

Study of Model for Selection of Priorities for Development of Cargo Transportation

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Abstract. The transport market of operator companies of various forms of ownership in Ukraine is constantly evolving, but the tasks associated with the selection and implementation of the priorities of the development of the transport market, the provision of railway services by the carriers - owners of rolling stock, are not fully resolved. There is no regulatory framework that determines the procedure for choosing the priorities of transport market development, their status is not defined, the relation of the selected priorities with the budget of Ukraine is not defined. Therefore, the task of improving the mechanism for selecting scientific and technological priorities for the development of these processes is relevant.

1 Introduction

Under current conditions of operation of the Ukrainian railway transport and operator companies (OC) that are owners of rolling stock, there are factors that are difficult to consider and control. The marketing subsystem can provide information support for making managerial decisions. Means of modern software and hardware provide an opportunity to solve the tasks of macroeconomic analysis of the operation of rail transport: to formulate tariff policies, to determine the return of individual areas on the network of railways, to calculate the yield on the type of rolling stock to determine the rent etc.

For the payback of the car OC need more than 30 years. If discounting and the value of the attracted investments are neglected, then the invested amount for a car can be returned in 8 years. But in fact, only captive OC can afford it – companies that export their own products or are part of large financial and industrial groups whose business guarantees the flow of goods.

The availability of a car model and an electronic card index of cars showing actual operations in real time gives the opportunity to receive all the established reporting, and also provides new opportunities in the management of car fleet.

2 Literature review

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The papers [1] do not take into account advanced information technologies at transporting organisation which may provide the development of using the railway services by users in the transport organisation.

The research [2-4] does not study in the full scale the approaches of forming the interaction technology between railway administration and rolling stock owners in conditions of the sole system operated by the different owners of cargo car fleet on the basis of information systems in order to optimize the capacity of railway transport systems.

The books [5-6] do not reveal the issues of determination the optimal fleet of operators.

The study [7] in the full scale does not analyse the issues of route transportations organisation with the same requirements for different rolling stock owners, especially considering international transportation, the issues about organisation of route transportation with the account of incomplete information.

The papers [8-9] published abroad showed basic principles of transportation organisation, but organisation of heavy and long cargo trains is not considered there.

3 The proposed organisation-technological model

As of 04.04.2019, the total rolling stock fleet of the **inventory cars** of Ukrzaliznytsia JSC (UZ) with the sign CTL is 91737 cars, including by owners: branch of PVRZ 26%; branch of DVRZ 26%; branch CTL 12%; branch of SVRZ 12%; Branch RVK 9%; Branch "Centre of transport service Liski" 1%. The general CTL fleet is divided according to the type of rolling stock: open (gondola) cars 52%, other 33%, tanks 9%, covered 6%, refrigerators 0.3%. The operated fleet there makes 61% of the total fleet, and in the non-operated fleet in repair or waiting is 39%.

The share of transportation in the total volume of transport by gondola cars owned by UZ and Ukrainian enterprises: UZ - 39%; large domestic producers (captive OC) - 24%; other owners of cars whose volumes of transportation make up more than 1% - 24%; other owners of cars whose volumes of transportation is less than 1% - 8%; small domestic producers (captive OC) - 5%.

The share of large domestic producers that carry goods independently (MPS Corporation, Lemtrans LLC, Poltavsky GOK PJSC, Metinvest-shipping, KMMC "Kryvorizhstal OJSC) is 24%. The share of small domestic producers that carry goods independently is 5%. Thus, 29% is a non-competitive railroad market, which together with the share of UZ makes up 68%.

In 2014, the total fleet of Ukrzaliznytsya Joint Stock Company comprised 182.1 thousand cars. In 2015, in comparison with the previous year, the fleet decreased by 2.0%, in 2016 by 2.9%, in 2017 by 0.7%, and in 2018 there was an increase of 4.2%.

In 2014, the Ukrzaliznytsia's inventory fleet totalled 40.6 thousand cars. In 2015, the fleet decreased by 6.0%, in 2016 by 3.7%, in 2017 by 5.4%, in 2018 by 79.4%. In 2014, the Ukrzaliznytsia's own fleet numbered 141.5 thousand cars. In subsequent years there was a decrease of own fleet, respectively, in 2015 by 0.8%; in 2016 by 2.7%. Since 2017 there has been an increase of 0.6%, and in 2018 this number was 25.4%. The change of the total fleet of Ukrainian cargo cars for the period 2014-2018 is shown in Figure 1.

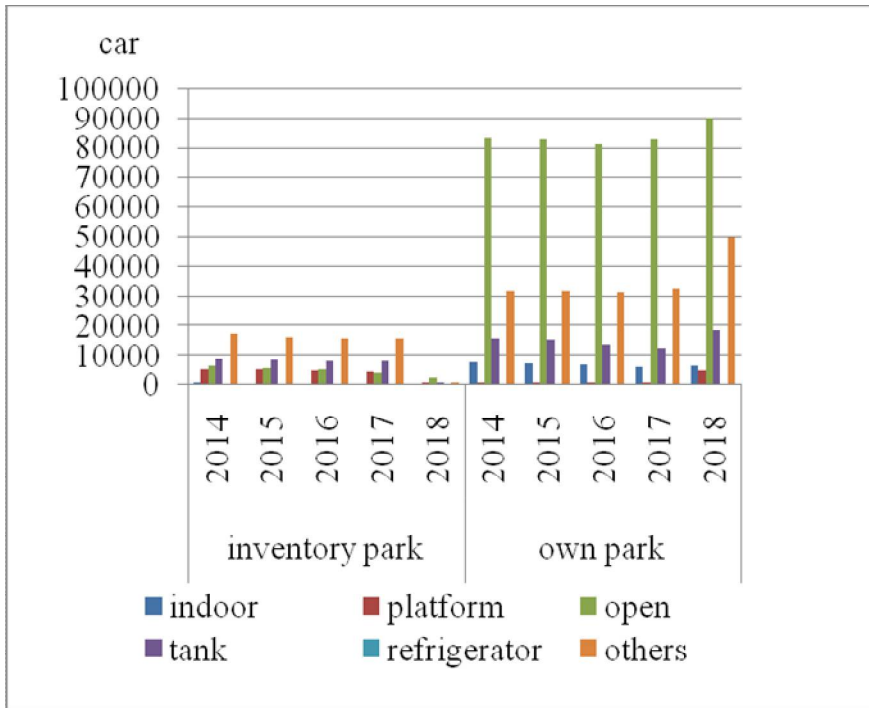


Fig. 1. Change of the total fleet of freight cars of Ukraine.

The aim of the research is to upgrade the route organisation and technological model organising from the different groups of cars of different owners using an interactive automated system map.

The organisation and formation of the route from the groups of cars of different owners may be provided according to the station technological processes by a transporter, operator - rolling stock owner, structural subdivisions of railways and access roads of senders or on station tracks, which are leased by the branch railway lines owners and their counterparties. The following routes of i-categories are taken in account in the routing: 1 — the main rail network direct routes of the operator; 2 — stepping routes under contracts for the operation of access to rail or for serving and cleaning cars taking into account the responsibility of the cargo sender; 3 — routes to the station for spraying or to spraying points for forwarding cars picked up at unloading stations, districts, cargo points and consignees within the limits established by the operator of the main railway network; 4 — routes to incoming or distribution stations receiving fuel cargoes agreed by the main rail network operator [2-4, 7]

The model of organization of the route from the groups of cars of different owners in the conditions of operation of the transport and logistics centre is a two-stage stochastic task with recursion and random right-hand side restrictions. The variables of the first stage are denoted n_j , and the recursive variables, respectively, S_i^l and x_{ik}^l . If the current state of the network $\{a_{ik}, y^0\}$ is given then the task is to minimize the costs of forming and following the departure route q_i^+ , the expected network maintenance costs and the conditions for non-compliance fees, and other car flows on the voyage route.

$$f(E_i) = \sum_{j=1}^r c_j n_j t_j + \sum_{l=1}^L p_l \left[\sum_{j=1}^r q_j \left(\sum_{i=1}^v \sum_{k \in K(t)} a_{kj} c_{ik} x_{ik} \right) + \sum_{i=1}^v q_i^+ s_i^l \right] \rightarrow \min \quad (1)$$

with restrictions

$$\left. \begin{aligned} \sum_{i=1}^m \sum_{k \in K(i)} a_{kj} x_{ik}^l &\leq n_j^0 + n_j, j = 1, \dots, r, l = 1, \dots, L, \\ \sum_{k \in K(i)} x_{ik}^l + s_i^l &= d_i^l, i = 1, \dots, v, l = 1, \dots, L, \\ 0 \leq n_j &\leq u_j, s_i^l \geq 0, x_{ik}^l \geq 0. \end{aligned} \right\} \quad (2)$$

where n – route of a train car; v – number of vertices of the network vector to be served; d – the random variable of maintenance requirements between pairs of vertices that are set using a list of implementations or probabilities; L – number of cars; p_i – probability of occurrence of a variant; d_i^l – i component vectors option; $K(i)$ – a set of paths that can be used to perform service between two points; $a_k \in Z^n$ – incident vector;

$$a_{kj} = \begin{cases} 1, j \in K \\ 0, j \notin K \end{cases}; \quad (3)$$

$y^0 \in R^n$ – existing number of technical routes that take the bandwidth of the network; s_i^l – number of requirements not fulfilled for the option r ; q_i^+ – unit of penalties for failure to comply s_i^l ; x_{ik}^l – number of connections serving the couple i by κ for the option l .

When choosing the optimal mode of car traffic on the network of stations from the sender to the consignee at the stage of planning operating costs does not take into account the third structural part of the model $\sum_{i=1}^v q_i^+ s_i^l$, when unknown deviations from transportation requirements.

The first structural part of the model involves the combined costs of the initial-end operations of the transport process - in our case, this is loading and unloading. The second structural part of the model reflects the cost of running the carriage.

Thus, in the built-in dynamic model, the problem is reduced to determining the priorities of the delivery of the car under load to specific customers – users of rail services – in order to optimize the volume of traffic, increase profits with available resources (cars, shunting and train locomotives, track development).

3 Conclusion

In order to achieve breakeven performance of gondola cars, the minimum required total cargo turnover per month should be not less than 76.8 thousand t-km (calculation of breakeven: average costs per car per month are 5902 UAH, average income rate (car) is 76.84 kop/10 t-km).

As a result of replacing old cars with new ones, the use of car fleets improves: the average number of turns of a new car is 12% more than the old one; the average number of clutches for technical reasons is reduced by 10 times; the average turnover of a new car is 40% more than the old one.

There is a need to develop services for the route formation in accordance with the contract of payment for the infrastructure use, accumulation of the route, the actual duration of idle on the route and each route from the groups of cars of different owners, operators,

finding the economic options of supply with significant changes in the number of cars in the groups of route formation.

The model of accumulation, transiting, unloading of the route allows taking into account the fluctuations of the car flow, the infrastructure capacity of these access tracks, first of all for mass transportation of senders and consignees of cargo.

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