Managing the operation of trucks: methodological aspects of evaluating the efficiency and justifying reserves to increase cargo turnover

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Abstract. The article outlines certain methodological aspects of substantiating ways to increase the efficiency of using freight transport. One of the priority areas in training highly qualified specialists in the economic field is teaching them the most rational and objective methods of analysis, the results of which are necessary for the development and substantiation of real and objective management decisions, the implementation of which in production and financial activities of enterprises will help to increase the economic efficiency of using material resources, including trucks. The system of performance indicators for the work of freight transport includes summarizing and particular indicators. The research results show that the efficiency of trucks has significantly decreased: the truck availability rate by 5.6%, the loaded mileage proportion by 24.0%, the load factor by 26.8%. The decrease in the efficiency of using trucks indicates the need to develop and substantiate optimal management decisions in order to improve the use of trucks. In order to increase the validity of management decisions, it is proposed to use a new coefficient characterizing the level of use of the operating factor of technically ready trucks. This makes it possible to improve the accuracy of calculating reserves and planning the work of freight transport.

1 Introduction

To assess the efficiency of freight transport, a whole system of both generalizing and particular indicators is used.

This is due to the fact that some indicators make it possible to characterize a specific aspect of the operation of trucks, but do not allow comprehensive characterizing the economic efficiency of using the company's truck fleet.

Particular indicators, as a rule, allow assessing some aspects of the use of freight transport: automobile-days in operation, time spent on duty, time in motion, total mileage,

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mileage of trucks with cargo, the truck availability rate, the load factor, the loaded mileage proportion, etc.

Particular technical and operational indicators are an integral part of summarizing indicators characterizing the performance of trucks and the cost of freight, that is, with their use, the final results of work are determined and an assessment of the efficiency of using trucks is given.

According to the results of the analysis, there is usually a need to develop and substantiate the directions for increasing the efficiency of using freight transport.

2 Materials and methods

For the purpose of an objective analysis of the use of freight transport, a system of initial indicators has been formed that characterizes the actual average listed availability of vehicles, days of their stay at the enterprise, the number of days waiting repair, the actual number of days in operation, the total capacity, the time spent on duty, the time spent in motion, the cargo performance, annual volume of work performed (cargo turnover) [1-4].

Based on the system of indicators of the initial data, the main coefficients and indicators are calculated that characterize the efficiency of the use of freight transport (Table 1).

Table 1. Dynamics of the efficiency of using freight transport

	2014	2015	2016	2017	2018	2018 to 2014, %
Average number of trucks, units	11	11	14	15	16	145.5
Average technical capacity of the truck, t	4.70910	4.70910	3.83992	4.90000	5.34375	113.5
Automobile-days of stay at the enterprise	4,015	4,015	5,124	5,475	5,840	145.5
Automobile-days of the truck availability: a) total b) per 1 truck	2,937 267	2,904 264	3,458 247	3,660 244	4,032 252	137.3 94.4
Automobile-days in operation	2,770	2,771	3,023	3,240	3,520	127.1
Time spent on duty, thousand hours	20.2	20.4	24.7	26.0	26.5	131.2
Time in motion, thousand hours	14.4	14.1	17.7	17.8	19.6	136.1
Total mileage of trucks, thousand km: a) total b) per 1 truck	536 48.727	774 70.364	1,077 76.929	1,083 72.200	1,045 65.313	195.0 134.0
Mileage of trucks with cargo, thousand km: a) total b) per 1 truck	386 35.091	412 37.455	562 40.143	545 36.333	572 35.750	148.2 101.9
Completed works (freight turnover), thousand tonne-kilometre	432.8	412.1	399.7	423.7	532.8	123.1
Completed works per 1 truck, tonne-kilometre	39,345.5	37,463.6	28,550.0	28,246.7	33,300.1	84.6
Average actual load of 1 truck, t	1.12124	1.000	0.711	0.77700	0.93147	83.1
Truck availability rate	0.73151	0.72329	0.67486	0.66849	0.69041	94.4
The rate of trucks in operation	0.68991	0.69016	0.58997	0.59178	0.60274	87.4
Operation factor	0.71287	0.69118	0.71660	0.68462	0.73962	103.8
Mileage factor	0.72015	0.53230	0.52182	0.50323	0.54737	76.0
Load factor	0.23810	0.21231	0.18516	0.15857	0.17434	73.2

The results of the studies, in the course of which the main indicators were calculated, characterizing the use of trucks over the past five years, made it possible to establish that the efficiency of the work of trucks has significantly decreased (Table 2).

It should be noted that for 2014-2018 the availability of trucks increased by 45.5% (or by 5 vehicles in absolute terms).

The average technical capacity of 1 truck increased by 13.5%.

During the same period, the value of almost all indicators characterizing the use of freight vehicles increased.

So, the total mileage of one truck increased by 34.0% and the mileage of a loaded truck increased by 1.9%.

At the same time, the volume of cargo turnover with an overall increase in the volume of work performed by 23.1% per truck decreased by 15.4% (from 39,345.5 tonne-kilometre in 2014 to 33,300.1 tonne-kilometre in 2018).

The value of all the coefficients characterizing the efficiency of the use of trucks has decreased quite significantly.

So, for example, the truck availability rate decreased by 5.6%, the loaded mileage proportion decreased by 24.0% and the load factor decreased by 26.8%.

The decrease in the efficiency of the use of trucks clearly indicates the need to develop and substantiate optimal management decisions that would significantly improve the use of trucks.

Thus, the problem arises to determine the "bottlenecks" in the management of the use of freight transport.

It seems quite realistic to solve this problem on the basis of studying the factor model of the cargo turnover of both one truck and the entire fleet.

3 Results and discussion

The methodological foundations of the factor analysis are quite widely covered in scientific research of Russian and foreign authors, such as Sheremet, A.D., Bakanov, M.I., Gilyarovskaya, L.T., Lysenko, D.V., Bank, V.R., Kovalev, V.V., Savitskaya, G.V., Hedderwick, K., Helfert, E. et al. [5-7].

Scientific studies of domestic and foreign economists, devoted to the theory and methodology of the factor analysis, present the basic rules and principles of the formation of factor models of various types (additive, multiplicative, multiple, etc.) and methods for assessing the impact of changing the values of factor indicators on the level of the effective indicator are developed.

The volume of work performed by trucks (cargo turnover) can be presented as a combination of factorial features.

The published scientific works highlighting the methods to assess the use of trucks present factor models of the volume of work performed, which most often consist of absolute factor indicators of the first order:

$VCT = NT \cdot ADO^{1T} \cdot DMC^{1A} * ATL$,

where VCT is the volume of cargo turnover (volume of work performed), tonne-kilometre;

NT is the average number of trucks, units;

ADO^{1T} are automobile-days in operation per 1 truck;

DMC^{1A} is the average daily mileage of 1 truck with cargo, km;

ATL is the average truck load, t.

However, here the question naturally arises: what factors do the indicators of this multiplicative factor model depend on?

Therefore, it becomes necessary to express these factor indicators in the form of factor models consisting of factor indicators of the first and second orders.

It should be noted that it is necessary to apply another coefficient to characterize the operating factor of technically ready trucks, which is calculated by the ratio of the number of days in operation to the number of days in technical readiness: $F^{OTRT} = ADO : ADTA$ or $F^{OTRT} = ADO^{1T} : ADTA^{1T}$.

Then: $ADO^{1T} = ADTA^{1T} \cdot F^{OTRT} = [(ADSE^{1T} \cdot R^{TA}) \cdot F^{OTRT})]$,

where $ADSE^{1T}$ are automobile-days of stay at the enterprise per 1 truck,

R^{TA} is the truck availability rate,

ADTA are automobile-days of trucks availability,

$ADTA^{1T}$ are automobile-days of the truck availability per 1 truck,

F^{OTRT} is the operating factor of technically ready trucks.

$DMC^{1T} = (ADM^{1T} \cdot P^{LM}) = [(DDM^{1T} \cdot AS) \cdot P^{LM}] = \{[(TWD^{1T} \cdot R^{WH}) \cdot AS] \cdot P^{LM}\}$,

where ADM^{1T} is the average daily mileage of 1 truck, km;

P^{LM} is the loaded mileage proportion;

DDM^{1T} is the daily duration of 1 truck movement, hour;

TWD^{1T} is the time spent on duty (daytime working hours) per 1 truck, hour;

R^{WH} is the daytime working hours rate;

AS is the average speed, km/hour.

$ATL = (ATC \cdot F^{L})$,

where ATC is the average technical capacity of 1 truck, t;

F^{L} is the load factor.

Then the factor model of the volume of cargo turnover of 1 truck (VCT^{1T}) will have the following form:

$VCT^{1T} = [(ADSE^{1T} \cdot R^{TA}) \cdot F^{OTRT}] \cdot \{[(TWD^{1T} \cdot R^{WH}) \cdot AS] \cdot P^{LM}\} \cdot (ATC \cdot F^{L})$.

And the volume of work performed as a whole for the freight transport fleet will be expressed by the following multiplicative factor model:

$VCT = NT \cdot \{[(ADSE^{1T} \cdot R^{TA}) \cdot F^{OTRT})] \cdot \{[(TWD^{1T} \cdot R^{WH}) \cdot AS] \cdot P^{LM}\} \cdot (ATC \cdot F^{L})\}$.

An extended factor model, including both absolute factor indicators and relative ones (coefficients), directly characterizing the efficiency of the use of freight transport, will allow a more in-depth analysis of the dynamics of the efficiency of its work and, thus, identify "bottlenecks" in the use of freight transport [8-10].

For this purpose, it is necessary to conduct a factor analysis and assess the degree of influence of changes in each factor indicator on the effective one.

Table 2. Influence of factors on the amount of work performed by one truck

	2014	2018	Deviation (+ / -) 2018 from 2014
Automobile-days of stay at the enterprise per 1 truck ($ADSE^{1T}$)	365	365	-
Truck availability rate (R^{TA})	0.73151	0.69041	-0.04110
Automobile-days of the truck availability per 1 truck ($ADTA^{1T}$)	267	252	-15
Operating factor of technically ready trucks (F^{OTRT})	0.94314	0.87302	-0.07012
Automobile-days in operation per 1 truck (ADO^{1T})	251.81818	220.00000	-31.81818
Operating factor of trucks at work (F^{OTW})	0.68991	0.60274	-0.07012
Time spent on duty (daytime working hours) per 1 truck (TWD^{1T}), hour	7.29242	7.52841	+0.23599
Daytime working hours rate (R^{WH})	0.71287	0.73962	+0.02675
Daily duration of 1 truck movement (DDM^{1T}), hour	5.19856	5.56816	+0.36960
Average speed (AS), km/hour	37.22222	53.31633	+16.09411
Average daily mileage of 1 truck (ADM^{1T}), km	193.50157	296.87386	+103.37229
Loaded mileage proportion (P^{LM})	0.72015	0.54737	-0.17278
Average daily mileage of 1 truck with cargo ($ADMC^{1T}$), km	139.35016	162. 49984	+23.14968

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Continuation of Table 2.

Average technical capacity of 1 truck (ATC), t	4.70910	5.34375	+0.63465
Load factor (F^L)	0.23810	0.17431	-0.06379
Average truck load (ATL), t	1.12124	0.93147	0.18977
Annual productivity of 1 truck (annual volume of cargo turnover performed by one truck) (VCT^{1T}), tonne-kilometre	39,345.525	33,300.130	-6,045.395
Deviation (+/-) of the annual productivity of 1 truck due to change, tonne-kilometre: a) of the truck availability rate (R^{TA}) b) of the operating factor of technically ready trucks (F^{OTRT}) c) of the time spent on duty (daytime working hours) per 1 truck (TWD^{1T}) d) of the daytime working hours rate (R^{WH}) e) of the average speed of movement (AS) f) of the loaded mileage proportion (P^{LM}) g) of the average technical capacity of 1 truck (ATC) h) of the load factor (F^L)	 x x x x x x x x	 x x x x x x x x	 -2,210.614 -2,760.858 +1,112.367 +1,331.559 +15,919.172 -12,652.737 +5,402.195 -12,186.488

The volume of cargo turnover (per 1 truck) in 2018 compared to 2014 decreased by 6,045.395 tonne-kilometre:

$\Delta\ VCT^{1T\ TOTAL}$ = 33,300.130 tonne-kilometre – 39,345.525 tonne-kilometre = -6,045.395 tonne-kilometre.

The assessment of the influence of each factor is presented in Figure 1.

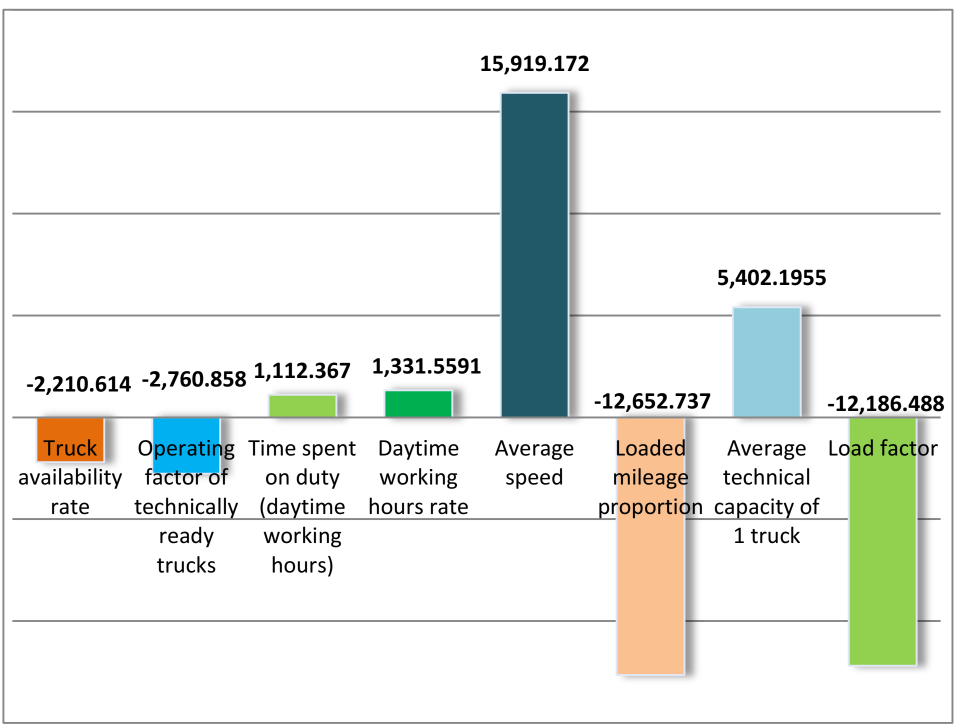

Fig. 1. Results of the factor analysis of the annual productivity of a truck.

The results of the analysis have shown that the main factors that negatively affect the volume of cargo turnover are the indicators of the efficiency of the use of freight transport.

The results obtained, in turn, will make it possible to develop and substantiate objective and real management decisions to improve the operation of trucks and increase the efficiency of using them.

This conclusion, in our opinion, is confirmed by the following example.

The value of any coefficient can be expressed in unit fractions (which was used when calculating the coefficients given in Tables 1 and 2) and in percent.

For example, the value of the load factor in 2018 was 0.17431 in unit fractions. This will amount to 17.431%, that is, the technical capacity of one truck was actually used only by 17.431% in 2018.

The value of each coefficient will be increased by 1 percentage point as an example for mastering the planning method for the use of trucks in the future. So, the technical readiness coefficient in 2018 was 0.69041 (or 69.041%). With an increase of 1 percentage point, its value will be 70.041% (or 0.70041 in unit fractions) [11-12].

An increase in the value of the coefficients (factor indicators) by 1 percentage point will allow to obtain an increase in the volume of work performed by one truck in the context of each factor (reserve) in the following volumes (Table 3).

Table 3. Reserves for increasing the volume of work performed by one truck

	1 percentage point increase in the value of the coefficient					TOTAL
	availability	the use of				
		an operating factor of technically ready trucks	working hours	mileage	technical capacity	
The volume of cargo turnover of 1 truck, tonne-kilometre: a) real b) forecast	33,300.130 33,782.455	33,300.130 33,681.567	33,300.130 33,750.400	33,300.130 33,908.497	33,300.130 35,210.615	33,300.130 37,133.014
Increase in freight turnover: a) in tonne-kilometre b) in %	482.325 1.45	381.437 1.14	450.270 1.35	608.367 1.83	1,910.485 5.74	3,832.884 11.51

Thus, the largest planned cargo turnover will be with an increase in technical capacity by 1 percentage point.

4 Conclusion

In order to assess more objectively the impact of changing the values of factor indicators on the effective one (the volume of cargo turnover), an extended factor model is proposed with the inclusion of the operating factor of technically ready trucks (F^{OTRT}), which allows more accurate assessing the level of using not all trucks in operation, but only those which were in a technically ready state.

The results of the factor analysis of the cargo turnover of one truck using the proposed factor model made it possible to identify specific factors that have a negative impact on the volume of work performed.

Based on the results obtained, an attempt was made to substantiate the reserves for increasing the volume of work performed by one truck.

For this purpose, the value of each coefficient was increased in turn by 1 percentage point and the estimated volume of cargo turnover was calculated.

The obtained calculation results indicate that the increase in cargo turnover was obtained in quite tangible volumes (Table 3).

In addition, the amount of work that one truck can perform while increasing all coefficients by 1 percentage point has been calculated:

$VCT^{1T}{}_{f\ (comp.)} = [(ADSE^{1T}{}_{18} \cdot R^{TA}{}_{f}) \cdot F^{OTRT}{}_{f})] \cdot \{[(TWD^{1T}{}_{18} \cdot R^{WH}{}_{f}) \cdot AS_{18}] \cdot P^{LM}{}_{f}\} \cdot (ATC_{18} \cdot F^{L}{}_{f}) = 37{,}287.289$ tonne-kilometre.

The received volume of cargo turnover is higher than the real one in 2018 by 3,987.159 tonne-kilometre (or 11.97%), which indicates a fairly significant increase in the volume of work performed and an increase in the efficiency of using freight transport.

All calculations were performed with the necessary and optimal accuracy of the values of the factor indicators used , that has confirmed the objectivity of the results obtained.

This technique will allow to plan objectively the scope of work of freight transport with different values of factor indicators (coefficients) and choose the most optimal option.

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