quad (1)$$

where A'_t - the vehicles estimated amount while joint TS all MF, units; *t* – Periods number, units.

Vehicles estimation number for joint MF's, found as:

$$A_t^{QMF} = \frac{\sum_1^M Q_t^{QMF} \cdot T_i^A}{T_t \cdot q_н^A \cdot \gamma_c^A}, \tag{2}$$

where Q_t^{QMF} – The transportation volume, t.; T_i^A – The TS MF's client average time, days; T_t – The time during which must perform TS, days; $q_н^A$ – The vehicle rated load capacity, t; γ_c^A – The load capacity utilization.

Transportation volumes are characterized by following variables: *Q* – quantity of transportation (*q* = 1, 2,..., *Q*); *F* – transportation technology (*F* = 1, 2, ..., *F*); *A* – vehicles (*a* = 1, 2, ..., *A*), each period *t* during the overall contract period τ:

$$A_g = f(Q, M, F), \tag{3}$$

Combination of parameters (*Q, M, F)* allocate separate investment project, with its own efficiency. Changing of value of any variables leads changes in efficiency of the project. The variety of projects described by index *G*, where g = 1,2, ..., *G*. Proceeding from the condition of full compliance with contractual obligations with the customer, the estimated amount of vehicle for maintenance of all clients is calculated as:

$$A_{est\_t} = A_{own\_t} + A_{hrd\_t}; \tag{4}$$

where A_{est_t} – estimated amount of vehicle in operation, units; A_{hrd_t} – amount of vehicle involved (hired) for TS, unit.; A_{own_t} – own fleet size, unit.

Changing the values of demand parameters in different periods *t* effect on estimated vehicles quantity in these periods. Since joint TS of clients can be executed both by their own/hired fleet, then, as a consequence, the efficiency of such activities will be different. The vehicle amount and routes in this case can be calculated by:

$$A_{est\_NMt} - A_{hrd\_NMt} = \sum_1^N \sum_1^M A_{est\_t}^{NM} - A_{hrd\_t}^{NM}. \tag{5}$$

Thus, different parameters of transportation process affect the efficiency of TS and, meanwhile, quantity of hired/own vehicles affect the efficiency.

2.2 Efficiency of transportation services

Investigating is basis on the dialectical methods that lead to a comprehensive and objective nature tasks study. The study used general scientific methods (analysis, synthesis, abstraction) and special economics and technics methods (Makarova, Mavrin, & Shubenkova, 2017): system analysis, the general theory of transport systems, logistics theory. An experimental method was used to investigate MF characteristics, define distance transported, determine tariff; economic modeling analysis was used to identify effect on the economic indicators of functioning TC. Project analysis used to substantiation of proposed project expediency decisions (Roslavtsev, 2010; Rajagopal, 2013).

TS planning for fleet estimation issue should be made on long strategy and considering: inflation risks, the discounts, the credits' cost. The costs composition and arrangement determined by the specifics of the carrier (rental, purchase, lease, etc.). Not only accounting costs should be considered, but also the possible alternative projects costs ("economic cost"). For the system conditions, the most appropriate measure can be considered as indicator the total net present value (NPV):

$$NPV_{TS} = \sum_{t=1}^{k} \frac{NCF_{TS\_t}}{(1+i)^t} - \sum_{t=1}^{k} \frac{IC_{TS\_t}}{(1+i)^t}, \tag{6}$$

where NCF_{TS_t} – Net cash flow on separate intervals of the project; IC_{TS_t} – investment costs for individual intervals of the project'; *i* – discount rate; *k* – the total period of calculation, *t* – periods number, units.

The TS performance criteria can be selected from profitable investment measures in the «long run» project. As a result, using the project analysis methodology, different alternatives with varied efficiency were simulated. Selecting investment criteria's of "alternative business" based on spending the same resources amount to achieve more effective results desire:

$$NPV_g = \max\left[NPV_1', NPV_2', ..., NPV_g'\right], \quad (7)$$

where NPV_g – net present value chosen project; $NPV_1', NPV_2', ..., NPV_g'$ – net present value of alternative projects.

Basing on the proposed economic and mathematical model of calculating investment TC indicators of the logistics (Galkin, 2017; Halkin et. al., 2017) conducted a research of the influence of technological parameters of TS on own/hired fleet selection.

3. Results

3.1 Variation Data

The analyses of transportation volumes and estimated amount of vehicles have been made. The TC has 15 tilts vehicles. The TC serves large customer numbers – above 60 per year. Demand for TS during the time period is variable. Each of them characterized by different transportation: conditions, dues, volumes, and other parameters, fig. 2.

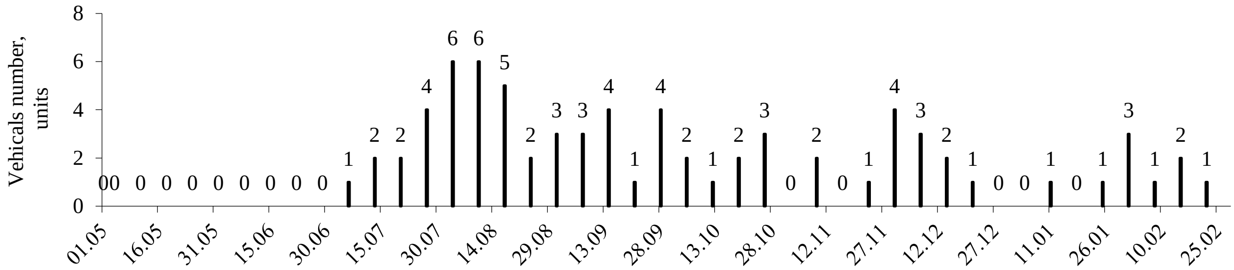

Fig. 2. The factual vehicles number variation for transport services one of the material flow

To reduce the non-productive runs and to increase the vehicles utilisation efficiency, the TC finds one-time orders via Internet. In this case it is necessary to take into consideration the joint MF's TS possibility. The TC performs TS on long-term contracts – 75 % of all and one-time orders about 25%. Long-term contracts analysis shows times and volumes irregularity during research periods. According to tab. 1 the factor of fleet usage and the load capacity utilization varied month-to-month. It depends on each MF parameters variation.

Table 1 – The Transport Company vehicles indicators for the research period

Months	The own fleet size at the TC, units	The factual amount vehicles in operation, units	The Estimated vehicles (via model 2), units	The factor of fleet usage	The load capacity utilization
May	15	10	5	0,67	0,56
June	15	14	14	0,93	0,65
July	15	14	14	0,93	0,70
August	15	14	14	0,93	0,82
September	15	13	13	0,87	0,74
October	15	13	13	0,87	0,71
November	15	12	12	0,80	0,71
December	15	11	11	0,73	0,82
January	15	6	6	0,40	0,81
February	15	9	9	0,60	0,89

For fulfilled contractual obligations TC requires to use maximum vehicles quantity in each case. Joint TS of all MF via own/hired vehicles in various time periods will improve the efficiency indicators (Ergun, Kuyzu, Savelsbergh, 2007). Ability to redistribute vehicles with less loaded traffic volumes clients, on routes with higher traffic volumes results on efficient of vehicles' use. This situation causes to change in the estimation quantity of vehicles on different MF. A range of variation data of mathematical models for further calculations present in tab. 2.

Table 2 – Data variation range

Num.	Title of Models' factor	unit of measure-ment	The numerical value factor Min	Max	Range changes	The base value factor
1	The average distance of TS of MF	km	300	1000	–	500
2	Deliveries' amount	ton	3800	432	–	2200
3	Total quantity of MF	units	1	3	–	3
4	Total quantity of clients (contacts)	units	1	3	–	3
5	The time period specified in traffic performance for the period	days	31	27	–	30
6	The cost of transportation services for the carriage of material flow	EUR/km	0,5	1	–	0,75
7	Loading time, including waiting time	h.	–	–	–	3
8	Unloading time	h.	–	–	–	3
9	Time for daily rest and hygiene of the driver	h.	–	–	–	10
10	Average time for Meals Breaks	h.	–	–	–	3,0
11	Average Time for daily maintenance and repairs of vehicle per day	h.	–	–	–	1,0
12	Average driving time per day	h.	–	–	–	8,00
9	Vehicle's capacity	ton	-	-	–	20,00
10	The price of fuel	EUR/l	–	–	–	1,00
11	Vehicle's price	EUR	-	-	–	50 000,00
12	The required number of wheels	units	–	–	–	12
13	The average price of one wheel	EUR	–	–	–	3 00,00
14	Average length of replacing one wheel	km	–	–	–	300 000,00
15	Factor comprising the cost of repairs for Vehicle	%	–	–	–	15
16	Average of fuel consumption per 100 km	litter	-	-	–	28,00
17	Costs associated with registration of vehicles	EUR	–	–	–	200,00
18	Carrying capacity utilization coefficient	–	0,4	1,0	0,2	0,95
19	The average technical speed	km/h.	30	65	–	55
20	Average vehicle utilization rate	–	0,5	1,0	0,25	0,75
21	Number of drivers	persons	–	–	–	15
22	The average lap's time	h.	48	72	–	58
23	The income tax	%	–	–	–	25
24	The VAT	%	–	–	–	20
25	Vehicle utilization fee	EUR	–	–	–	2000
26	Factor comprising the collection of environmental value	–	–	–	–	0,05
27	Average on salaries deductions	–	–	–	–	0,37

3.2 Technological indicators of fleet usage

Field research shows, in case of an increase in demand for transportation and absence of own vehicles, carriers are faced with the need of hire vehicles. Based on the carried out calculations, the amount of vehicle to ensure all contractual obligations is 15 units (Fig. 3).

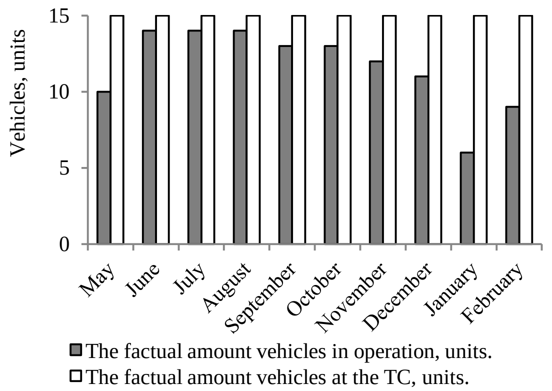

Figure 3 – Factual own vehicles amount variation

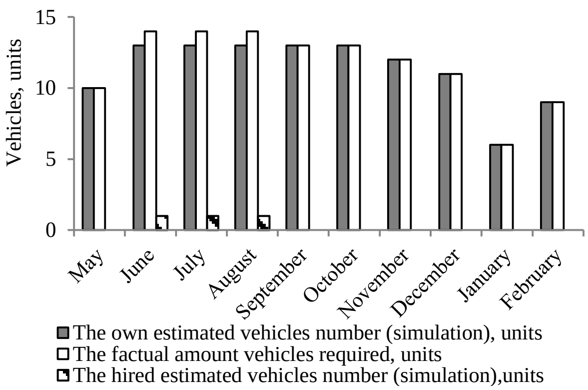

Figure 4 – The own and hired vehicles amount variation (simulating)

At the same time, they can either use their own, or hired fleet or both the options. Combined options of TS make available to use of hired vehicles in "peak" demand periods (June, July, August) and increase the technical and economic indicators of TC functioning (Fig. 4). The average load capacity utilization variation on different own and hired vehicles for three MF joint TS is shown at Fig. 5.

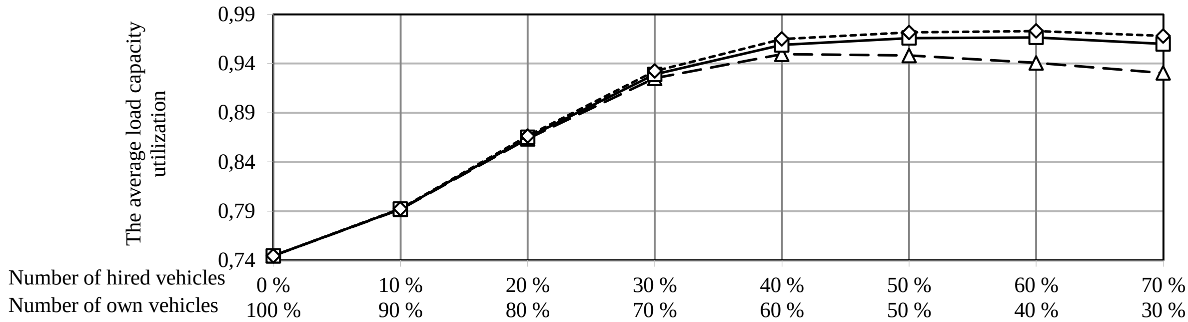

Fig. 5. Change of the average load capacity utilization on the quantity and ratio of own and hired vehicles in fleet
– while TS first MF by hired vehicles; – while TS second MF by hired vehicles; – while TS third MF by hired vehicles.

There can be plenty of combinations of TS variants with different efficiency. The index variation range is from 0,75 to 0,983. Maximum ratio observed in the combined version: 30% own and 70% hired, and TS 3rd MF by hired vehicles – 0,983. Applying only own vehicles there is been minimum load capacity utilization factor – 0,745. As can see, the estimated total vehicles quantity in the combined joint TS of all customers is unchanged, but the efficiency of TS will change with their ratio.

Results of simulation of other indicators of fleet usage are presented on fig. 6 and fig. 7.

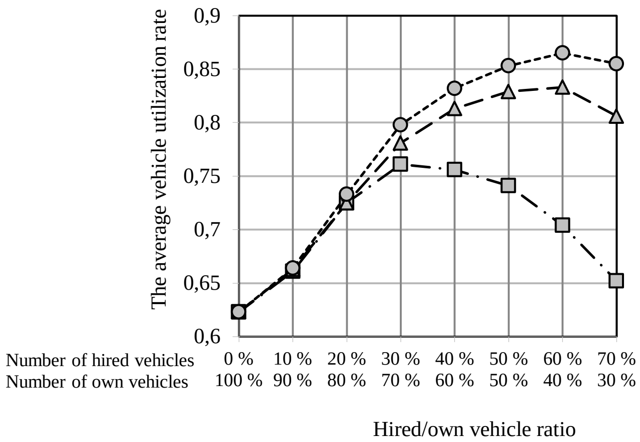

Fig. 6. Change of the average vehicle utilization rate on the quantity and ratio of own and hired vehicles in fleet:
– while TS first MF by hired vehicles; – while TS second MF by hired vehicles; – while TS third MF by hired vehicles.

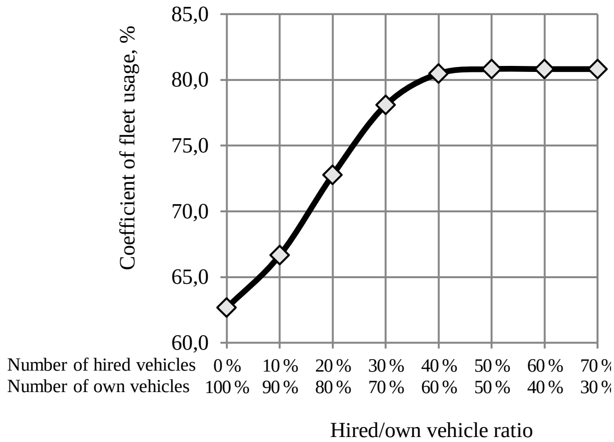

Fig. 7. Change of the coefficient of fleet usage own fleet usage on quantity and ratio of own and hired vehicles

According to Fig. 6 the average vehicle utilization rate of using own/hired vehicles during the TS of different MFs would unconstraint. According to the obtained data, the variation range stays between 0.664 to 0.87. The results shows influence own/hired ratio on efficiency of TS.

Reducing own vehicles' in operations by hiring allows to fulfil contractual obligations and increases the utilization factor of own fleet. The optimum option of fleet usage is observed with 60% of own vehicle and 40% hired, further reduction of own vehicle does not change the value of the factor (Fig. 7).

3.3 NPV patterns identifying

The results of joint TS using out/insourcing vehicles depending on the cargo class carried for three MF, are presented in Fig. 8.

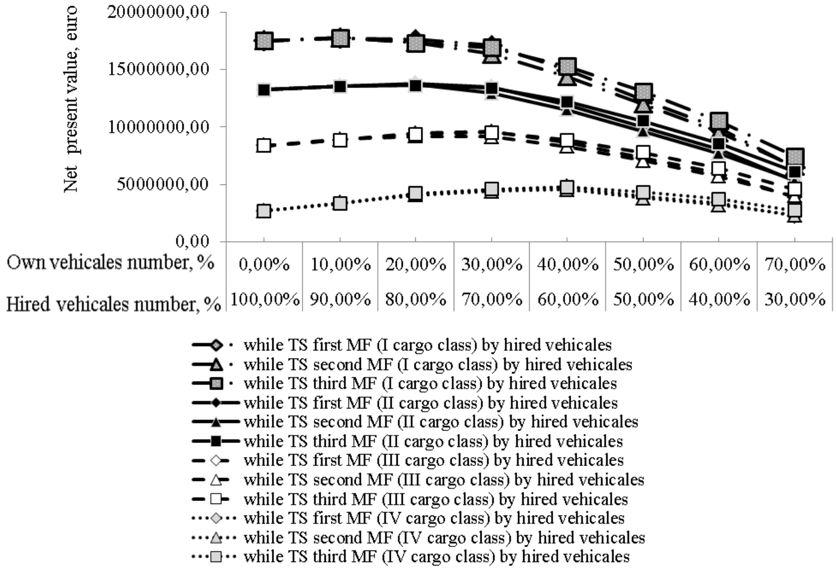

Fig. 8. Net present value depending from own and hired vehicles number use considering cargo class

Conducted Simulations shows effect of different transportation options on efficiency of fleet usage fig. 9, 10.

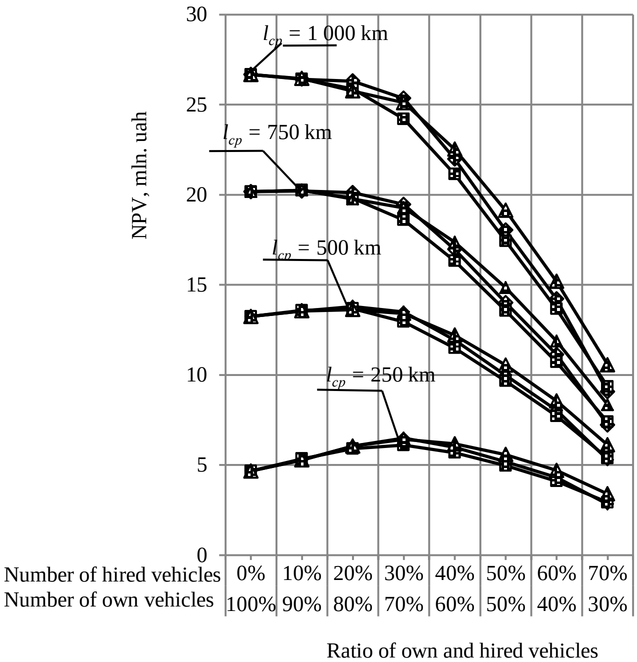

Fig. 9. Dependence of NPV on the number and ratio of own/hired fleet for different average transportation distances (l_{cp}): – while TS first MF by hired vehicles; – while TS second MF by hired vehicles; – while TS third MF by hired vehicles.

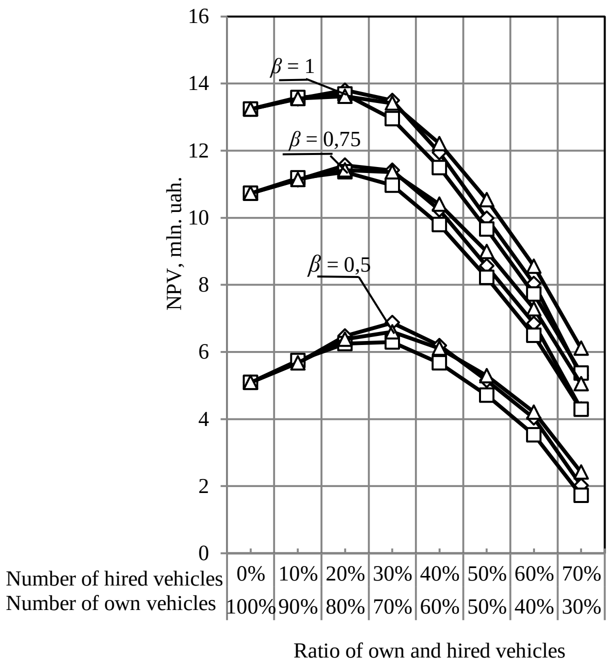

Fig. 10. Dependence of NPV on the quantity and ratio of own/hired fleet for different average vehicle utilization rate of MF: – while TS first MF by hired vehicles; – while TS second MF by hired vehicles; – while TS third MF by hired vehicles.

The patterns analysis on Fig. 8 leads to the following conclusions: 1. Analysis results indicate on rational vehicles ratio for TS that can be efficiency use for several MF TS with fulfil contractual obligation. 2. Redistribution of own/hired fleet TS by increasing the ratio of hired one will increases the project investments performances, up to a certain value, then NPV will decreasing. 3. Increase the load factor (cargo class) increases the NPV. 4. Simulation show necessary to use more hired vehicles (outsourcing) for TS “light” MF (Cargo class - IV), and vice versa more own vehicle if cargo class is I (insourcing). Analysis of Fig. 9 showed the dependence of NPV on the average transport distance while maintaining several MF. Therefore, at a distance of 1, 000 km it is rational to use all own fleet. In the case of reducing the distance of transportation it is advisable to attract more rented vehicles. In accordance with the simulation results, with an average distance of 250 km, the optimum ratio of fleet is 30% of rented and 70% of own vehicles. Projects of TS with low average vehicle utilization rate of 0.5 show less efficiency than with $\beta = 1$ (fig. 10). Changing the average vehicle utilization rate changes the rational ratio of own/hired fleet. Thus, when $\beta = 0.5$, the rational ratio of vehicles (the maximum NPV), is within the following limits: 30% of hired and 70% of own vehicles allocation. With the increase in the factor, the rational ratio of hired vehicle will decreased to 10%, and own - increased to 90%.

Conclusions on the research and prospects, further development in this direction

The research establishes the influence of technological process indicators on project investment performances with different out/insourcing vehicles. The hired and own vehicles estimation for TS is based on a comparison of investment projects. The model simulation results showed that outsourcing increases the investment performances. Increase hired vehicles number (outsourcing) increasing variation range of investment project indicators. This situation explains via different transport services efficiency via own and hired fleet.

The results obtained in paper can be used in determining the rational quantity and ratio of own and hired vehicles in the servicing of several material flows. Developed approaches can be used in planning parameters of the transportation process. The results of the research showed that there lies opportunity to increase the productivity of vehicles due to their optimal redistribution between the routes and clients.

References

Cruijssen, F., Bräysy, O., Dullaert, W., Fleuren, H. & Salomon, M. (2007). Joint route planning under varying market conditions. International Journal of Physical Distribution & Logistics Management, 37(4), 287-304.

Ergun Ö., Kuyzu, G., Savelsbergh W. P. (2007) Shipper collaboration. Computers & Operations Research, 34, 1551-1560.

Galkin, A. (2017). Urban environment influence on distribution part of logistics systems. Archives of Transport, 42(2), 7-23.

Halkin, A., Skrypin, V., Kush, E., Vakulenko, K., & Dolia, V. (2017). Invest Approach to the Transportation Services Cost Formation. Procedia Engineering, 178, 435-442.

Haugen, D., Musser, S. and Lovelace, K. (2009). Outsourcing. Detroit: Greenhaven Press.

Imai, A., & Rivera IV, F. (2001). Strategic fleet size planning for maritime refrigerated containers. Maritime Policy & Management, 28, 361-374.

Olkhova, M., Davidich, Y., Roslavtsev, D., & Davidich, N. (2017). The efficiency of transportating perishable goods by road and rail. Transport Problems, 12(4), 37-50.

Litomin, I., Tolmachov, I., & Galkin, A. (2016). Use of the Distribution Center in the Ukrainian Distribution System. Transportation Research Procedia, 16, 313-322.

Krajewska M. A., Kopfer H., Laporte G., Ropke S., Zaccour G. (2008) Horizontal cooperation among freight carriers: request allocation and profit sharing. Journal of the Operational Research Society, 59, 1483-1491.

Makarova, I., Mavrin, V., & Shubenkova, K. (2017, September). System Approach to the Mass Production Improvement. In International Conference Mechatronics, 95-102. Springer, Cham.

Makarova, I., Shubenkova, K., & Pashkevich, A. (2017). Logistical costs minimization for delivery of shot lots by using logistical information systems. Procedia Engineering, 178, 330-339.

Rajagopal, S. (2013) Portfolio management. Hapmshire: Palgrave Macmillan.

Roslavtsev D. (2010) Evaluation of efficiency of decisions in modernization of logistic loads. East European Journal of advanced technologies, 5(3), 18-20. Available at: http://journals.uran.ua/eejet/article/download/3094/2897.

Schiffer, M., & Walther, G. (2018). Strategic planning of electric logistics fleet networks: A robust location-routing approach. Omega, 80, 31-42.

Stojanović, Đ., Nikoličić, S., & Miličić, M. (2011). Transport fleet sizing by using make and buy decision-making. Economic Annals, 56(190), 77-102.

Van Duin, J. H. R., Tavasszy, L. A., & Quak, H. J. (2013). Towards E (lectric)-urban freight: first promising steps in the electric vehicle revolution.

Żak, J., Redmer, A., & Sawicki, P. (2011). Multiple objective optimization of the fleet sizing problem for road freight transportation. Journal of advanced transportation, 45(4), 321-347.