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TRUCK OPERATION EFFICIENCY ASSESSMENT

The article considers the issue of truck efficiency based on the cost of freight road transportation. Two groups of component costs are analyzed in detail: 1) which directly depend on the technical characteristics of trucks (costs of fuel, lubricants and other operating materials, costs of wear and tear and restoration of automobile tires; costs of maintenance and repair); 2) which are determined by the organizational features of the functioning of the motor transport enterprise (drivers' wages, deductions for social needs, depreciation of automobile rolling stock and general economic expenses). The general structure of the cost of freight transportation by automobiles is presented as the sum of indicators that make up two groups of costs: 1) which depend on the volume of cargo; 2) which are related to the characteristics of cargo and organizational work on cargo handling. The formulas for determining the first group of costs (conditional and technical costs) are considered in detail and given, since the value of these costs makes it possible: to assess the efficiency of using vehicles in monetary terms; compare the efficiency of different brands and models of cars in monetary terms; choose the most rational fleet of automobile rolling stock; evaluate the efficiency of the operation of automobiles in various motor transport enterprises in monetary terms.

To assess the feasibility of updating the fleet of motor vehicles, it is proposed to use the value of the economic effect, which is defined as the difference in proportionally reduced annual costs.

The purpose of the article is to provide methodological recommendations to motor transport enterprises on determining the components of transport costs and assessing the feasibility of updating the motor transport rolling stock.

Keywords: cost; expenses; efficiency; profit; reliability; truck; cost price.

INTRODUCTION

Currently, in Ukraine, the fleet of commercial trucks is being updated with modern foreign models. At the same time, owners of motor transport companies choose cars, focusing on the prestige of the brand, the availability of certain models on the market, their cost, etc. But during operation it turns out that the purchased car has high operating costs compared to competitors, although it meets the requirements of the transportation process. In most cases, this is due either to vehicle failures or to the high cost of spare parts and lubricants. The efficiency of vehicle operation in commercial cargo transportation is ultimately determined by the owner's obtaining maximum profit. The amount of profit received depends on the efficiency of vehicle use and the cost of cargo transportation, which in turn depend on the amount of operating costs.

When determining the efficiency of a fleet of trucks, it is necessary to distinguish between the economic efficiency of operation and the more general concept of efficiency, which includes not only economic, but also social, environmental aspects related to the operation of vehicles [1; 2]. Currently, the efficiency of vehicle operation is functionally related to the economic efficiency, reliability and reliability of vehicles (Fig. 1).

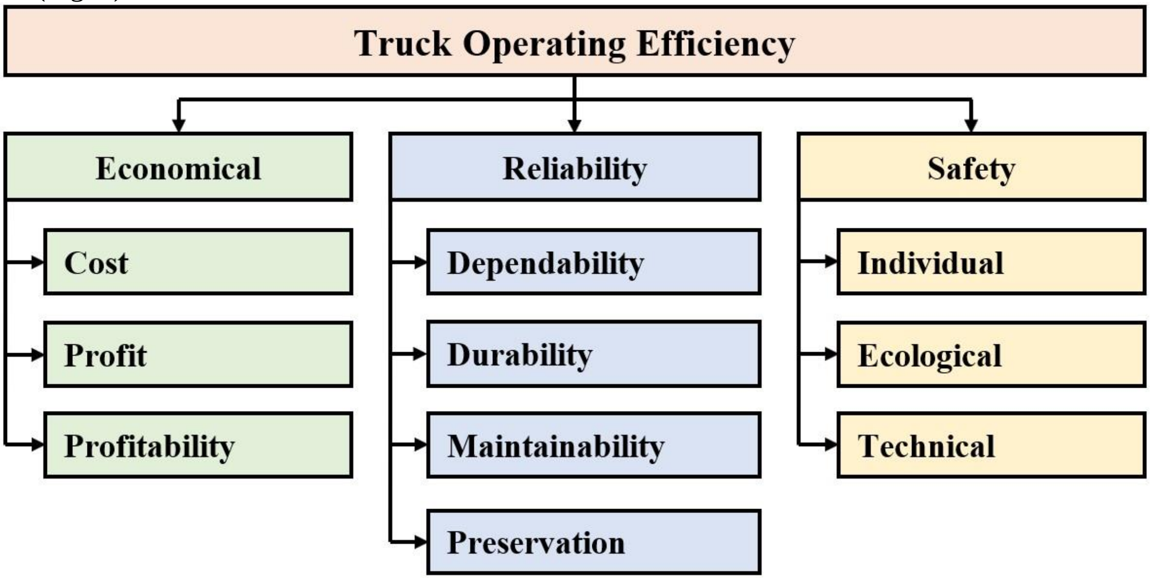

Fig. 1. Structural and functional diagram of relationships when considering the efficiency of truck operation

Given that business entities that provide road transport services, in particular in cargo transportation, pay primary attention to issues of reducing current costs (reducing the cost of transportation) and increasing the volume of services, and therefore the economic efficiency of truck operation is of paramount importance, therefore, the assessment of the efficiency of truck operation must be carried out based on the analysis of the relevant components of the cost of transportation.

LITERATURE REVIEW AND PROBLEM STATEMENT

The issue of the efficiency of using road transport was analyzed in their works, in particular, by such researchers as: M. G. Bosniak, V. V. Varchuk, T. P. Voloshko, V. O. Doroshchuk, V. E. Kanarchuk, V. A. Kashkanov, I. S. Klymenko, O. K. Kryvenko, M. E. Krystopchuk, O. O. Kucher, P. R. Levkovets, O. O. Lobashov, O. O. Solarev, O. V. Tatsenko, E. I. Thoruk [3–9].

The authors' research is limited to three areas: 1) finding the standardizing parameters and clarifying the indicators of transport work; 2) choosing the optimal routes for cargo transportation; 3) analyzing the technical and operational costs of enterprises when operating the existing vehicle fleet.

However, cargo transportation services are provided by motor transport enterprises, for which the primary tasks are to find ways to reduce the cost – the operating costs of vehicles, and therefore it is advisable to additionally consider the issue of determining the components of the cost of road transportation and the magnitude of the economic effect when updating the fleet of vehicles.

PURPOSE AND OBJECTIVES OF THE STUDY

Assess the efficiency of using trucks based on the components of transportation costs and the magnitude of the economic effect when updating the fleet of motor vehicles.

RESEARCH RESULTS

Increasing profits when renewing the vehicle fleet is possible as a result of increases in the productivity of the fleet, decreases in the costs of transporting goods, decreases in the number of road accidents (Fig. 2). In this case, the cargo turnover increases and (or) the cost of transportation decreases, which leads to an increase in the economic effect (and ultimately, profits) for the owner of the vehicles.

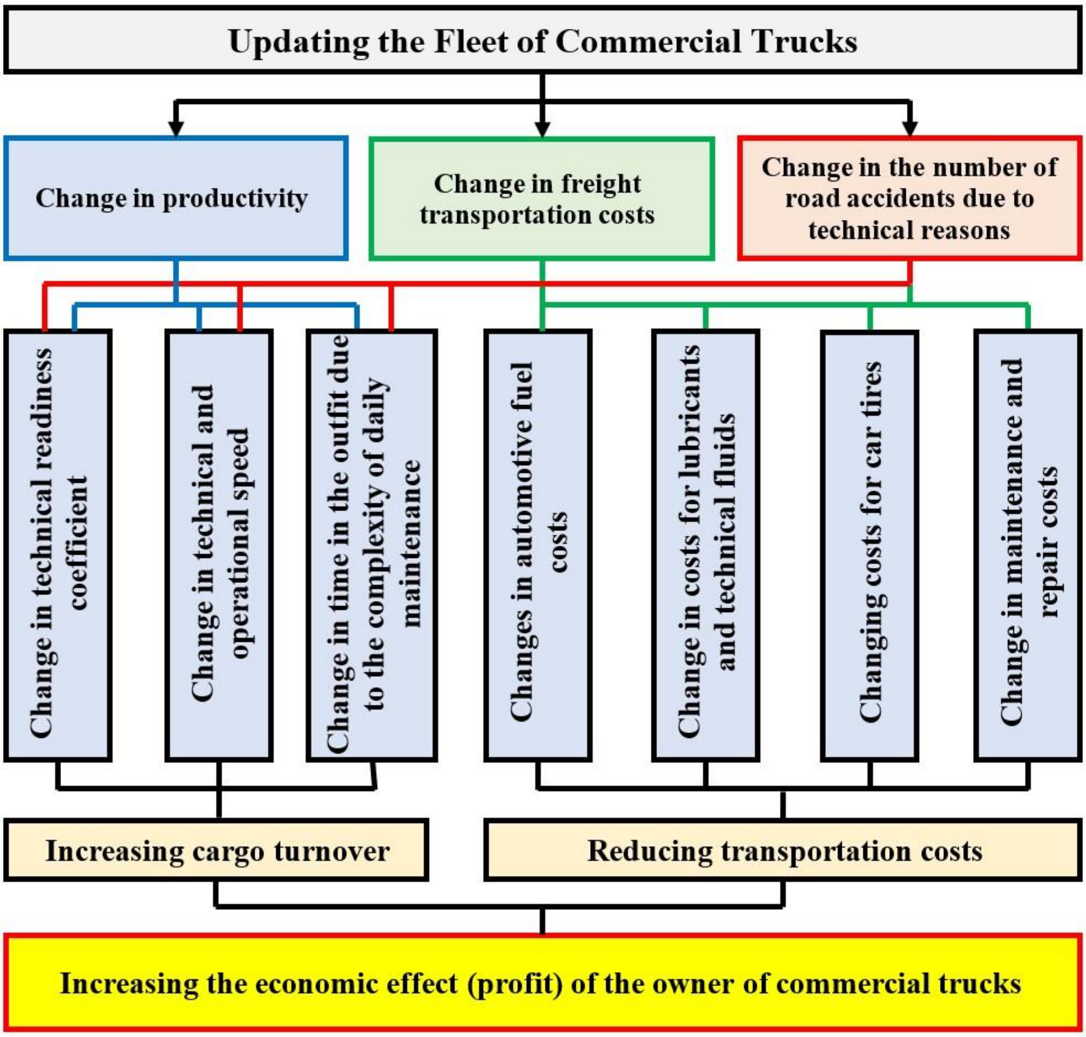

Fig. 2. Expected effect of operating trucks when renewing vehicles

When evaluating and selecting trucks, the equilibrium state of transportation is determined based on the criterion of productivity and cost of transportation [10; 11].

The cost of transportation is a component of the net profit of a motor transport company:

$$P_{net} = f(T_{ann}, S_{ann}, \Sigma TCT_{ann}), \text{ UAH}, \quad (1)$$

where: T_{ann} – tariff cost of transporting annual cargo flow, UAH;

S_{ann} – annual transportation cost, UAH;

ΣTCT_{ann} – trucking company taxes, UAH.

To identify reserves for increasing the efficiency of truck operation (in this case, the profit of the rolling stock owner), we will analyze the variables that affect its value.

T_{ann} – the tariff cost of transportation of annual cargo flow, UAH, determines the gross income or revenue from the sale of services of a motor transport enterprise for the transportation of goods. The tariff cost of transportation is determined by the value of the tariff, which is the price of transportation of goods and passengers. Currently, tariffs are formed on market terms based on costs, demand and supply. Increasing the tariff for transportation in order to increase the profit of a motor transport enterprise can lead to the opposite, when customers may refuse the service in favor of competing enterprises. The positive effect of using this resource is possible only in cases where the enterprise is clearly stronger than its competitors, or there are other guarantees that give confidence in preserving the customer base of the motor transport enterprise.

S_{ann} – annual cost of transportation. To identify reserves for increasing the profit of motor transport enterprises, the structural components of cost items must be divided into two subgroups. The first includes items whose value directly depends on the technical characteristics of trucks. These are costs for fuel, lubricants and other operating materials, costs for wear and tear and restoration of automobile tires, and costs for maintenance and repair. The second group includes items whose values are determined by the organizational features of the functioning of the motor transport enterprise. These are drivers' salaries, deductions for social needs, depreciation of rolling stock and general expenses.

For finding reserves to increase the profit of a trucking company, the first group is of greatest interest, since the values of these items vary significantly depending on the type, model, and modification of trucks.

ΣTCT_{ann} – taxes of transport enterprises. Let’s analyze the taxes levied by the state on transport enterprises.

Taxes are levied on gross profit: profit tax (18% of gross profit); value added tax (20%); land tax (the tax rate for land plots, the normative monetary assessment of which has been carried out, is set at no more than 3% of their normative monetary assessment).

The amount of taxes depends little on the type of rolling stock, therefore, it will change little when choosing a fleet. Thus, the analysis of the components of formula (1) showed that the only significant variable in the formation of this dependence of the profit of a motor transport enterprise when choosing the most rational fleet of vehicles is the cost of transportation S_{ann}.

The cost of transportation characterizes a wide range of factors that affect the profit of the enterprise. Let's analyze the cost items in order to identify the parameters that affect the formation of its value:

1) drivers’ wages and social contributions. The value of this item is determined by the number of drivers employed in the transportation process, the form of remuneration and its value.

The number of drivers for a given volume of transportation is determined by the formula:

$$C_{drivers} = \frac{D_w \cdot d_w \cdot \alpha_T \cdot A_{lq}}{F_{dwh}}, \text{ peoples}, \quad (2)$$

where: D_w – number of days of operation of the transport enterprise per year, days;

d_w – duration of the working day, hours;

α_T – coefficient of technical readiness;

A_{lq} – registered number of vehicles of the transport enterprise, units;

Fvod – annual fund of drivers’ working hours, hours.

F_{dwh} – annual fund of working hours of drivers, hours.

As can be seen from formula 2, the number of drivers is affected by the form of organization of the transportation process and the actual number of cars used in transportation. The annual working time of drivers is determined by the number of working days and the duration of the work shift.

Social contributions amount to 27% (22% – single social contribution + 5.0% – military levy) of the salary. These indicators are of a social nature, that is, they directly determine the social component of the efficiency of car operation.

2) depreciation of rolling stock. Currently, the depreciation fund, even if it is formed, can be directed not just to restoring the value of cars, but generally to the development of the enterprise, at the request of the enterprise management; 3) automotive fuel. The cost of automotive fuel is determined by its cost and actual consumption during the operation of trucks. The cost of fuel is set in market conditions, that is, by the magnitude of demand and supply. This is a factor that is little controlled by the enterprise and little predictable, which depends on the set of processes taking place in the macroeconomics. Fuel consumption during the operation of trucks is directly determined by their technical characteristics, both technical and operational, and the technical condition of trucks. Fuel consumption is determined by the fleet, model of trucks, conditions of their operation, technical condition of vehicles, nature of transportation, rationality of transportation routes, fleet of cargo transported. Existing fuel consumption rationing methods take into account all these factors, therefore, their accounting in the formation of the enterprise’s profit is quite simple, but at the same time, it takes into account many technical and technological factors; 4) lubricants and operating materials. The value of this item depends on the price of these materials and their market value, therefore, this item characterizes the set of technical and technological factors that affect the formation of profit, but at the same time is quite simply determined by existing methods [12]. 5) wear and tear and repair of automobile tires. This cost item takes into account the costs of a motor transport enterprise, firstly, for the purchase of new tires to replace worn-out ones and secondly, the costs of restoring the performance of tires during their operation. Tire costs are determined by:

$$C_t = N_t \cdot P_t + \frac{R_{wt}}{100} \cdot k_t \cdot P_t \cdot n_t \cdot \frac{L_g}{1000}, \text{ UAH}, \quad (3)$$

where: N_t – annual tire wear, units;

P_t – price of one set of tires (tyre, tube, rim tape), UAH;

R_{wt} – tire wear and repair rate in % to the cost of the set per 1000 km of mileage %;

k_t – tire mileage adjustment factor, which takes into account the operating conditions of the rolling stock and tire mileage;

n_t – number of tires on cars, units;

L_g – car mileage per year, km.

The first term in formula 3 characterizes the cost of tires and their number on the car, that is, it directly characterizes the car fleet, its model and brand, as well as the car owner's preference for installing one or another model of tires on the car. That is, it indirectly characterizes the production capacity of the enterprise and the organization of repair production. The second term characterizes the quality of tires used on cars, the operating conditions of cars, the quality of drivers' work, and the operating modes of cars. Thus, this parameter takes into account a large set of factors that affect the profit of the enterprise and the efficiency of operating trucks;

6) maintenance and repair of vehicles. The calculation of costs for maintenance and repair of trucks is carried out through the cost norms established in UAH per 1000 km of mileage. These norms were developed for domestic models of cars [13]. Currently, these norms can be used taking into account indexation in accordance with the market value of spare parts and materials and the reliability of cars in the conditions of operation of transport enterprises. It is more difficult to determine the costs for new models of imported trucks, for which similar norms have not been established. In this case, the enterprise must organize work on the accumulation and processing of statistical information on the actual cost of spare parts and their market value;

7) general expenses. This item of the cost of vehicle operation is taken equal to 25% of the total costs of the previous items of the cost of vehicle operation, and therefore indirectly takes into account the entire set of factors that affect the profit of the enterprise and the efficiency of vehicle operation. The values of the cost items are also quite simply calculated using well-known methods [14]. The structure of the cost of cargo transportation by automobiles [15]:

$$\Sigma S = (S_{LU} + S_{PCT} + S + S_s)\cdot W_Q + R_1 + R_2 + R_3 + R_4 + R_5 + R_6 + R_7 + R_8 + R_9 + R_{10}, \text{ UAH}, \quad (4)$$

where: W_Q – transportation volume, t;

S_{LU} – costs of loading and unloading operations, UAH/t;

S_{PCT} – costs of preparing cargo for transportation, UAH/t;

S – costs of transporting 1 t of cargo, UAH/t;

S_s – costs of storing cargo, UAH/t;

R_1 – costs associated with increasing the distance of transporting cargo, UAH;

R_2 – costs associated with the mismatch of rolling stock with the type and nature of the cargo, UAH;

R_3 – costs associated with damage and loss of cargo, UAH;

R_4 – costs associated with performing additional loading and unloading operations, UAH;
R_5 – costs associated with additional storage of cargo, UAH;
R_6 – costs associated with the inertia of the transport process, UAH;
R_7 – costs associated with increasing the cost of transportation, UAH;
R_8 – costs associated with an increase in the cost of loading and unloading operations, UAH;
R_9 – costs associated with an increase in the cost of preparing cargo for transportation, UAH;
R_{10} – costs associated with an increase in the cost of storing cargo, UAH.

The costs of transporting cargo have the following structure [14; 15]:

$$S = S_F + S_{lM} + S_{MR} + S_{TWR} + S_D + S_O + S_T, \text{ UAH}, \quad (5)$$

where: S_F – fuel costs, UAH;
S_{LM} – costs for lubricants and other operating materials, UAH;
S_{MR} – costs for maintenance and repair, UAH;
S_{TWR} – costs for tire wear and repair, UAH;
S_D – depreciation costs, UAH;
S_O – overhead costs, UAH;
S_T – costs for taxes, UAH.

These operating costs for freight transportation by car can be divided into conventionally technical (variable) – S_F, S_{lM}, S_{MR}, S_{TWR} and conventionally organizational (conditionally constant) – S_D, S_O, S_T. The last group of components changes when updating the fleet of commercial vehicles approximately the same for any choice, so it can be neglected in further calculations.

In practice, the costs of the cost items: fuel S_F, lubricants and other operating materials S_{LM} and restoration of worn tires and repair S_{TWR} are determined according to existing methods, and sufficiently correspond to the actual production values [16]. Maintenance and repair costs S_{MR} in these methods consist of the costs of labor for repair workers, costs for spare parts and materials. Maintenance and repair costs are calculated based on specific norms for specific models of cars, UAH/1000 km. The existing values of this norm were developed for outdated car models and are currently used taking into account indexation coefficients, there are none for foreign car models and modern domestic ones.

In this expense item, we will include only the costs of spare parts and materials used in the maintenance and repair of vehicles, designating them as S_{SPM}.

The costs of paying repair workers are attributed to the group «conditional and organizational». Then the conditional and technical costs have the form:

$$CTC = S_F + S_{LM} + S_{TWR} + S_{SPM}, \text{ UAH} \quad (6)$$

This indicator of truck usage indirectly takes into account, in monetary terms:
1) design features of the vehicle, directly related to the operation of rolling stock on the line;
2) actual reliability of the vehicle in specific operating conditions of the motor transport enterprise;
3) efficiency of the vehicle for specific operating conditions;
4) cost and consumption of spare parts and materials for a specific model of vehicle.

This indicator allows:
1) to assess the efficiency of the use of vehicles in monetary terms;
2) to compare the efficiency of different brands and models of vehicles in monetary terms;
3) to choose the most rational fleet of rolling stock;
4) to indirectly assess the efficiency of the operation of the vehicle operation service in various motor transport enterprises in monetary terms.

Having analyzed the conventional and technical costs (CTC) when using vehicles, we obtain:
1) fuel costs [14]:

$$S_F = P_F \cdot Q_{FC} = P_F \cdot 0{,}01 \cdot (N_L \cdot L + N_{thkm} \cdot W)(1 + 0{,}01 \cdot k), \text{ UAH} \quad (7)$$

where: P_F – price of 1 liter of fuel, UAH;
Q_{FC} – fuel consumption, l;
N_L – fuel consumption rate of the vehicle, l/100 km;
L – vehicle mileage for the reporting period, km;
N_{thkm} – fuel consumption rate for transport work, l/100 thkm;
W – volume of transport work, thkm;
k – surcharge taking into account operating conditions, %.

$$W = Q_{CW} \cdot L_{CM}, \text{ thkm}, \quad (8)$$

where: Q_{CW} – cargo weight, t;
L_{CM} – cargo mileage, km.

Then:

$$S_F = P_F \cdot Q_{FC} = P_F \cdot 0{,}01 \cdot (H_L \cdot L + N_{thkm} \cdot Q_{CW} \cdot L_{CM})(1 + 0{,}01 \cdot k),\ \text{UAH} \quad (9)$$

2) lubricant costs [14]:

$$S_{LM} = P_{LM} \cdot Q_{LM} = 0{,}01 \cdot S_F \cdot Q_F \cdot N_{LM},\ \text{UAH} \quad (10)$$

where: P_{LM} – price of 1 liter (kg) of lubricant;

Q_{LM} – lubricant consumption, l (kg);

N_{LM} – lubricant consumption rate, l(kg)/100 l of fuel.

3) tire costs [14]:

$$S_{TWR} = P_T \cdot N_T + 0{,}01 \cdot N_T \cdot k_T \cdot n_T \cdot (0{,}001 \cdot L),\ \text{UAH} \quad (11)$$

where: P_T – tire price, UAH;

N_T – tire consumption, units;

N_T – tire wear and repair rate in % of the cost of the set per 1000 km of mileage, %;

k_T – tire mileage adjustment factor, which takes into account the operating conditions of the rolling stock and tire mileage;

n_T – number of tires on cars, units;

L – vehicle mileage for the reporting period, km.

The annual tire consumption is:

$$N_T = \frac{n_T \cdot L}{L_N}, \quad (12)$$

where: L_N – tire mileage, km;

L – vehicle mileage for the reporting period, km.

Therefore:

$$S_{TWR} = P_T \cdot \frac{n_T}{L_N} + 0{,}001 \cdot N_T \cdot k_T \cdot n_T \cdot \left(0{,}001 \cdot L\right),\ \text{UAH} \quad (13)$$

4) costs of spare parts and materials used in maintenance and repair [14]:

$$S_{SPM} = L \cdot P_{SPM},\ \text{UAH}, \quad (14)$$

where: L – vehicle mileage for the reporting period, km.

P_{SPM} – specific costs for spare parts and materials, UAH/km.

To determine the value of conventional and technical costs, formulas 9, 10, 13 are used. Multiplying the obtained formulas by the cost of these materials C_i, UAH/unit. of material, we will obtain their absolute values. To bring them into a comparable form, when comparing cars by this indicator, it is necessary to divide it by the volume of freight transport work performed for the reporting period W, thkm. Then formula (6) for specific conventional and technical costs for the operation of a car when delivering goods can be written as:

$$STC = \frac{1}{W} \cdot [(P_F \cdot 0{,}01 \cdot (N_L \cdot L + N_{thkm} \cdot Q_C \cdot L_{EC}) \cdot (1 + 0{,}01 \cdot k) + P_{LM} \cdot 0{,}01 \cdot Q_F \cdot N_L + \\ + P_T \cdot \frac{n_T \cdot L}{L_N} + 0{,}001 \cdot N_T + k_T \cdot n_T \cdot L + L \cdot P_{SPM})],\ \text{UAH/thkm} \quad (15)$$

where: W – volume of freight transport work performed during the reporting period, thkm;

P_F – price of 1 liter of fuel, UAH;

N_L – basic fuel consumption rate, l/100km;

L – vehicle mileage for the reporting period, km;

N_{thkm} – fuel consumption for transport work, l/100 thkm;

Q_C – weight of the cargo being transported, t;

L_{EC} – distance with cargo, km;

k – allowance taking into account operating conditions, %;

P_{LM} – price of 1 l (kg) of lubricants, UAH

N_{LM} – lubricant consumption rate, l (kg)/100 l of fuel;

P_T – tire price, UAH;

n_T – number of tires on cars, units;

L_N – standard tire mileage, km;

N_T – tire wear and repair rate in % of the cost of the set per 1000 km of mileage, %;

k_T – tire mileage adjustment factor, which takes into account the operating conditions of the rolling stock and tire mileage;

P_{SPM} – specific costs for spare parts and materials, UAH/km.

Let us simplify formula 15 by denoting:

$A_{dd} = (1 + 0{,}01 \cdot k)$ – fuel consumption allowance depending on operating conditions;

$P_F^{WCA} = N_L \cdot L$ – fuel consumption of cars without load;

$C_T^W = N_{thkm} \cdot Q_C \cdot L_{EC}$ – fuel consumption for transport work;

$W_T = \dfrac{n_T \cdot L}{L_N}$ – wear (consumption) of car tires;

$C_T^C = 0{,}01 \cdot N_T \cdot k_T \cdot n_T \cdot (0{,}001 \cdot L)$ – tire retreading costs.

Then we get the formula:

$$STC = \frac{1}{W} \cdot [P_F \cdot 0{,}01 \cdot (P_F^{WCA} + C_T^W) \cdot A_{dd} + P_{LM} \cdot 0{,}01 \cdot (P_F^{WCA} + C_T^W) \cdot N_{LM} + \\ + P_T \cdot W_T + C_T^C + L \cdot P_{SPM}], \text{ UAH/thkm} \quad (16)$$

When assessing options for updating the rolling stock fleet, it is recommended to use the value of the economic effect as the main criterion, which is defined as the difference of proportional reduced annual costs:

$$E_Y = (S_1 + E_R \cdot K_1) - (S_2 + E_R \cdot K_2) = S_1 - S_2 \pm E_R \cdot \Delta K, \text{ UAH}, \quad (17)$$

where: S_1, S_2 – current annual production costs for the 1st and 2nd options, UAH;

K_1, K_2 – capital investments by options, UAH;

ΔK – difference in capital investments, UAH;

E_R – coefficient of reduction of capital investments by options to current annual production costs.

Then the effect achieved by the owner of the commercial truck fleet, UAH, when updating it can be expressed as:

$$E_V^O = (CTC_1 + E_R \cdot K_1) - (CTC_2 + E_R \cdot K_2) = CTC_1 - CTC_2 \pm E_R \cdot \Delta K, \text{ UAH}, \quad (18)$$

where: CTC_1, CTC_2 – conventionally technical components of operating costs for cargo transportation according to the 1st (base) and 2nd (new) options.

The value of the E_R coefficient in our time should be understood as the spread of the cost of capital investments by the years of their implementation. Therefore, the value of this coefficient will be determined directly at the production site, individually for each car. Provided that the cars selected for operation are in the same price category and will be operated for the same number of years, the coefficient in our case can be neglected. Then the annual effect of the rolling stock owner E_V^O, which is achieved when putting into operation car models with lower *CTC* (provided that all other components affecting the company's profit are equal):

$$E_V^O = \Delta CTC = CTC_1 - CTC_2, \text{ UAH} \quad (19)$$

The specific effect E_V^O (UAH/thkm) is equal to [14]:

$$E_V = \Delta GCTC = \frac{1}{W} \cdot (CTC_1 - CTC_2), \text{ UAH/thkm}, \quad (20)$$

where: W – volume of transport work carried out by cars, thkm.

Fuel cost difference:

$$\Delta S_F = P_{F1} \cdot 0{,}01 \cdot (P_{F1}^{WCA} + C_{T1}^W) \cdot A_{dd1} - P_{F2} \cdot 0{,}01 \cdot (P_{F2}^{WCA} + C_{T2}^W) \cdot A_{dd2} = \\ = 0{,}01 \cdot P_{F1} \cdot P_{F1}^{WCA} \cdot A_{dd1} + 0{,}01 \cdot P_{F1} \cdot C_{T1}^W \cdot A_{dd1} - 0{,}01 \cdot P_{F2} \cdot P_{F2}^{WCA} \cdot A_{dd2} - 0{,}01 \cdot P_{F2} \cdot C_{T2}^W \cdot A_{dd2}, \text{ UAH} \quad (21)$$

Let us denote: $Q_{S1}^{FA} = P_{F1}^{WCA} \cdot A_{dd1}$; $Q_{S1}^C = C_{T1}^W \cdot A_{dd1}$; $Q_{S2}^{FA} = P_{F2}^{WCA} \cdot A_{dd2}$; $Q_{S2}^C = C_{T2}^W \cdot A_{dd2}$.

Then we get:

$$\Delta S_F = 0{,}01 \cdot P_{F1} \cdot (Q_{S1}^{FA} - Q_{S1}^C) - 0{,}01 \cdot P_{F2} \cdot (Q_{S2}^{FA} - Q_{S2}^C) \quad (22)$$

Let us introduce the relative comparison coefficient [14; 15]:

$$K_i = \frac{S_i^n}{S_i^b}, \quad (23)$$

where: S_i^n, S_i^b – value of the *i*-th cost item in the new and basic variants, respectively.

In accordance: $K_{PF} = \frac{P_{F1}}{P_{F2}}$ – evaluation criterion based on fuel cost. Then we get: $P_{F1} = K_{PF} \cdot P_{F2}$; $K_{QS} = \frac{Q_{S1}^{FA} - Q_{S1}^{C}}{Q_{S2}^{FA} - Q_{S2}^{C}}$ – fuel consumption evaluation criterion. Therefore: $Q_{S1}^{FA} - Q_{S1}^{C} = K_{QS} \cdot (Q_{S2}^{FA} - Q_{S2}^{C})$.

We get the following formula:

$$\begin{aligned}\Delta S_F &= 0,01 \cdot \left(K_{PF} \cdot P_{F2} \cdot K_{Q_S} \cdot \left(Q_{S2}^{FA} - Q_{S2}^{C}\right) - P_{F2} \cdot \left(Q_{S2}^{FA} - Q_{S2}^{C}\right)\right) = \\ &= 0,01 \cdot P_{F2} \cdot \left(Q_{S2}^{FA} - Q_{S2}^{C}\right) \cdot \left(K_{PF} \cdot K_{QS} - 1\right), \text{ UAH}\end{aligned} \quad (24)$$

Difference in lubricant costs:

$$\begin{aligned}\Delta S_{LM} &= P_{LM1} \cdot \left(0,001 \cdot (P_{F1}^{WCA} + C_{T1}^{W}) \cdot A_{dd1}\right) \cdot N_{LM1} - P_{LM2} \cdot \left(0,001 \cdot (P_{F2}^{WCA} + C_{T2}^{W}) \cdot A_{dd2}\right) \cdot N_{LM2} = \\ &= 0,001 \cdot P_{LM1} \cdot \left(Q_{S1}^{FA} - Q_{S1}^{C}\right) \cdot N_{LM1} - 0,001 \cdot P_{LM2} \cdot \left(Q_{S2}^{FA} - Q_{S2}^{C}\right) \cdot N_{LM2}, \text{ UAH}\end{aligned} \quad (25)$$

Denote: $K_{PLM} = \frac{P_{LM1}}{P_{LM2}}$ – lubricant evaluation criterion. Then: $P_{LM1} = K_{PLM} \cdot P_{LM2}$; $K_{QS} = \frac{Q_{S1}^{FA} - Q_{S1}^{C}}{Q_{S2}^{FA} - Q_{S2}^{C}}$ – fuel consumption evaluation criterion. Then: $Q_{S1}^{FA} - Q_{S1}^{C} = K_{Q_S} \cdot (Q_{S2}^{FA} - Q_{S2}^{C})$. Similarly: $K_{NLM} = \frac{N_{LM1}}{N_{LM2}}$ – evaluation criterion based on the lubricant consumption rate. Then: $N_{LM1} = K_{NLM} \cdot N_{LM2}$.

Therefore:

$$\begin{aligned}\Delta S_{LM} &= 0,001 \cdot (K_{PLM} \cdot P_{LM2} \cdot K_{Q_S} \cdot \left(Q_{S2}^{FA} - Q_{S2}^{C}\right) \cdot K_{NLM} \cdot N_{LM2} - P_{LM2} \cdot \left(Q_{S2}^{FA} - Q_{S2}^{C}\right) \cdot N_{LM2} = \\ &= 0,001 \cdot P_{LM2} \cdot \left(Q_{S2}^{FA} - Q_{S2}^{C}\right) \cdot N_{LM2} \cdot \left(K_{PLM} \cdot K_{QS} \cdot K_{NLM} - 1\right), \text{ UAH}\end{aligned} \quad (26)$$

Tire cost difference:

$$\Delta S_{T1} = P_{T1} \cdot W_{T1} - P_{T2} \cdot W_{T2} \quad (27)$$

Let's express: $K_{PT} = \frac{P_{T1}}{P_{T2}}$ – criterion for evaluating the value of car tires. Then: $P_{T1} = K \cdot P_{T2}$; $K_{WT} = \frac{W_{T1}}{W_{T2}}$ – tire wear (consumption) evaluation criterion. Ago: $W_{T1} = K_{WT} \cdot W_{T2}$. In accordance:

$$\Delta S_T = K_{PT} \cdot P_{W2} \cdot K_{WT} \cdot W_{T2} - P_{W2} \cdot W_{T2} \cdot W_{T2} = P_{W2} \cdot W_{T2} \cdot (K_{PT} \cdot K_{WT} - 1), \text{ UAH} \quad (28)$$

Tire retreading cost difference:

$$\Delta S_P^T = P_{P1}^T - P_{P2}^T \quad (29)$$

Let's express: $K_{P_P^T} = \frac{P_{P1}^T}{P_{P2}^T}$ – evaluation criterion based on the cost of retreading automobile tires. Then: $P_{P1}^T = K_{P_P^T} \cdot P_{P2}^T$. In accordance:

$$\Delta S_P^T = K_{W_P^T} \cdot P_{P2}^T - P_{P2}^T = P_{P2}^T \cdot \left(K_{W_P^T} - 1\right), \text{ UAH} \quad (30)$$

The difference in costs for spare parts and materials with the same mileage of the compared cars *L* (km) [14; 15]:

$$\Delta S_{SPM} = L \cdot (P_{SPM1} - P_{SPM2}), \text{ UAH} \quad (31)$$

By analogy with the previous formulas, we transform, then:

$$\Delta S_{SPM} = L \cdot P_{SPM2} \cdot (K_{SPM1} - 1), \text{ UAH} \quad (32)$$

Transforming formula 20 taking into account formulas 24, 26, 28, 30 and 32, we obtain:

$$\Delta GCTC = \frac{1}{W} \cdot \Big[0,01 \cdot P_{F2} \cdot \left(Q_{S2}^{FA} - Q_{S2}^{C} \right) \cdot \left(K_{PF} \cdot K_{Q_S} - 1 \right) + \\ + 0,001 \cdot P_{LM2} \cdot \left(Q_{S2}^{FA} - Q_{S2}^{C} \right) \cdot N_{LM2} \cdot \left(K_{PLM} \cdot K_{Q_S} \cdot K_{NLM} - 1 \right) + \\ + P_{LM2} \cdot P_{T2} \cdot \left(K_{PT} \cdot K_{WT} - 1 \right) + P_{P2}^{T} \cdot \left(K_{W_P^T} - 1 \right) + L \cdot P_{SPM2} \cdot \left(K_{SPM1} - 1 \right) \Big], \text{ UAH/thkm} \quad (33)$$

Let us denote: $P_{F2} = 0,01 \cdot P_{F2} \cdot (Q_{S2}^{FA} - Q_{S2}^{C})$ – fuel costs of the new car variant; $P_{LM2} = 0,001 \cdot P_{LM2} \cdot (Q_{S2}^{FA} - Q_{S2}^{C}) \cdot N_{LM2}$ – costs for lubricants of the new version of the car. Then the specific conventional and technical costs for transporting goods ($GCTC_{1i}$) can be written like this: $GCTC_{1i} = K_i \cdot GCTC_{2i}$. Substituting this expression into formula (20), we obtain the value of the specific effect when replacing the base car model with a new version:

$$E_{RSO} = GCTC = K_i \cdot GCTC_{2i} - GCTC_{2i} = GCTC_{2i} \cdot (K_i - 1), \text{ UAH/thkm}, \quad (34)$$

where: $GCTC_{2i}$ – specific conventional and technical costs for operating a new vehicle variant in the rolling stock fleet, UAH/thkm.

Expanding this formula taking into account the accepted notations, we will obtain the value of the annual economic effect achieved by the owner of commercial trucks when updating the fleet:

$$E_{RSO} = \Delta GCTC = \frac{1}{W} \cdot \sum_{i=1}^{n} \Big[P_{F2} \cdot \left(K_{PF} \cdot K_{QS} - 1 \right) + P_{LM2} \cdot \left(K_{PLM} \cdot K_{NLM} - 1 \right) + \\ + P_{WT2} \cdot \left(K_{PT} \cdot K_{WT} - 1 \right) + P_{PT2} \cdot \left(K_{W_P^T} - 1 \right) + P_{SPM2} \cdot \left(K_{SPM} - 1 \right) \Big], \text{UAH/thkm} \quad (35)$$

where: P_{F2} – fuel costs, UAH;

P_{LM2} – costs for lubricants and other operating materials, UAH;

P_{WT2} – costs for tires, UAH;

P_{PT2} – costs for tire repair and restoration, UAH;

P_{SPM2} – costs for spare parts and materials, UAH;

relative coefficients of comparison of options, respectively:

K_{PF} – by fuel cost;

K_{QS} – by lubricant cost;

K_{PLM} – by lubricant consumption;

K_{PT} – by tire consumption;

K_{WT} – for tire restoration and repair costs;

$K_{W_P^T}$ – by the cost of a set of tires;

K_{SPM} – by spare parts and materials costs.

When determining the economic effect of E_{RSO} for a fleet of vehicles, it is necessary to sum up all vehicles.

DISCUSSION OF RESEARCH RESULTS

Therefore, the above formulas make it possible to determine the following components of the cost of road transportation, such as costs for: 1) fuel, lubricants and other operating materials; 2) wear and tear and restoration of car tires; 3) costs for maintenance and repair of cars.

In the general structure of the cost of cargo transportation (formula 2.4), it is possible to distinguish two groups of costs: 1) which depend on the volume of cargo; 2) which are associated with the characteristics of cargo and organizational work on cargo processing.

One of the ways to reduce the current costs of operating cars is to update the fleet of motor vehicles, the main criterion for the feasibility of updating is the value of the economic effect, which is defined as the difference between proportional reduced annual costs (formula 2.35).

CONCLUSIONS

The structure of operating costs of cars includes in particular the costs of maintenance and current repairs, the amount of which depends on the level of prices for car services and spare parts. It is also necessary to take into account that the units of modern cars have a high operational resource, but in the event of their malfunctions the price of repairs will be quite high.

Motor transport enterprises that carry out cargo transportation are constantly faced with the issue of increasing profits from their activities, which is impossible without increasing the efficiency of use, reducing the current costs of operating the vehicle fleet. One of the directions is to reduce the cost of transportation.

The implementation of this direction begins with an assessment of the operating costs of specific brands of cars and the selection of the most suitable cars to ensure the transportation process.

LITERATURE

1. Adamovska, V.S. Features of the methodology for calculating the efficiency of using new equipment compared to the baseline. Efektyvna ekonomika. 2011. №5. Source of electronic access: http://www.economy.nayka.com.ua/?op=1&z=540

2. Krasheninin, O.S.; Shapatina O. O. Determination of transport efficiency by different vehicles. Information and control systems at railway transport. 2021. №2. P. 3–8.

3. Bosniak, M. G. Freight road transportation. Kyiv. Publishing House «Slovo». 2010. 408 p.

4. Kashkanov, V. A.; Kashkanov, A. A.; Varchuk, V. V. Organization of road transportation. Vinnytsia. VNTU. 2017. 139 p.

5. Klymenko, I. S.; Kryvoshieieva, s. V.; Kryvenko, O. K. Problems and prospects for the development of the passenger road transportation market in Ukraine. Scientific notes of Taurida National V.I. Vernadsky University Series: Economy and Management. 2019. Vol. 30(69). №6. P. 21–26.

6. Krystopchuk, M. E.; Lobashov O. O. Suburban passenger transportation. Kharkiv. NTMT. 2012. 224 p.

7. Thoruk, E. I.; Kucher O. O.; Doroshchuk V. O. Freight transportation. Rivne. NUWEE. 2015. 132 p.

8. Solarev, O. O.; Tatsenko, O. V.; Voloshko T. P. Criteria for selecting vehicles for transporting goods. Municipal economy of cities. 2022. Vol. 6, Issue 173. P. 189–194.

9. Kanarchuk, V. E.; Levkovets P. R.; Melnychenko O. I. Methods, models and algorithms for managing cargo transportation processes in the transport complex. Kyiv. NTU. 2001. 145 p.

10. Maslova, T. V. Efficiency of cargo transportation by road in international traffic for one-time orders. Author's abstract. Kharkiv. 2020. 20 p.

11. Remekh, I. O. Increasing the efficiency of cargo transportation by road in international traffic. PhD. Diss. Kyiv. 2023. 196 p.

12. Methodological recommendations for the rationing of fuel, electricity, lubricants, and other operating materials by vehicles and equipment. Revision 1 dated 11/17/2023. Kyiv. SE «DerzhautotransNDIproject». 2023. 51 p.

13. 200 84001-3-88 Cost norms for maintenance and current repairs of cars and buses. Source of electronic access: https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=61251

14. Dmytriiev, I. A; Ivanilov, I. S.; Shevchenko, I. YU.; Kyrchata, I. M. Economics of road transport enterprises. Kharkiv. Brovin O.V. 2018. 308 p.

15. Lutsenko, I. V. Enterprise economics: theory and practice. Lozova. 2017. 128 p.

16. Car tire mileage standards. Order of the Ministry of Transport of Ukraine. December 8, 1997 No. 420. Database «Legislation of Ukraine». Source of electronic access: https://zakon.rada.gov.ua/rada/show/v0420361-97#Text

Хаврук В. О. **Оцінка ефективності експлуатації вантажних автомобілів**

У статті розглядається питання ефективності вантажних автомобілів на основі собівартості вантажних автомобільних перевезень. Детально аналізуються дві групи складових витрат: 1) які безпосередньо залежать від технічних характеристик вантажних автомобілів (витрати на паливо, мастила та інші експлуатаційні матеріали, витрати на знос та відновлення автомобільних шин; витрати на технічне обслуговування та ремонт); 2) які визначаються організаційними особливостями функціонування автотранспортного підприємства (заробітна плата водіїв, відрахування на соціальні потреби, амортизація автомобільного рухомого складу та загальногосподарські витрати).

Загальна структура собівартості вантажних перевезень автомобілями представлена як сума показників, що складають дві групи витрат: 1) які залежать від обсягів вантажів; 2) які пов’язані з характеристиками вантажів та організаційною роботою з обробки вантажів. Детально розглянуті і наведені формули для визначення першої групи витрат (умовно-технічні витрати), оскільки за величиною цих витрат можливо: оцінювати ефективність використання автомобілів в грошовому еквіваленті; порівнювати ефективність різних марок і моделей автомобілів в грошовому еквіваленті; вибирати найбільш раціональний парк автомобільного рухомого складу; оцінювати ефективність роботи служби експлуатації автомобілів в різних автотранспортних підприємствах в грошовому еквіваленті.

Для оцінки доцільності оновлення парку автотранспортних засобів пропонується використовувати величину економічного ефекту, який визначається як різниця пропорційно приведених річних витрат.

Метою статті є надання методичних рекомендацій автотранспортним підприємствам щодо визначення складових транспортних витрат та оцінки доцільності оновлення автомобільного рухомого складу.

Ключові слова: вартість; витрати; ефективність; прибуток; надійність; вантажний автомобіль; собівартість

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