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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 global modern markets. The growth of trading, transport, forwarding, warehousing and other enterprises lead to increased complexity between these stakeholders. Adoption of logistics management process of transport services due to increased transportation of goods, material flows, and uneven volumes can improve the efficiency of the logistics system. In this regard, the research paper investigates the use of own vis a vis hired fleet and their impact on technological parameters, demand and efficiency of transportation services. The own/ hired fleet ratio estimation for transportation services has been done using project analysis methodology. The developed economic-mathematical model allows modeling of the technological and economic results of the transport service system.


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*Keywords:* transportation, demand, investments

## 1. Introduction

Continuous 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 aspects of these costs is the costs associated with the delivery. The transportation cost depends on a wide range of indicators and conditions, in particular the strategy of transportation service: using own fleet (the creation of a functional unit), outsourcing, or a certain ratio of both. The question of the formation of a fleet, its

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maintenance and replacement, can be termed as technical support to 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 have researched the issue of the forming rational structure of fleet. Multi-objective optimization of the fleet size planning problem for road freight transportation was developed by Żak, Redmer, Sawicki (2011) and provided theoretical background and methodological framework for Fleet Size Planning determination. The two stage simulating model was used in the Fleet Size Planning by Imai & Rivera (2001). An analytical model was first discussed to estimate the optimal Fleet Size Planning . Then, various scenarios were analysed to determine the hired fleet in extremely unbalanced trade periods. An optimal fleet configuration model was developed by Van Duin, Tavasszy & Quak (2013) using alternative fleet scenarios and their performance. Transport fleet sizing through 'make and buy' decision-making was explored based on the impact of time demand characteristics in supply chain by Stojanović, Nikoličić & Miličić (2011), results of paper showed that demand variability and uncertainty directly impacts the optimal quantity of vehicles in own fleet. The variation of cargo volumes, time windows, and size of distribution area in Fleet Size Planning was developed by Cruijssen et. al. (2007). The possible options of Transport Service is presented in Fig. 1.

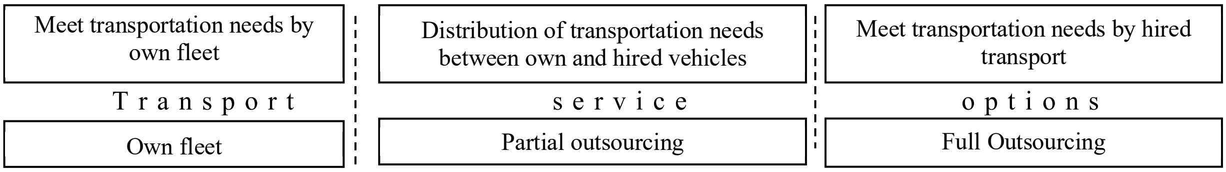


Fig. 1. Transport service options (by road)

Further, options for using own or hired vehicles is via allocation of demand by own fleet; allocation of demand upon hired vehicles or allocation of demand between own fleet and hired vehicles (Schiffer and Walther, 2018). When using the first two options, there is no requirement for ratio based modelling for customer allocation against to be served by own against or by the hired vehicles. Mixing of own and hired vehicles based on certain ratio will be based on as well as will require determination of transportation company effectiveness, with varying amounts of own and hired vehicles. Further, variation in ratio of own and hired vehicles for demand management will lead to variation in overall efficiency thereby affecting the profit margins. Additionally, hiring vehicles to fulfil contractual obligations reduces cost e.g. maintenance, loans and lease payments for own vehicles, however, systematic usage of the hired vehicles cost more than owning them (Haugen, Musser and Lovelace, 2009). Further, during peak demand seasons, vehicle unavailability might lead to losses (penalties) for the Transport Company (Olkhova, et. al., 2017). However, at the same time owning large fleet to cater to peak demand is also not the most economical or efficient model (Krajewska, et. al., 2008). Therefore, it becomes important in long-term that Transport Service contracts for seasonal demand management should look into the mix of own and hired fleet sizes. Our extant literature review shows limited research contribution has been made for using project investment indicators to assess efficiency of Fleet Size Planning problem. Therefore, the problem of using own and hired fleet for demand fulfilment requires further research. Existing approaches to Transport Service management do not estimate specification influence of technological parameters upon own/ hired fleet selection. The purpose for this research is therefore to evaluate the influence of technological parameters of Transport Service on own/ hired fleet selection.

## 2. Materials and methods

### *2.1 Compatible transport services*

Demand variation and intensity of consumption together indicate the seasonal goods movement and it's variation. Making it important in the long-term Transport Service management to optimize load distribution among different stages of transportation. This allows the transport company to avoid seasonal excess capacity underutilization or lack of it. In a scenario of mixing own and hired fleet, the transport company can redistribute vehicles between various clients for demand management to manage transport service during different time periods. Vehicle estimated quantity

($A$) for the entire period ($\tau$) of the Transport Service contract period can predict the vehicle requirement for every time period ($t$) and demand *(M)* during all the periods $t$:

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

Where $A'_t$ - the vehicles estimated amount for joint Transport Service for all demand, during time periods; $t$.

Vehicles estimation number for joint demand management will be:

$$A_t^{QMF} = \frac{\sum_{1}^{M} Q_t^{QMF} \cdot T_i^A}{T_t \cdot q_н^A \cdot \gamma_c^A}, \tag{2}$$

where $Q_t^{QMF}$ – The transportation volume, t.; $T_i^A$ – The transport service demand volume movement for client average time, days; $T_t$ – The time during which the demand must be fulfilled (in days); $q_н^A$ – The vehicle rated load capacity, t; $\gamma_c^A$ – Load capacity utilization.

Transportation volumes are characterized by following variables: $Q$ – quantity for 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 $\tau$:

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

Combination of parameters *(Q, M, F)* require separate investment projections, with their own efficiency values. Change in the value of any of the variables will lead towards variation in the efficiency of the investment projections. The variations of the investment projections can be 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 demand fulfilment of each of the 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 $t$, affects the estimated vehicle requirement during these periods. Since joint demand fulfilment of clients can be executed both by their own/ hired fleet, then, as a consequence, the efficiency of each combination of own and hired fleet will be different. The vehicle requirement and routes in these scenarios 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 transport service management and, meanwhile, combination of hired/ own vehicles affects the overall service efficiency.

### *2.2 Efficiency of transportation services*

The study used general scientific methods (analysis, synthesis, abstraction) and special economics and techniques methods (Makarova, Mavrin, & Shubenkova, 2017): system analysis, the general theory of transport systems, logistics theory. An experimental method was used to investigate material flow and demand fulfilment characteristics, distance transported, tariff determination. Economic modeling analysis was used to identify effect on the economic indicators. Project investment analysis was used to substantiate proposed project expediency decisions (Roslavtsev, 2010; Rajagopal, 2013).

Transport service planning for fleet estimation requires long-term strategic considerations including inflation risks, discounts and credits' cost. The costs composition and arrangement determined by the specifics of the carrier (rental, purchase, lease, etc.). In this regard 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 the total net present value (NPV) approach.

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

Where $NCF_{TS\_t}$ – Net cash flow during 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 transport service performance criteria can be selected from profitable investment measures in the long-run of the 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 require:

$$NPV_g = \max\left[NPV_1', NPV_2', \ldots, NPV_g'\right], \tag{7}$$

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

Based on the proposed economic and mathematical model of calculating investment, by using transport service indicators of logistics management (Galkin, 2017; Halkin et. al., 2017), influence of technological parameters of transport service on own/ hired fleet selection was done.

## 3. Results

### *3.1 Variation Data*

The analyses of transportation volumes and estimated amount of vehicles was done. The transportation company had 15 tilt vehicles. The transportation company serves large customer numbers – above 60 per year. Demand fulfilment during these periods is varied in nature. Each of them is characterized by different set of transportation: conditions, dues, volumes, and other parameters (Fig. 2).

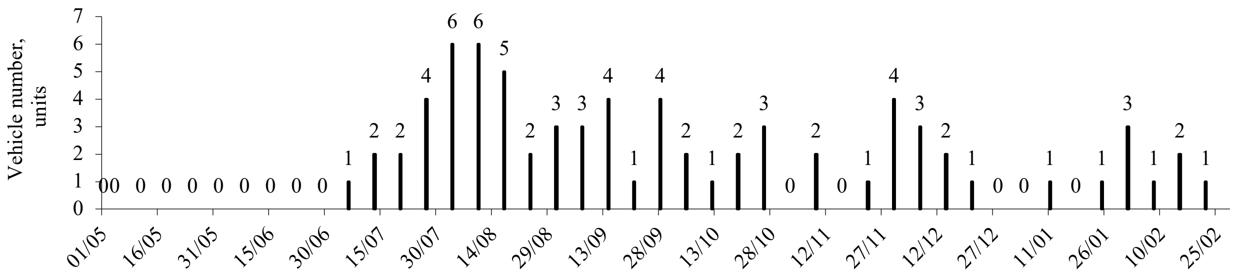


Fig. 2. Vehicle number variation for transport services for one of the customer demand fulfilment

To reduce the non-productive runs and to increase the vehicles utilisation efficiency, the transportation company receives one-time orders via internet. In this case it is necessary to take into consideration the joint demand fulfilment is transport service responsibility. The transportation company fulfils demand through long-term service contracts (75 %) and about 25% are one-time orders. Long-term contracts analysis shows time and volume irregularity between periods. As shown in Table1, the fleet usage and the load capacity utilization varied month-to-month and depended upon each demand fulfilment parameters variation.

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

| Months | Own fleet size, units | Number of vehicles in operation, units | Estimated vehicles (via model 2), units | Fleet utilization factor | 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 fulfilling contractual obligations, the transportation company required using maximum number of vehicles. Joint demand fulfilment via own/ hired vehicles in various time periods further improved the efficiency indicators (Ergun, Kuyzu, Savelsbergh, 2007). Ability to redistribute demand upon vehicles with lesser load, from routes with higher volumes resulted towards efficient vehicle utilization. This situation causes to change in the estimation quantity of vehicles on different MF. The range of output using the mathematical model for further calculations has been presented in Table 2.

Table 2 – Data variation range

| Sl. № | Model factors | unit of measurement | Value Range Min | Value Range Max | Range changes | Base value |
|---|---|---|---|---|---|---|
| 1 | Average distance for demand fulfilment | km | 300 | 1000 | – | 500 |
| 2 | Delivery amount | ton | 3800 | 432 | – | 2200 |
| 3 | Total Demand | units | 1 | 3 | – | 3 |
| 4 | No. of clients (contacts) | units | 1 | 3 | – | 3 |
| 5 | Time period specified for transportation during the demand fulfilment period | days | 31 | 27 | – | 30 |
| 6 | Rate of transportation services for demand fulfilment | 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 | Price of fuel | EUR/l | – | – | – | 1,00 |
| 11 | Vehicle’s price | EUR | - | - | – | 50 000,00 |
| 12 | Required number of wheels | units | – | – | – | 12 |
| 13 | 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 | Average 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 | Average lap time | h. | 48 | 72 | – | 58 |
| 23 | Income tax | % | – | – | – | 25 |
| 24 | 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 utilization*

In case of increase in demand for transportation and absence of own vehicles, carriers are faced with the need to hire vehicles. Based on the calculations, number of vehicles to ensure all contractual obligations is 15 units (Fig. 3).

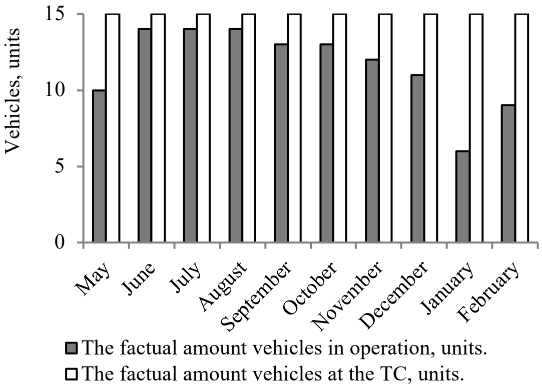


Figure 3 – Factual (Grey) and Own (White) vehicles number variation

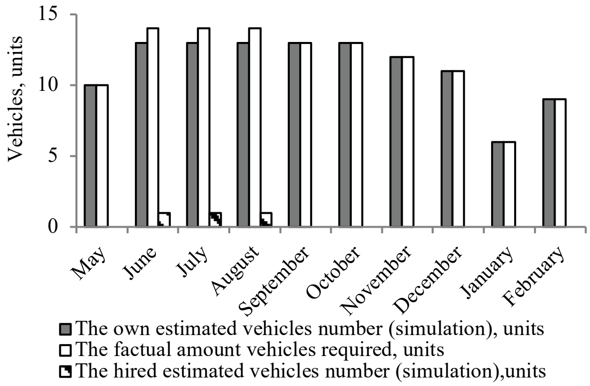


Figure 4 – The own and hired vehicles amount variation (simulating)

At the same time, they can either use their own, or hired fleet or a mix of both. Combined options of transport service makes use of hired vehicles in "peak" demand periods (June, July, August) and increase the technical and economic indicators of transportation company functioning (Fig. 4). The average load capacity utilization variation on different own and hired vehicles for three demand fulfilment and combined transport service for three services are shown in Fig. 5.

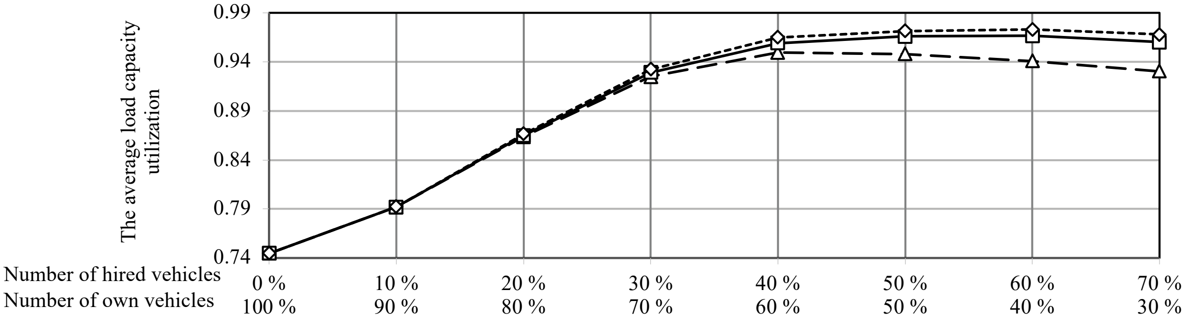


Fig. 5. Change of average load capacity utilization on the quantity and ratio of own and hired vehicles in fleet
– while TS first MF by hired vehicles; – while transport service second MF by hired vehicles; – while TS third MF by hired vehicles.

There can be plenty of combinations of transport service variants with different efficiency. The index variation range is from 0,75 to 0,983. Optimal efficiency was observed for the combination: 30% own and 70% hired. Applying only own vehicles led to minimum load capacity utilization factor – 0,745. As one can see, the estimated total vehicles quantity in the combined joint transport service for all customers remains unchanged, but the efficiency of transport service will change with their ratio. Results of simulation of other indicators of fleet usage are presented in Fig. 6 and Fig. 7.

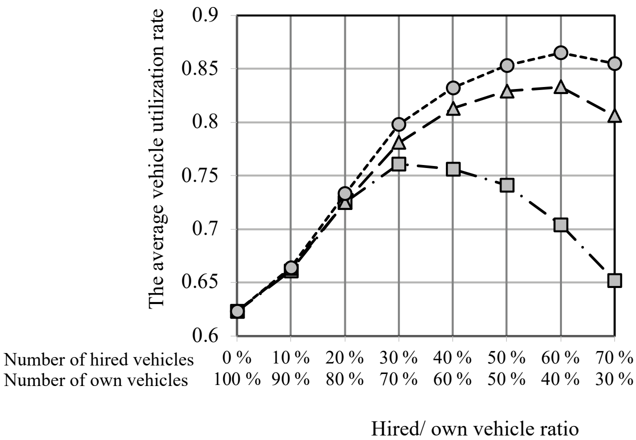


Fig. 6. Change of the average vehicle utilization rate on the quantity and ratio of own and hired vehicles in fleet: – while TS first MF by hired vehicles; – while TS second MF by hired vehicles; – while TS third MF by hired vehicles.

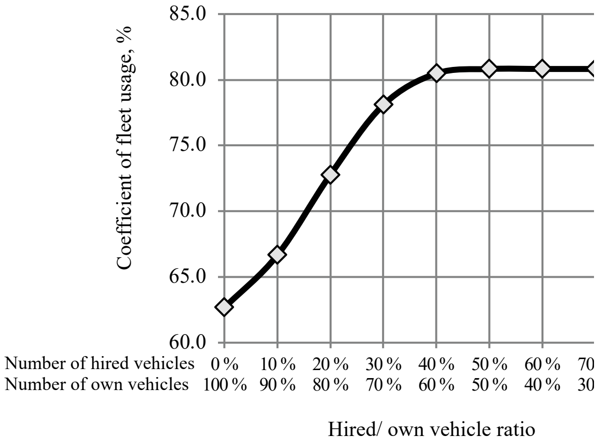


Fig. 7. Change of the coefficient of fleet usage own fleet usage on quantity and ratio of own and hired vehicles

As shown in 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.

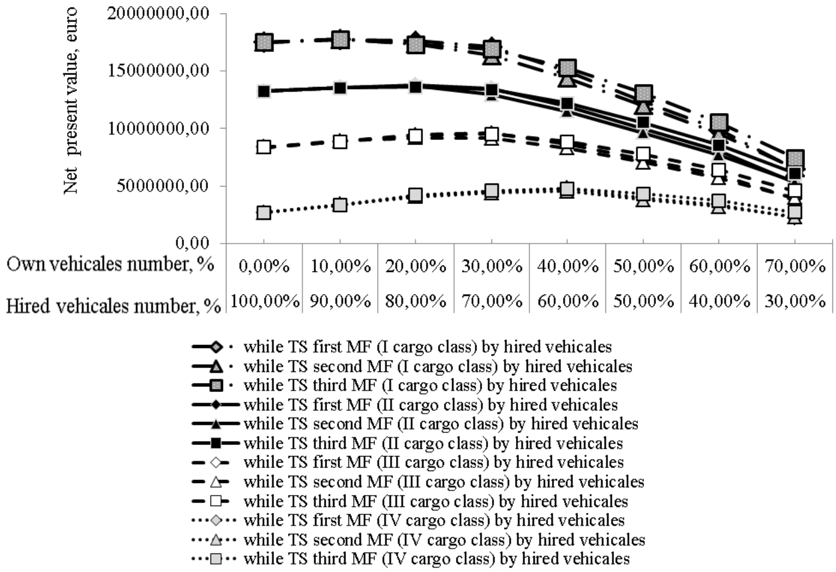


Fig. 8. Net present value depending from own and hired vehicles number use considering cargo class

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

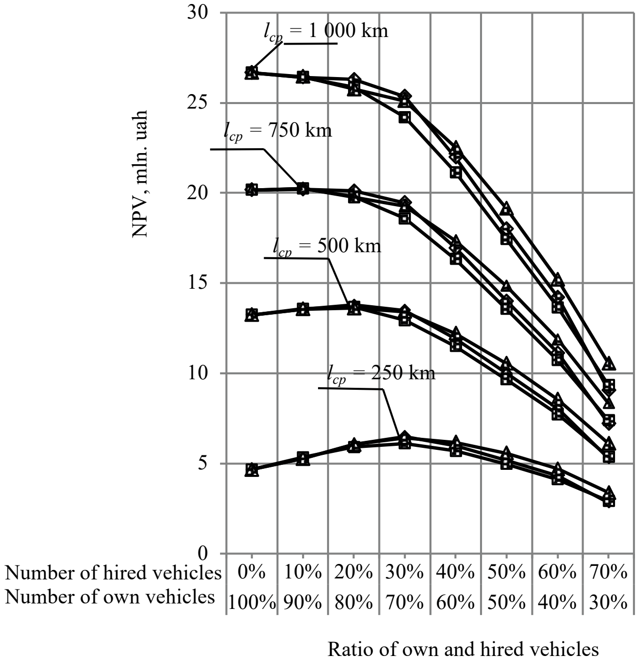


Fig. 9. Dependence of NPV on the number and ratio of own/hired fleet for different average transportation distances ($l_{cp}$): – while TS first MF by hired vehicles; – while TS second MF by hired vehicles; – while TS third MF by hired vehicles.

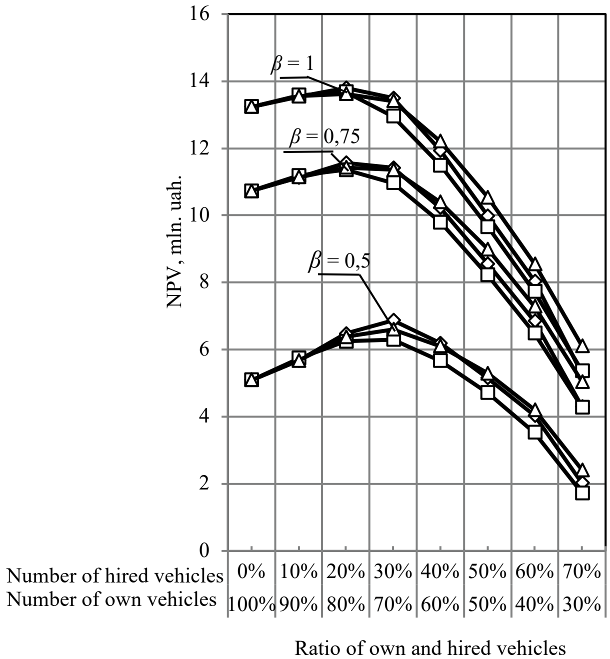


Fig. 10. Dependence of NPV on the quantity and ratio of own/hired fleet for different average vehicle utilization rate of MF: – while TS first MF by hired vehicles; – while TS second MF by hired vehicles; – while TS third MF by hired vehicles.

The patterns analysis shown in Fig. 8 leads to the following conclusions: 1. Analysis results indicate that there are optimal vehicles ratios that can be efficiently used for multiple and mixed demand fulfilment while addressing all contractual obligation. 2. Redistribution of own/ hired fleet by increasing the ratio of hired vehicles will increases the project investment performance, up to a certain value, beyond the inflexion point the NPV starts decreasing. 3. Increase in the load factor (cargo class) improves the NPV. 4. Simulation shows that it's necessary to use more hired vehicles (outsourcing) for "light" demand fulfilment (Cargo class - IV), and vice versa for cargo class I (insourcing) i.e. more own vehicles.

Analysis of Fig. 9 shows that dependence of NPV on the average transport distance while fulfilling multiple demand. Therefore, at a distance of 1, 000 km it is rational to use your own fleet. In case of lesser distance than that, it is advisable to use more hired vehicles. In accordance with the simulation results, with an average distance of 250 km, the optimum ratio of fleet is 30% of hired and 70% of own vehicles. Low average vehicle utilization rate in the range of 0.5 shows lesser efficiency ($\beta$ = 1; Fig. 10). Varying the average vehicle utilization rate changes the optimal ratio of own/ hired fleet. Thus, when $\beta$ = 0.5, the optimal ratio of own/ hired vehicles (the maximum NPV), is within the range of 30% hired and 70% own vehicles. With the increase in the factor, the optimal ratio of hired vehicle will decreased to 10%, and own vehicles will increase to 90%.

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

The research establishes the influence of technological process indicators on project investment performance with different out/ insourcing vehicles. The hired and own vehicles estimation is based on a comparison of investment projects. The model and the results showed that outsourcing improves the investment performance. Increase in hired vehicles number (outsourcing) increases variation range of investment project indicators. The results obtained in paper can be used in determining the optimal quantity and ratio of own and hired vehicles for demand fulfilment to different clients. Developed approach can be used in planning parameters for 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. Further, research can be taken to develop a network of sharing of fleet by third party logistics players, or firms owning their own fleet for demand fulfilment.

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