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MECHANISMS FOR INCREASING OF TRANSPORTATION EFFICIENCY USING JOINT SERVICE OF LOGISTICS SYSTEMS

Andrii GALKIN

O. M. Beketov National University of Urban Economy in Kharkiv, Department of Transport Systems and Logistics, Kharkiv, Ukraine

Abstract:

More and more attention become to Transport Company's functioning efficiency due to growing of goods' nomenclature and specific requirements for their service. Existing scientific and practical approaches to managing of transportation process consider separate service of each contract individually. Up-today requirements for transportation services complicate such evaluation. These requirements primarily include transportation frequency and volumes variation in each logistics system due to seasonal consumption of material flows. Different seasonality leads to irrational use of vehicles and decrees of their efficiency. All this gives rise to the mechanism of compatible transportation service of numerous logistics systems and their material flows by any enterprise.
The paper consist of next sections the analysis of scientific framework and methods on the transportation services, fleet estimation, efficiency evaluations, analysis of requirements of transportation services; Mechanism of joint transportation services; Modelling of transportation services in logistics systems, where joint efficiency estimation of transportation functioning and logistics system and conclusions.
The proposed methods and tools in the complex allow to identify and evaluate the effectiveness of the joint motor transport service of logistic systems by own and hired vehicles compared to the separate on the basis of performance indicators, which vary depending on the technological parameters: transport distances, runway usage factor, cargo class, load capacity of motor vehicles . The offered approach will reveal: regularities of change of indicators of efficiency of variants of the joint motor transport service between the traditional approach (a separate calculation of efficiency for each logistics system) and the proposed (calculation of compatible services), which allows to determine the equivalent cost of transport services during motor transport maintenance of material flows. The calculations confirm the effect of use compared to the separate combined transportation of material flows, which will be shown in reducing the required amount of vehicles by 31,8% and increasing efficiency from 5% to 60%, depending on the initial values of the transportation services parameters. The results of the project can be used in the formation of a freight vehicle fleet of any enterprise that is faced with the issue of hiring transport or have its own, PL providers, transport companies, and others.

Keywords: *transportation services, material flows, investments, synergistic, net present value*

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Contact:

1) galkin.tsl@gmail.com [https://orcid.org/0000-0003-3505-6170]

1. Introduction

Logistics concept based on the integration of transport, supply, manufacture and marketing into logistics systems (LS) for find optimal solutions of material flows (MF) movement (Naumov, Nagornyi & Litvinova, 2015). But, new economic conditions, derivation and rise of rivalry between companies on current market give new challenges for transportation. Growing of goods' nomenclature and specific requirements for their service presuppose the existence of required fleet at Transport Company with set quality for fulfilling contract's obligation. Simultaneously, seasonality and irregularity consumption of different MF make transport use unsustainable and inefficiency. Alternatively, transportation of various MF in different periods by single compatible vehicles raises the issue about ability for joint planning of transportation process for them and evaluating its efficiency. In this case, the mechanism for joint transportation services (TS) of several MF is required development.

Existing methods consider fleet estimation for TS specific client. In this case, the vehicles cannot be used effectively. This provides enhancing the transportation service cost (TSC), and lead to losses for LS because of rising of each separate contracts TS, figure 1. In case when requirement for MF TS in different LS are match the one vehicle's type can be used, figure 2.

In this case, the efficiency of the LS will depend on the effectiveness of the organization of the functioning of the transport participant (carrier). Joint planning of MF TS of different LS will allow more efficient use of available vehicles and thereby optimize transportation costs. Hence, the mechanism of joint transportation of several LS: the evaluation of necessary vehicles amount, the coordination of transportation process with other participants, the evaluation of effectiveness of proposed scenario are require development.

Paper organizes as follow: 1. Introduction 2. Analysis methods of logistics functioning and requirements for it; 3. Mechanism of joint transportation services; 4. Modeling of transportation services in logistics systems, where joint efficiency estimation of transportation functioning and logistics system where described and conclusions.

2. Analysis methods of logistics functioning and requirements for it

2.1. Technologies and vehicle selection

Today, car manufacturers produced different types and models of vehicles, which differ in design, as well as technical, operational and economic indicators. Estimates and operating experience indicate that it is possible to use various types and models vehicles, which under different conditions of operation have different efficiency in transportation of the same goods. When choosing a certain vehicle's type, take into consideration large number of factors, which can be dived into 4 groups (Table 1).

The choice of vehicle's type and model passes in two stages:

1) on the first – external, explicit conditions of operation, according to which the body type is selected, is analyzed, acceptable load carrying capacity and main operational characteristics of the vehicle (axial and full weight, speed of movement, ect.) are determined;

2) on the second – compare the selected at the previous stage of the vehicles by individual or generalized indicators.

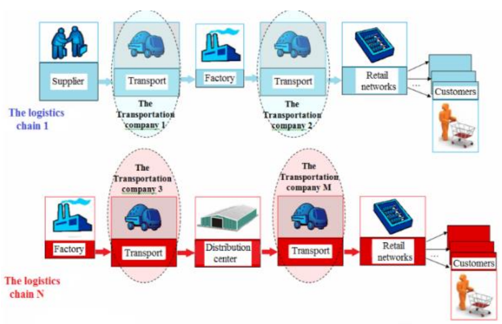


Fig. 1. Logistic system participants and their links (known)

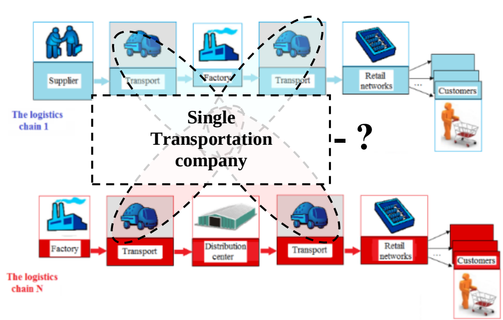


Fig. 2. Logistic system participants and their links (Proposed)

Table 1. Factors that influence on vehicle's choice (obtained from the analysis)

Groups of factors	Factors
Normative	Climatic conditions, road conditions, loading and unloading tools in vehicle, etc..
Technological	Productivity, nominal carrying capacity, load factor, millage factor, length of the trip, technical speed, quantity of single order delivery, etc..
Technical means	Type of vehicle, type of loading, max speed, maximum permissible of axle load, term of vehicle's service, acceleration and breaking time, etc..
Economic	Cost of transportation, freight costs, car cost, operating costs, income, etc..

The described methods include the comparison and selection of the vehicles for individual performance indicators (KPI): productivity, cost price, ect. – depending on specific technical and operational indicators (carrying capacity, load factor, length of the trip with load, mileage factor, technical speed, and downtime under loading and unloading operations, ect.). Solving such tasks requires numerous calculations to compare productivity and TSC of any types and models of vehicles (Halkin, et. al, 2017).
Overall analysis show that vehicle's selection methods mostly based on normative, technological, technical, economic criteria. But, up-today economic condition and opportunity to make alternative investments force to use progressive method such as project analysis, which is have been barely apply for assessing transport technology.

2.2. Methods of fleet evaluation

Estimating the optimal vehicles amount issue for the TS particular MF is one of the most important tasks in theory and practice of transportation. The reasons for estimating the required amount of vehicles are the data about: cargos (Naumov & Kholeva, 2017), requirements for transportation (Fisher, 1995), technology (Kodialam & Nandagopal, 2003), ect.
The presence of unknown or variable factors in models begins to develop a new direction of tasks of fleet evaluation, which takes into account the uncertainty demand. These tasks solve evaluation the rational relationship between vehicles with different specializations, load-carrying capacity, load factor, the quantity of empty hauls, ect. (Kholeva, 2017). These approaches are based on defining fleet, with some assumptions: certain degree of TS reliability (Filina-Dawidowicz, Iwańkowicz & Rosochacki, 2015), the volumes of cargo, time window, size of distribution area (Cruijssen, Bräysy, Dullaert, Fleuren & Salomon, 2007), ect. These methods are limited by finding data intervals and according to this evaluate optimal vehicle capacity, type, amount, ect (Crainic, Ricciardi, & Storchi, 2009). Tasks with stochastic and random distribution characteristics: distance transportation, time of services, cargo volumes, ect. (Naumov, Nagornyi & Litvinova, 2015). The general description of the methods for estimating the fleet, as well as the place of the joint TS in the system of methods is shown in Fig. 3.
Existing methods for motor fleet estimation issues do not sufficiently consider the joint vehicles use (fleet sharing) for servicing of several contracts in separate periods of time. There plenty of works that describe vehicle routing problem (Cruijssen et al., 2006; Kodialam & Nandagopal, 2003; Psaraftis, 1995) but they considering less loading and unloading subsystems. Also, this works present daily algorithms which is not give information next periods. Seasonality influence in different periods make great affects the vehicle quantity and their usage. Presented approaches used productivity, costs or profit comparisons, but modern conditions oblige to use approach which based on project analysis indicators: net present value (NPV) and payback period (PP).

2.3. Theoretical bases for assessing the efficiency of transport in the logistics system

The MF management in the LS is carried out on regular interaction with the participants of commodity movement: carriers and cargo transshipment terminals or ports, which are been control entity of the LS. The MF of a particular owner is been part of the transportation flow (in the case of transport participant) or cargo flow (in case of transshipment) by Gansterer & Hartl (2017) and participates in the LS as a control entity. The effectiveness of managing a LS depends on how close goals of transport, warehouse and other flows managing relevant with MF managing (LS goals).
On fig. 4 shows three areas, indicating the set of traffic, warehouse and MF objects. The coincidence of interest's area between carrier, warehouse and LS is represented by the imposition of tree circles.

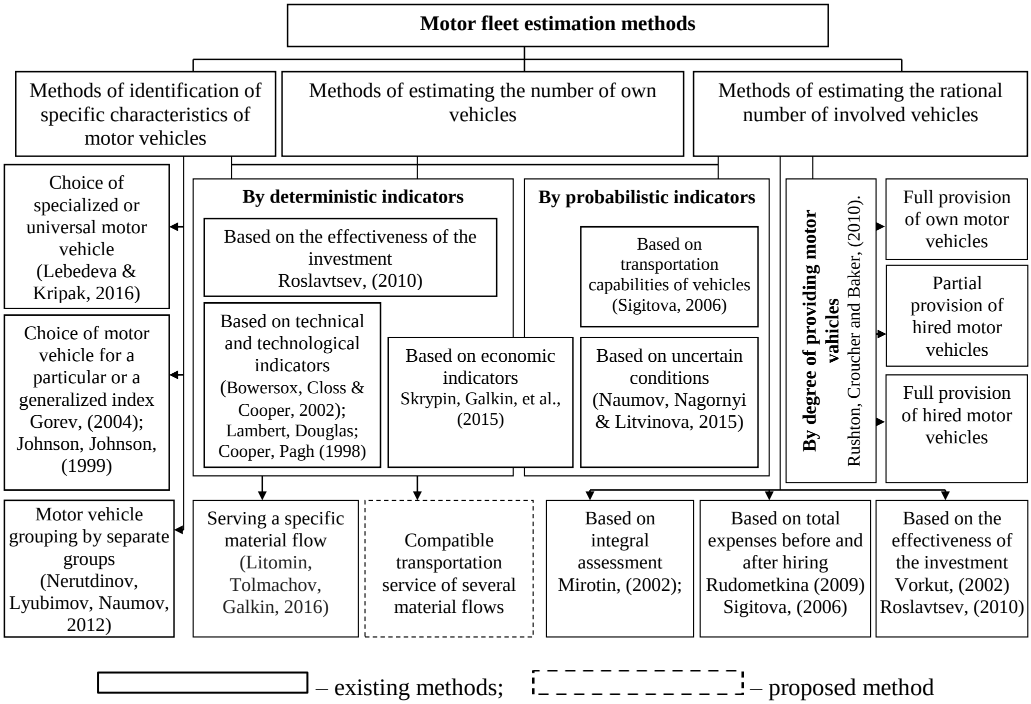


Fig. 3. Results of rolling stock estimation methods analysis

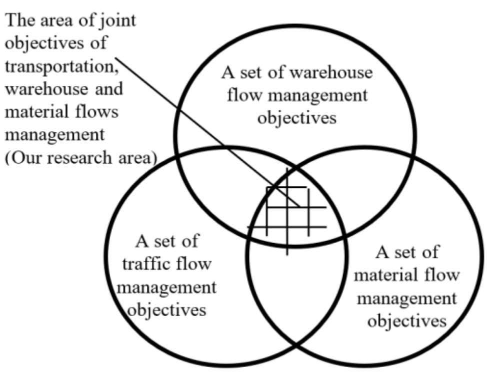


Fig. 4. The area of joint objectives of transportation, warehouse and material flows management

The more this area is larger, the more effective is the activity of the coordinator, which ensures the implementation of the criteria for the preferences of the cargo owner while ensuring the process of commodity circulation. The Collaborative Transportation Management (CTM) (Esper and Williams, 2003) features include the possibility of increasing the goal's coincidence area, setting limitation and requirements between them. Therefore, the MF management goals that are not included in the joint field should be analyzed for their possible correspondence to the most desirable value of the parameter, but to the possible scope values, which fit to shipper request.

The main difference between the logistics chain and the transport participant is shown in tab. 2.

Differences in goals, control action, constituent elements of system, KPI in these two systems lead to a conflict of criteria for the effectiveness of transport with the criteria for the LS effectiveness. Accordingly, the solution of the problem of assessing the transport operation may be based on finding compromises of such conflicts. On the other hand, the non vicious character of the LS allows to study links with other market systems, the affiliation of individual participants to different LS, that possibly belonging to compete LS (Figure 5).

Table 2. The main differences between the logistics system and the transport participant

Factors	Logistics system	Transportation participant
Goals	Material flow movement to the consumer in accordance with the criteria of shipper requests	Fulfillment of transportation contract conditions with minimal costs for the carrier
Constituent elements of system	Intermediaries that ensure the advancement of the material flow from the seller to the buyer (freight forwarders, carriers, etc.)	Technical and transport means of carrier
The head of control action	Interaction of actions of all participants participating in the process of commodity circulation	Vehicle's traffic management
The initiator of the control action	Economic market entity (Shipper)	Carrier manager
Key performance indicators (KPI)	Value expect a beneficial effect (result) (Anand, Yang, Van Duin, & Tavasszy, 2012), the probability of achieving the expected beneficial effect (result) (Crainic, 2000); cost of resources to achieve the expected beneficial effect (result) with a given probability (Mirotin, 2002); the minimum total logistics costs while ensuring of the necessary logistics service quality (Makarova, Shubenkova & Pashkevich, 2017)	Maximum daily operations (Kumar, Mangaraj & Vijayaraghavan, 2015), maximum profit (Sigitova, 2006), capture maximum market share (Lambert, Cooper and Pagh, 1998), hold positions in the sales market (Gromov, Persianova, 2003), the maximum value of the exchange rate of shares of the firm (Gorev, 2004), minimize costs (Makarova, Shubenkova & Pashkevich, 2017), ect.

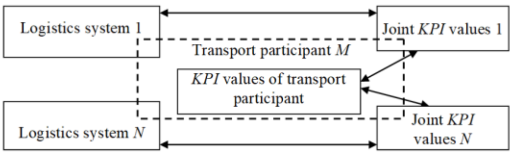


Fig. 5. Scheme of effectiveness evaluation of transport participant and logistics system

Therefore, the goals of some LS may not coincide with the objectives of others, and different goals of the transport company can coincide with the objectives of different LS. Uncertainty in such circumstances necessitates further research. On the other hand, there is no joint evaluation efficiency it's mechanism for several MF TS, which taking into account compatible indicators of various LS functioning.

There were several general algorithms for integer transport (Mole, 1975) and logistics system developed (Crainic, 2000) But, they do not developed specific transportation feathers and unloading and loading subsystem functioning that taking into account particular technology of material flow distribution and handling have not been consider in this studies.

Object of research: The process of managing the joint motor transport service of several logistics systems.

Goal: evaluation of transportation services mechanism for joint transportation services of material flows.

3. Mechanism of joint transportation services

3.1. Coordination of the functioning of transportation process participants

Important aspect of LS is rational organization of joint transportation process and origin (loading) and destination (unloading) subsystems functioning. Possible delays can arise due to a non-rational organization of TS, causing an increase in the estimated amount of vehicle. The technological traffic capacity of carrier is expressed in transport activity and amount of traffic that can be performed by a separate vehicle, fig. 6.

Estimating the above indicators requires calculating the quantity of turnaround trips performed by each separate vehicle during the TS of several MF customers for a specified period. For this purpose, the return trip time, which takes into account the discrete traffic volumes and conditions of loading and unloading operation points, is evaluated. Transportation process interaction with loading (Consignor) and unloading (Consumer) points can be described in three variants of the system functioning:

1) the trip time ($T_{їзд}$) and that the turnaround trip time ($T_{об}$) is less than or equal to the compatible daily operation time of consignor and consumer;

2) the turnaround trip time ($T_{об}$) is bigger than daily operation time of consignor and consumer ($T^{н-р}_{доб}$) or equal to it, and one way carriage trip time ($T_{їзд}$) less or equal to compatible daily operation time of consignor and consumer points ($T^{н-р}_{доб}$);

3) the turnaround trip time ($T_{\text{об}}$) and the travel time ($T_{\text{їзд}}$) are bigger than time of compatible daily operation time of consignor and consumer per day ($T^{\text{н-р}}_{\text{доб}}$).
Compilation of system limits for TS that takes account of these processes:

$$TO=\begin{cases} T^{A}_{\text{їзд}} \le T^{A}_{\text{об}} \le T^{\text{н-р}}_{\text{доб}} \\ T^{A}_{\text{об}} \ge T^{\text{н-р}}_{\text{доб}} \ge T^{A}_{\text{їзд}} \\ T^{A}_{\text{об}} > T^{A}_{\text{їзд}} > T^{\text{н-р}}_{\text{доб}} \end{cases}, \qquad (1)$$

where $T^{A}_{\text{їзд}}$ – one way travel time, h; $T^{A}_{\text{об}}$ – the turnaround trip time, h; $T^{\text{н-р}}_{\text{доб}}$ – compatible daily operating time of consignor and consumer, h.

In view of above, it is necessary to consider and operation rhythm of Consignor (loading subsystem) and Consumer (unloading subsystem), shown in Fig. 7.
Operating time of the system per day will be equal to start time of the Consignor ($T^{s.\text{н}}_{daily}$) and Consumer ($T^{e.p}_{daily}$):

$$T^{\text{н-р}}_{\text{доб}} = T^{s.\text{н}}_{daily} - T^{e.p}_{daily}. \qquad (2)$$

Daily operating time of the loading and unloading subsystem ($T^{\text{н-р}}_{\text{доб}}$) reflects the joint operation time of all systems per day. If the vehicle's turnaround time ($T^{A}_{\text{об}}$) less than joint functioning time of consigner and consumer ($T^{\text{н-р}}_{\text{доб}}$), than vehicle can perform at least one turn ($T^{A}_{\text{об}}$). It is advisable to consider the system as discrete. The quantity of trips we find on dependencies (3 – 5):

$$N_{\text{об}}=\left[\frac{T_{\text{м}_i}}{T^{A}_{\text{об}}}\right]; \qquad (3)$$

$$N'_{\text{об}},\ if\ \begin{cases} \Delta T_{M_i} \ge (t_{\text{нав}}+t_{\text{розв}}+t_{\text{їв}}) \to N_{\text{об}}+1 \\ \Delta T_{M_i} \prec (t_{\text{нав}}+t_{\text{розв}}+t_{\text{їв}}) \to N_{\text{об}} \end{cases}; \qquad (4)$$

$$\Delta T_{M} = T_{M} - \left[\frac{T_{M}}{T_{\text{об}}}\right]\cdot T_{\text{об}}. \qquad (5)$$

Consider the simetric pendulum route with all way carrige $T^{A}_{\text{об}} \le T^{\text{сист}}_{\text{доб}}$ (fig. 8).
In addition, the number of turnovers can be found by imposing limits of driver schedules (6), (7):

$$\begin{cases} T^{A}_{\text{їзд}} \le T^{\text{вод}}_{\text{доб}} \le T^{\text{сист}}_{\text{доб}} \le 8\ h.; \\ if\ T^{A}_{0} \le 2; \to T^{A}_{\text{об}} + T^{A}_{0} \le 10\ h.; \\ if\ T^{A}_{0} \ge 2; \to T^{A}_{\text{об}} + T^{A}_{0} - 2h. \le 8\ h. \end{cases} \qquad (6)$$

where T^{A}_{0} – run without cargo, h; $T^{\text{вод}}_{\text{доб}}$ – time for which one or two drivers are directly employed by the vehicle management day. If there are two drivers:

$$\begin{cases} T^{A}_{\text{їзд}} \le T^{\text{вод}}_{\text{доб}} \le T^{\text{сист}}_{\text{доб}} \le 16\ h.; \\ if\ T^{A}_{0} \le 2; \to T^{A}_{\text{об}} + T^{A}_{0} \le 18\ h.; \\ if\ T^{A}_{0} \ge 2; \to T^{A}_{\text{об}} + T_{0} - 2h \le 16\ h.; \end{cases}, \qquad (7)$$

On condition that $T^{\text{вод}}_{\text{доб}} \le 16$ h, a $T^{\text{вод}}_{\text{тиждн}} \le 80$ h.

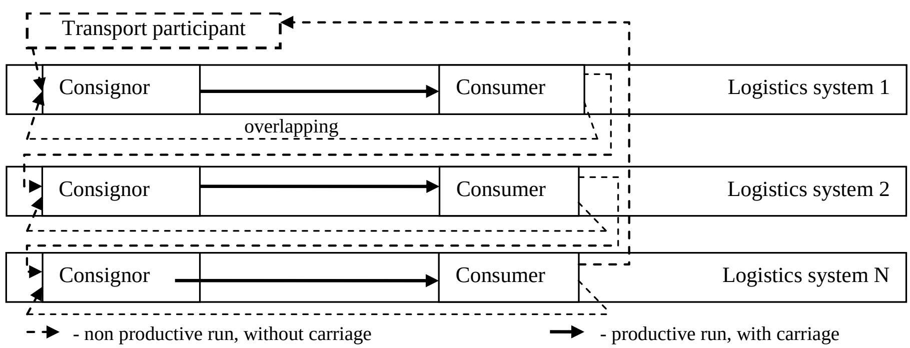


Fig. 6. Functioning transport participant in *N*-th logistics systems

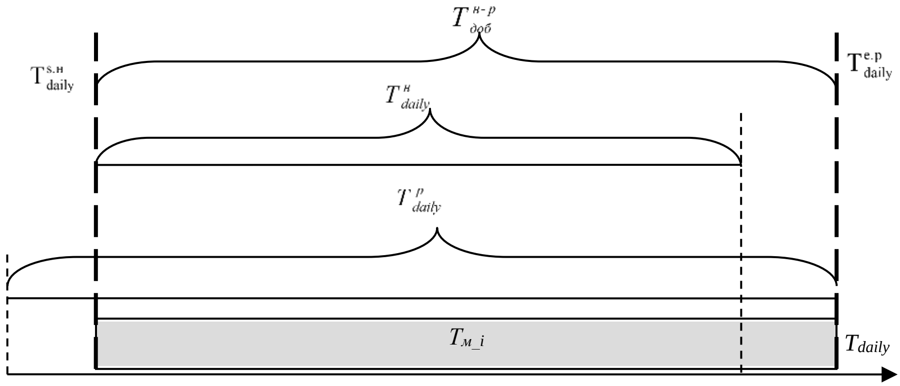


Fig. 7. Compatible daily operating time of subsystems of loading and unloading: $T^{н}_{daily}$ – operation time of consigner (loading subsystem) during the day, h; $T^{р}_{daily}$ – operation time of consumer (unloading subsystem) during the day, h; $T^{s.н}_{daily}$ – start of working hours of consigner, h; $T^{e.p}_{daily}$ – end of working hours of consumer point, h .; $T_{м\_i}$ – TS time on route, h.; T_{daily} – daily time of joint systems operation, h.

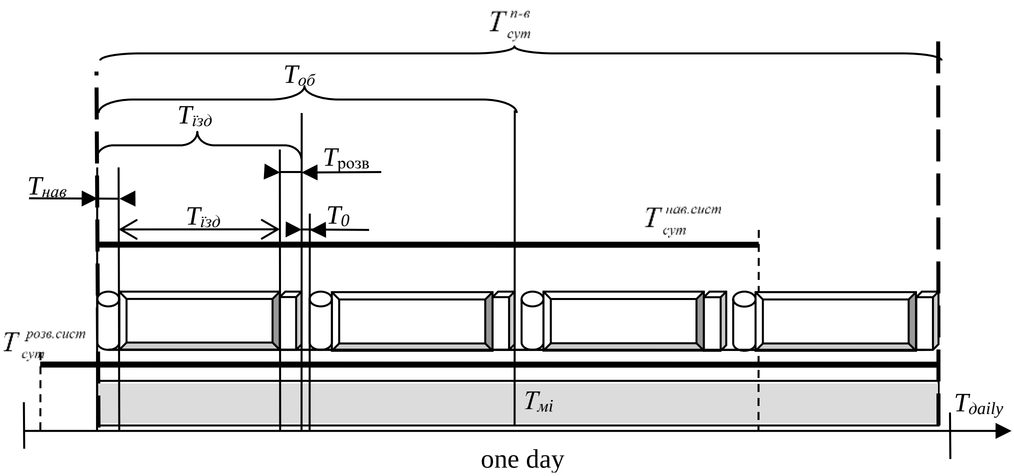


Figure 8 – One motor vehicle functioning time in two systems at $T^{A}_{їзд} \le T_{об} \le T^{н-р}_{доб}$ during one day

Everyday each driver possible to drive up to 2 hours over his main working time (8 hours), but not more than twice a week, provided that the driver's time does not exceed 45 hours per week ($T^{вод}_{тижд} \le 45$ hours). Accordingly, if $T^{вод}_{доб}$ is greater than the limits, the turning point will exceed the daily operating time of the system ($T^{A}_{об} \succ T^{сист}_{доб}$). Upon completion of the ride, the vehicle may be physically located at a long distance from the place of the next load ($T^{A}_{хол}$) and ($T^{A}_{нул}$). Functioning of vehicle in conditions $T^{A}_{об} \ge T^{н-р}_{доб} \ge T^{A}_{їзд}$ for four days is shown in Fig. 9.

If the carriage trip time in one direction is less than loading operating time of the subsystem or equal to it, large systems can be described using the formulas of small systems (Nicolin, 1986) in view of restrictions related to the driver's operation:

$$T_{їзд}^{A} = \frac{l^{A}{}_{їв}}{V_t^{A}} + t_i^{н-р} \leq 8 \; h.; \tag{8}$$

$$T_{їзд}^{A} \leq T_{доб}^{н\text{-}р} \leq T_{об\_i}^{A} \leq 8 \text{ h.} \tag{9}$$

$$\begin{cases} if \; T_0^A \leq 2 \rightarrow T_{об}^A + T_0^A \leq 10 \; h.; \\ if \; T_0^A \geq 2 \rightarrow T_{об}^A + T_0^A - 2 \, h. \leq 8 \; h. \end{cases} . \tag{10}$$

where V_t^{A} – technical speed, km/h .; $l^{A}{}_{їв}$ – carriage transportation distance, km; T_0^A – non carriage run time, h.; $t_i^{н-р}$ – joint time functioning of loading and unloading subsystems, h.; $T_{їзд}^{A}$ – trip time, h.

Models for describing transportation process and estimating time and quantity of turnovers are summarized in Table 3.
In this case, the transpiration time in each case will be different:

$$T_{TS\_1} \neq T_{TS\_2} \neq T_{TS\_3} \neq T_{TS\_n}, \tag{11}$$

In which $T_{TS\_1}, T_{TS\_2}, T_{TS\_3}, T_{TS\_n}$ – TS time for the first, second, third and n-th contract.

Consideration of the technology of transportation and the joint loading and unloading operation is the basis for estimating vehicle's quantity and economic calculations.

3.2. Calculation of vehicle's amount during the joint transportation service of material flows

Different customers have different parameter values: the location of loading and unloading points, the volumes of shipments for periods t, ect. The compliance of the carrier with the technological, economic and other requirements of each m MF of n customers raises the question of the possibility of their joint TS for a period of time. Separate estimation of the vehicles amount for each customer is determined by the condition of the maximum amount of traffic in a specific time period. Under such conditions, the estimated vehicle's amount for the n-th customer to the all period of the TS is estimating by the maximum value of the required amount for all periods t, under the condition of full compliance with the contractual obligations:

$$A_{max\,n} = max\left[A_{11}, A_{12}, \ldots, A_{nt}\right], \tag{12}$$

where $A_{max\,n}$ – Estimated amount of vehicles for TS of the n-th during the whole period τ, units; A_{nt} – the required amount of vehicles for TS of the n-th LS in the period t, units.

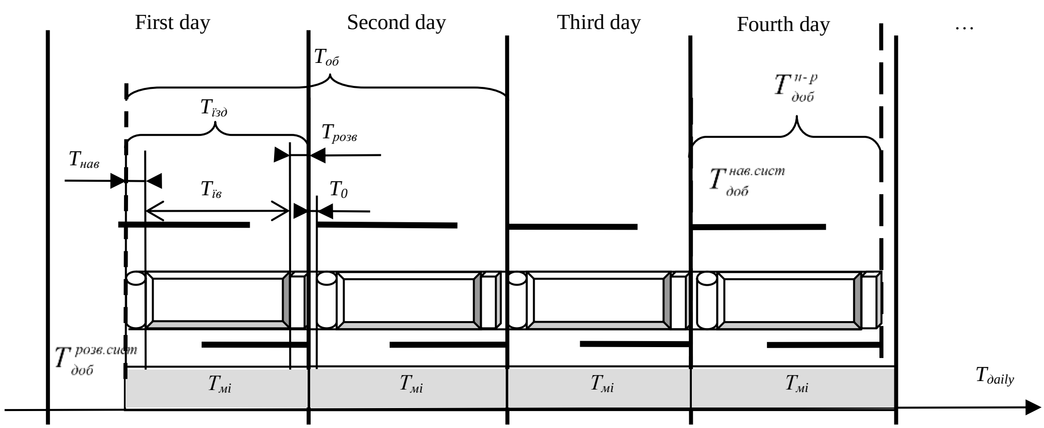


Fig. 9. Motor vehicle transportation service according to compatible conditions of loading and unloading operation (in terms of $T_{об}^{A} \geq T_{доб}^{н\text{-}р} \geq T_{їзд}^{A}$ four days functioning example): $T_{їв}$ – Carriage goods time while trip, h.; $T_{їзд}$ – trip time, h; $T_{нав}$ – loading operation time, h.; $T_{розв}$ – unlading operation time, h.

Table 3. Models for estimating the trip time, turnaround time and possible quantity of trips

№	System functioning option	Dependence
		$T_{їзд}$ Trip time, hours (including driver's schedules limitation)
1	$T^{A}_{їзд} \le T^{A}_{об} \le T^{п\text{-}в}_{доб}$	2 drivers: $T^{A}_{їзд\_i} = \frac{l_{їв\_i}}{V_{t\_i}} + T_{пв} \le 16$; 1 driver: $T^{A}_{їзд\_i} = \frac{l_{їв\_i}}{V_{t\_i}} + T_{пв} \le 8$
2	$T^{A}_{об} \succ T^{п\text{-}в}_{сут} \geq T^{A}_{езд}$	$T^{A}_{їзд\_i} = T^{вод}_{доб\_i} - T^{A}_{хол\_i} + T^{A}_{0\_i} \le T_{daily}$; $T^{A}_{їзд\_i+1} = T^{вод}_{доб\_i+1} - (T^{A}_{хол\_i+1} - \Delta T^{A}_{хол\_i}) + T^{A}_{їзд\_i+1} + T^{A}_{0\_i+1} \le T_{daily}$.
3	$T^{A}_{об} \succ T^{A}_{e} \succ T^{п\text{-}в}_{доб}$	$T^{A}_{їзд} = \frac{T^{н.нав.сист}_{доб} + T^{A}_{їв}}{T^{н\text{-}р}_{доб}}$
		$T_{об}$ Turnover time (including driver's schedules limitation), hours
4	$T^{A}_{їзд} \le T^{A}_{об} \le T^{п\text{-}в}_{доб}$	2 drivers: $T^{A}_{об\_i} = \frac{l_{M\_i}}{V_{t\_i}} + T_{пв} + T_{хол} \le 16$; 1 driver: $T^{A}_{об\_i} = \frac{l_{M\_i}}{V_{t\_i}} + T_{пв} + T_{хол} \le 8$
5	$T^{A}_{об} \succ T^{п\text{-}в}_{сут} \ge T^{A}_{езд}$	$T^{A}_{об} = T^{водит}_{доб\_1} + T^{водит}_{доб\_2}$
6	$T^{A}_{об} \succ T^{A}_{e} \succ T^{п\text{-}в}_{доб}$	$T^{A}_{об} = \left(\sum_{n=1}^{n} \frac{T^{з.н.}_{daily\_i+1} + T^{A}_{їв}}{T^{н\text{-}р}_{доб\_i+1}}\right) + \left(\frac{\sum_{n=1}^{n} T^{A}_{хол} + \sum_{n=1}^{n} T^{A}_{0} + \sum_{n=1}^{n} T^{A}_{п.з.} + \sum_{n=1}^{n} T^{A}_{ом} + \sum_{n=1}^{n} T^{A}_{нав} + \sum_{n=1}^{n} T^{A}_{роз}}{T^{н-р}_{дов\_i} \cdot 24}\right)$
		$N_{об}$ Quantity of turnovers, units
7	$T^{A}_{їзд} \le T^{A}_{об} \le T^{п\text{-}в}_{доб}$	$N^{A}_{об} = \left[\frac{T_{м_i}}{T^{A}_{об}}\right]_e$
8	$T^{A}_{об} \succ T^{п\text{-}в}_{доб} \ge T^{A}_{езд}$	$N^{A}_{об} = \left[\frac{Д_{э} \cdot T^{сист}_{лоб}}{T^{A}_{об}}\right] + Z'_{об}$
9	$T^{A}_{об} \succ T^{A}_{езд} \succ T^{п\text{-}в}_{доб}$	$N^{A}_{об} = \left[\frac{T^{роб}_{дн\_t}}{T^{A}_{об}}\right] + Z'_{об}$

The MF intensity consumption indicated seasonal goods movement. In the long term TS implementation it 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 transport enterprise can redistribute vehicles between various clients MF for them TS in different time periods.

Vehicles estimated quantity for the entire period (τ) of TS (the contract period) can find as vehicles maximum amount from every time period (t) and every MF N-th clients, including all periods t (Skrypin, et., 2015):

$$A'_t = \max \begin{bmatrix} (A_{11} + A_{21} + ... + A_{n1}); \\ ...; \\ (A_{1t} + A_{2t} + ... + A_{nt}) \end{bmatrix}, \tag{13}$$
$$= \max \left[\sum_{i=1}^{n} A'_{n1}, ..., \sum_{i=1}^{n} A'_{nt} \right]$$

where A'_t - the vehicles estimated amount while joint TS all MF, units; t – periods number, units.
Vehicles estimation number for compatible MF's TS, according to (Skrypin, et., 2015):

$$A^{NMA}_{розр\_t} = \frac{\sum_1^n \sum_1^m Q_t \cdot \sum_1^n \sum_1^m T^A_{об\_i}}{\sum_1^n \sum_1^m T^{раб}_{дн\_t} \cdot q^{Amn}_н \cdot \gamma^{Amn}_c}, \tag{14}$$

where Q_t – The transportation volume by individual contract, *t*.; T^A_i – The TS MF's client average time, days; T_t – The time during which must perform TS, days; $q^A_н$ – The vehicle rated load capacity, t; γ^A_c – The capacity utilization coefficient.

Variations in traffic volumes served at individual contracts, increases the estimated quantity of vehicles, in contrast to the service at the time *t*, by allowing TS MF *N*-s contracts in the "peak" periods. Thus, advisable if estimate the amount of vehicles not for individual contract, but for all orders in the time period. This will increase the efficiency of the park through the "imposition". Vehicles' estimating amount presented at figure 10.
Figure 10 analysis shows that the "total vehicles quantity" for separate TS of *M*'s MF is different with "total vehicles quantity" for combine TS. Approaches are differences in vehicle's calculation between TS types are expressed by quantity number ΔA. The change of the MF TS conditions, in seasons, leads to a change in the required vehicle's amount in periods. The estimation quantity for each individual LS is realized by choosing the maximum amount of vehicles among all TS periods, fig. 10. The total estimated amount of vehicles for the periods (during the joint TS) is defined as the maximum required vehicle's amount for TS on current time.

4. Modelling of transportation services in logistics systems

4.1. Designing and planning of logistic management of compatible transportation services

Carrier is complex socio-technical system, consisting of a production system (means of production, human resources, information communication) and management systems. Changes of its functioning should affect all its spheres. Scheme selection market segment for TS is shown in fig. 11.

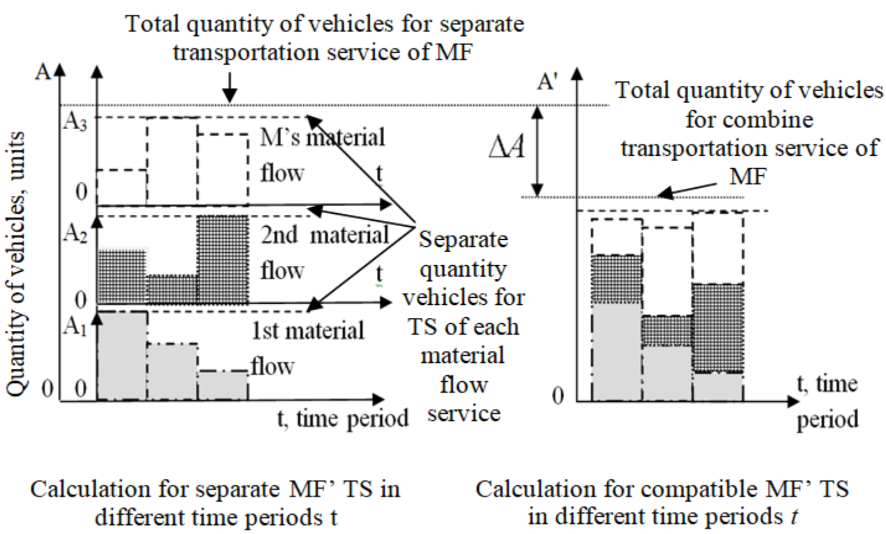


Fig. 10. Approaches' differences in vehicles calculation between transport service types

View of the complexity TS processes and MF's requires the participation of their diversity in a single system. The general scheme for evaluating effectiveness for compatible TS has been proposed at figure 12.
The market segment choice contracted to transport any cargo, and provides for the purchase of vehicle contractual obligations fulfillment – requiems of LS. Match for carriage by same type vehicle or body adaptation to transport various cargoes enables to serve other customers within selected segment limits. Transport enterprise consists of different market segments, similar vehicle group which serve this segment, transport services buyers and their MF.
First level is to select marketing segment. TS general analysis can establish its limitations, shipper and consignee requirements to TS. The second stage is selected technology of TS. Existing methods of managing TS are evaluated and established technological possibility for same type vehicle. Next stage is to determine the process parameters it is necessary to choose an efficiency criterion. To identify possible technological options for all vehicles, the estimation laps number for each own and outsource vehicles can be analyzed.

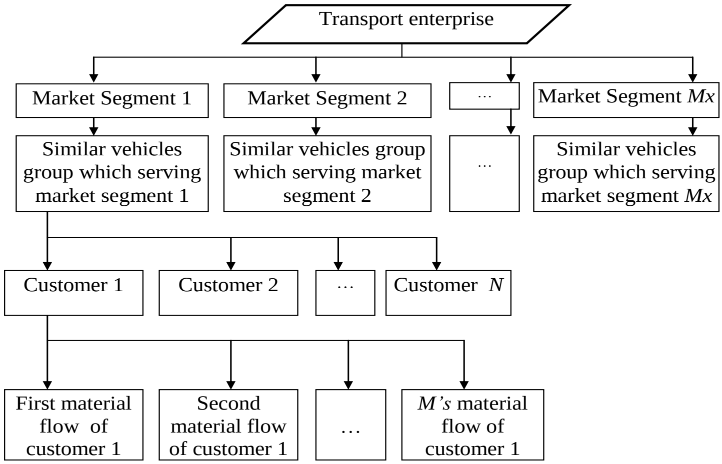


Fig. 11. Market segment choice for transport enterprise (own developed)

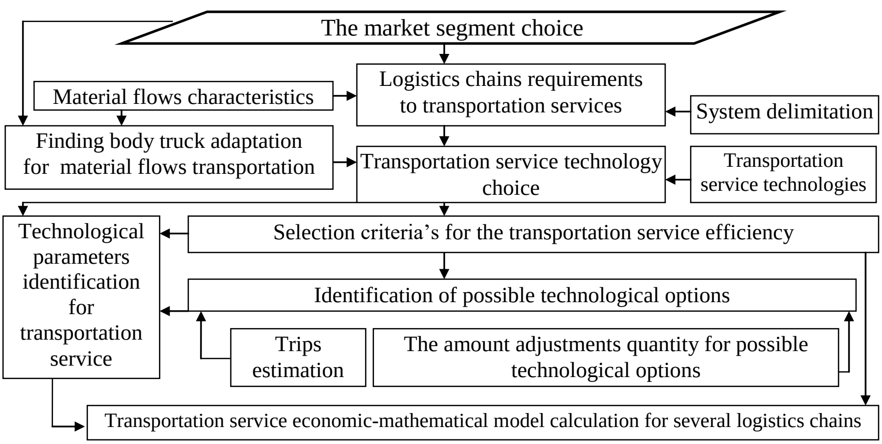


Fig. 12. Scheme for the vehicles rational quantity on a particular criterion (own developed)

The possibility to transportation several MF with their parameters by own and hired vehicles represent alternatives assign for joint TS. The next step is adjusting the vehicle considering changing amount including changing parameters in times. Based on the socio-technological data and selected effectiveness criteria the own and hired vehicle rational amount have to be chosen for joint MF TS. Change of any parameter MF (Y) can lead to a change in TS technology (F). Therefore, the technology of the TS can be filed as a function of the MF parameters:

$$F = f(Y_1, Y_2, ..., Y_n), \quad (15)$$

where Y_1, Y_2,…, Y_n – MF parameters.

In this case, need to consider each MF in contract for TS of multiple clients (N – number of clients N = 1,2, ..., n) Carrier agrees to transport a given volume of goods (MF – Q, q = 1, 2 ... Q) from the consignor to the consignee of the defined technology (F), and routes (B) using vehicles and, in each period t during the contract period τ:

$$A_g = f(Q, N, M, F, B, J), \quad (16)$$

Assign requirements for TS (Q, N, M, F, A, J) during TS contracts for each investment project is own. If you change one of the parameters the efficiency of the project is also changing. The potential number of projects can be described by variable G, where g = 1,2,..., G. During the design and organization of joint transportation in the model (Figure 13) involved the following indicators: M – MF (m = 1,2, ... M); F – MF technology services (F = 1,2, ... F); A – vehicles (a = 1,2, ... A). Each of these characteristics affects the structure and composition of the possible investment projects.

Technological variants of TS have a certain structure: the formulation of the purpose of implementation; market analysis; analysis of technological options; production plan; organization plan; establishing the position from which will be analyzed the income and expenses of technological option. The technological process is been core on the calculation of income and expenditure. Also, the large quantity of its participants affects the technological process of TS, which is have to be integrative for all of them. Ability to TS LS while daily planning makes improves indices vehicles use at the expense of distribution between different MF. The technological scheme of TS clients separately or compatible represents at fig. 13.

Different vehicles are carrying the same cargos with different efficiency. The transporter while making decision should take into account investments: inflation risks, the discounts, the cost of credit, and so on. The KPI of TS can be selected from commercial investment criteria in the «long run» project. As a result, using the project analysis methodology can be simulating different alternative projects with different performances and different efficiency.

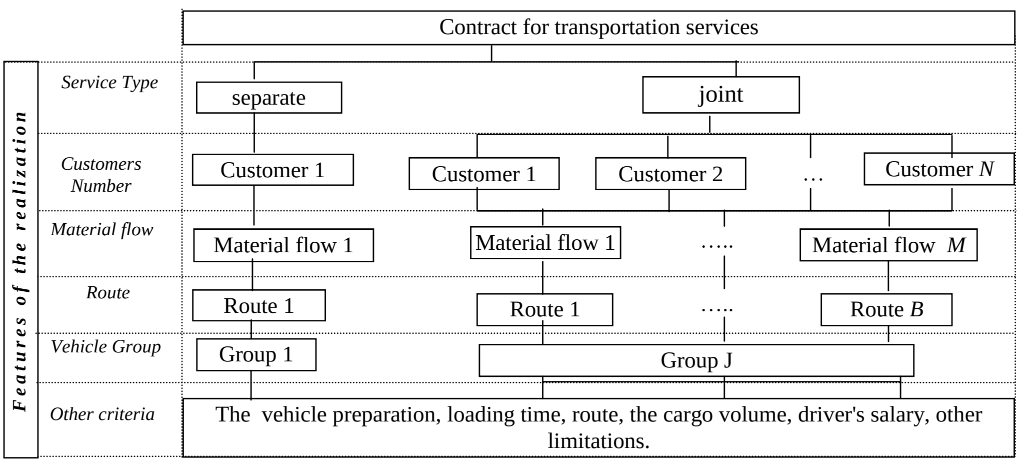


Fig. 13.The technological scheme of transportation services separately or joint (daily planning)

4.2. Project analysis method for efficiency evaluation

The Project analysis method for LS efficiency evaluation that was developed in previous research has been used (Galkin (2017; Halkin, et al., 2017). Calculations of positive and negative flows have been according to these models according to design technology of separate and joint TS:

$$\sum_{1}^{n} NPV'_{TS\_n} \neq \sum_{1}^{n} NPV_{TS\_n} . \quad (17)$$

where NPV_{TS_n} – the NPV of the *n*-th systems when separate TS several MF, usd; NPV'_{TS_n} – the NPV of the *n*-th systems when compatible TS several MF (synergic effect from rational organization of transportation process).

One of the results of progressive integration processes (creation of integrated information systems, rationalization of sources and centralization of stocks) is the synergistic effect. The possibility of efficiency (profitability) functioning is to consolidation compatible servicing of several LS raises the question about rational management of MF. In this case, *NPV* of several separate TS which serve different contracts and *NPV* of one carrier which serving several LS are different. That is:

$$\sum_{1}^{n} NPV_{TS\_n} = NPV_{TS\_1} + NPV_{TS\_2} + \ldots + NPV_{TS\_n} \quad (18)$$

$$\sum_{1}^{n} NPV'_{TS\_n} = NPV'_{TS\_1} + NPV'_{TS\_2} + , \ldots. + NPV'_{TS\_n} = \quad (19)$$

Moreover, if properly organize the transport of one participant in several LS, we get the so-called synergetic effect:

$$\sum_{1}^{n} NPV'_{TS\_n} \geq \sum_{1}^{n} NPV_{TS\_n} , \quad (20)$$

Simulation allows assessing the impact of the requirements for TS on the efficiency of the carrier functioning. The vehicle quantity for particular joint TS of several MFs from NPV can be estimated.

4.3. Data collecting and its variation range

Demand analyze is been made on one of the TC example. TS is been made in intercity and international connection. The TC serves large customer numbers – above 60 per year. Each of them is characterized by different transportation conditions, volumes and other parameters. Survey analysis of TC functioning is presented in tab. 4.

TC used different technology (separate and joint). According to it, joint TS give rise for technological indicators in autumn and winter, comparing with summer. In summer traffic growth is observed generally. Vehicles in autumn and winter period are use on the same level as in summer, but the «Total mileage by all vehicles» is decreased. The «Run utilization factor» stays on same level. Value of technological indicators is forming economical performances. Data for other future periods was simulating basing on obtained one via «forecast.exe» software. Other indicators which described Ukrainian economic environment are taken from papers Galkin (2017) and Halkin, et al. (2017). The simulation of unloading and loading subsystems and different technologies of TS ware made.

4.4. Results of simulations

The service time on distribution routes is assessed based on the monitoring of the elements of the transportation process. Overall, 412 experiments was record during the research. Assessed the influence of each considering factor on the overall service time on distribution routes of retail network. The mathematical description of the change service time was carried out based on the methods of correlation and regression analysis. The regression coefficients were calculated using the least-squares method (Jiang, 2013). The results of the calculations are given in Table 5, 6.

The model for changing the overall service time on distribution routes of various retail networks in Kharkiv is obtained:

$$T = 0,0689 \cdot Q^{1,6} + \frac{1,5213}{q_H} + 0,0423(N \cdot L_{cp})^{1,1} + 0,027 \cdot L_o^{1,5} , \quad (21)$$

where: Q – transportation amount, ton; $q_н$ – vehicle capacity, ton; N – quantity of stores in retail network, units; L_{cp} – The average distance between stores in retail network, km; L_0 – none productive run, km.

Table 4. Indicators of vehicles' for the survey period (own observation at Transport company)

Months (Type of service)	Total transportation volume amount, ton	The Vehicles utilization factor	Average traffic volume value per trip, ton	Total carriage mileage by all vehicles, km	Total mileage by all vehicles, km	The Run utilization factor
May (separate)	804	0,56	11,17	47397	49891,5	0,95
June (separate)	1716,8	0,65	12,91	80023	86981,5	0,92
July (separate)	1703,2	0,70	13,96	70759	77757,1	0,91
August (separate)	2072,8	0,80	16,32	73777	79330,1	0,93
September (Joint)	2108	0,74	14,74	84711	90118,1	0,94
October (Joint)	1950,6	0,71	14,24	76175	84638,8	0,9
November (Joint)	663,4	0,71	14,11	23341	25649,4	0,91
December (Joint)	1131,4	0,82	16,40	39837	43301,1	0,92
January (Joint)	518,4	0,81	16,20	16629	18896,5	0,88
February (Joint)	761,6	0,89	17,71	24164	26848,8	0,9

Table 5. Measuring limits for model parameters

Parameters	Dimension	Minimal value	Max value	Average value
Quantity of stores in retail network	N, units	2	56	
Overall service time on distribution routes of a retail network	T, hours	0,55	149,17	74,86
None-linearity factor	-	1,2	1,8	1,5
Transportation amount	Q , kg	6	538835	259486
The average distance between stores in retail network	L_{cp}, km	2,965	16,895	11,413
None productive run	L_0, km	0,4	129	57,6
Vehicle capacity	$q_н$, ton	2,5	12,5	7,5

Table 6. Measuring limits for model parameters

Indicator	Model 1
T-test:	
Calculated	1,97
Actual	
None productive run	12,7729
Vehicle capacity	5,38777
Transportation amount	7,7188
The average distance between stores in retail network multiply on quantity of stores in retail network	34,2436
F-Test:	
Calculated	3,88
Actual	1666,94
correlation coefficients	0,982

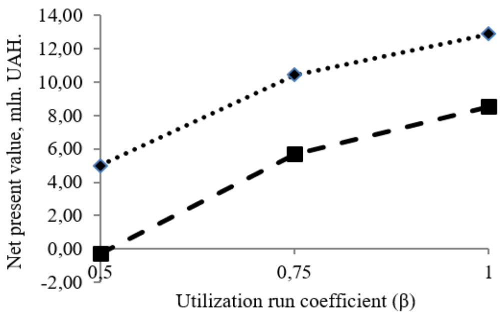
Results of modelling shows, overall service time on distribution routes of a retail network is affected by following parameters: the Transportation amount, vehicle capacity, Quantity of stores in retail network, the average distance between stores in retail network, None productive run.

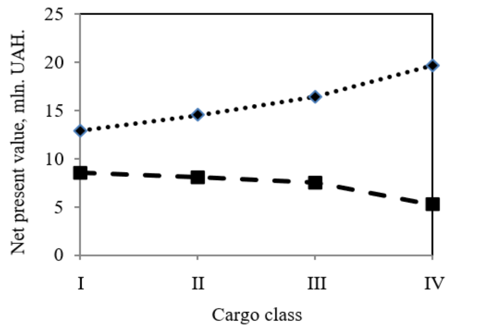
Thus, of all the factors studied, only seven were significant, as evidenced by the actual value of the Student's T-test, which is bigger than the calculated value, and the absence of zero in the confidence interval of each model coefficient.

After the development of the regression model of the change in the overall service time, its statistical evaluation was carried out. The multiple correlation coefficients of the model was 0,982, and the average approximation error was 9,4%. The obtained results made it possible to draw a conclusion about the admissibility of using the obtained model for changing the average transportation speed when designing the parameters of the technological process of freight transportation.

The opportunity to ensure compatible TS of MF provides efficient use of investment results compared with separate service. Calculation economic model involves determining process parameters and circumstances of the model. In this case, change one of the parameters of the model or technology it can completely change the investment performance results.

Comparing of efficiency in change of the utilization run coefficient when a compatible or separate TS, shown Figure 14. Figure 14 analysis show that increasing of utilization run coefficient (β) increase *NPV* of the any project (joint or separate technology). Transportation distance influence on *NPV* for compatible and separate TS technology of MF is shown in Fig. 15.
Fig. 16 analysis showed the increasing of transportation distance also increase NPV of the project. The simulation results depending NPV form distance of transportation showed that the effectiveness of the organization of compatible TS higher then separate one. NPV variation of projects depend on the carrying capacity of the vehicle is used is shown in fig. 17. Analytical computations and calculations resulted can establish the positive effect of using a compatible TS MFs, compared with separate. Redistribution of vehicles between MF's, has shown decrease of their total quantity, between joint and separate TS. Based on the foregoing, we can conclude that NPV depends of TS requirements, transportation technology (parameters of TS process), level of taxes, credits, MF's parameters.

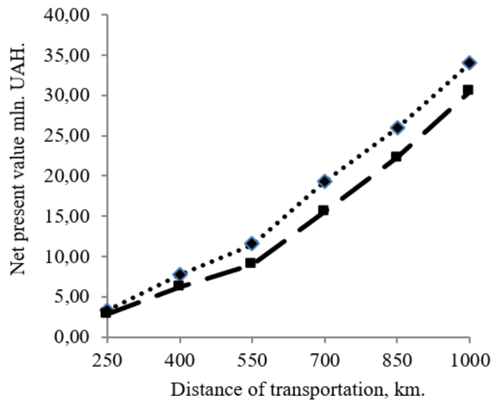


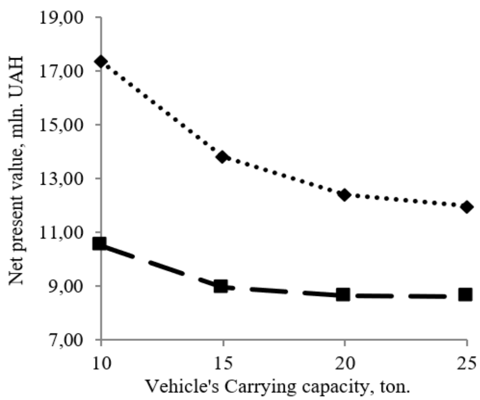


– The NPV at compatible TS, UAH;
– The NPV at separate TS, UAH.

Fig. 14. Variation of net present value depending on utilization run coefficient

Fig. 15. Variation of net present value depending on cargo class





– The NPV at compatible TS, UAH;
– The NPV at separate TS, UAH.

Fig. 16. Variation of net present value depending on distance of transportation

Fig. 17. Variation of net present value depending on carrying capacity of vehicles

4.5. Joint efficiency estimation of transportation functioning and logistics system

The cost of transportation effects on final logistics costs. If assume that the transportation functioning is auxiliary and is aimed to ensuring functioning of other participants in the LS, then the following conclusion can draw. The assessment of transportation functioning should be based on indicators values located in the zone of "logistic expediency". The term "logistic expediency" proposes to understand the meaning of transportation KPI that range from the minimum to the maximum possible values (meaning physical befit to the indicators), as well as between the minimum and maximum efficiency values of the LS. Directions of the transport's KPI values can be different. Therefore, it may be necessary to have a framework of bringing the KPI of transportation in these areas into a single assessment system. Previous research (Halkin, et. al, 2017) indicate about possibility of invest project approach to regulate TSC value. Using this approach allows to measure any cost decrease for compatible service relative with separate's variant. It provides extra advantages for clients and transport enterprise. This approach provides support decision between own profit of transport company and LC minimizing cost, fig. 18. Different life time circle characteristics of the LS and transport participant development should be distinguished. In analyzing a LS, a situation in which individual participants of the LS undergo various stages of their development (e.g. a wholesaler is at the stage of uprising of life circle, and the transport participant completes his investment cycle) can be determined.

The effectiveness operation of the transport intermediary, the conditions for its appearance and the transformation of the LS from the system of the lower level hierarchy to the system of a higher hierarchy remain unexplored. One can assume that there could be situation when transport participants, who implement their services for different LS, reach a critical value. In this case, it is expedient to use the part logistics provider.

The transport KPI can be described as: The ratio of TSC to the volume (the percentage of total transportation costs to the full amount of traffic); The ratio of transportation costs to full costs (the percentage of total transportation costs to full operating costs of the company); The vehicles use (the volume of goods placed in the volume of cargo premises available); The fleet utilization use (the total volume ratio of cargo transported in delivered real time to the maximum possible volume of fleet capacity taking into account whole period of transport functioning).

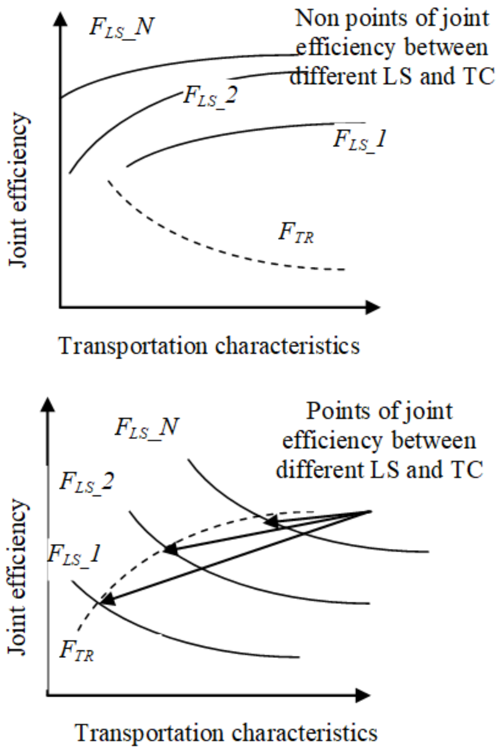


Fig. 18. Scheme curve of joint efficiency between logistics systems and transport company (own developed): F_{LS}, F_{TR} – the logistics system and transport participant joint efficiency

5. Conclusions

The needs for business in transport services is caused by the impossibility of carrying out production and commercial activity without the physical movement of goods from one place to another, and during the sale of goods – from the seller-to-buyer enterprise. In this process, the main element is the transport service. Modern market conditions and the integration of transport in the logistics chain prompts any carrier to review the nature of commercial and production activities, directing it to efficient analysis, study and satisfaction of the demand of consumers of transport services with their joint service. To reduce operating costs and increase the efficiency of the company, transport companies need to increase their competitiveness. Therefore, one of their priority tasks is the rational use of transportation capacities.

The results can be widely used in trade when assessing prospective markets for collapsed goods, purchasing, and incorporating their profitability. Also for consulting agents, as grounded (mathematical) mechanisms of decision support. Decision-making on production or outsourcing of transportation services within the framework is made at particular logistics system and its participants. Set up of optimal parameters of the transportation participant when servicing several logistic systems and mechanisms of their calibration to ensure maximum compatible efficiency.

The proposed methods and tools in the complex allow to identify and evaluate the effectiveness of the joint motor transport service of logistic systems by own and hired vehicles compared to the separate on the basis of performance indicators, which vary depending on the technological parameters: transport distances, runway usage factor, cargo class, load capacity of motor vehicles . The offered approach will reveal: regularities of change of indicators of efficiency of variants of the joint motor transport service between the traditional approach (a separate calculation of efficiency for each logistics system) and the proposed (calculation of compatible services), which allows to determine the equivalent cost of transport services during motor transport maintenance of material flows. The calculations confirm the effect of use compared to the separate combined transportation of material flows, which will be shown in reducing the required amount of vehicles by 31,8% and increasing efficiency from 5% to 60%, depending on the initial values of the transportation services parameters.

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