ANALYSIS AND MODELING OF THE MAIN PERFORMANCE INDICATORS OF RAILROADS

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Abstract:
In this article modeled and analyzed the main performance indicators of JSC "Railways of Uzbekistan" in the process of corporate system management.

Keywords: ISO 9000 standards, financial and economic indicators, volume and quality indicators, cargo turnover, unloading, working fleet and average daily productivity of wagons, correlation-regression model.

INTRODUCTION

JSC "Railways of Uzbekistan" assists in modeling and analysis of the main indicators of railway transport activity as a result of selection of controlled parameters of indicators, determination of correlation coefficients of indicators and correlation analysis.

The ISO certificate obtained by "Railways of Uzbekistan" JSC in 2011 emphasizes the importance of using statistical methods, especially in the quality management system. The basic principles of SJB (statistical process management) are simple to understand and easy to apply. Of the nine basic requirements of ISO 9000 standard for the production process, the following 3 groups can be distinguished:

- corrective and proactive actions,
- statistical methods,
- quality data recording.

METHODOLOGY

The reporting form adopted in JSC "Railways of Uzbekistan" is based on ten groups of key performance indicators characterizing certain features of the transport process.

This paper is devoted to the analysis and modeling of these indicators, identification of regularities of their changes, identification of independent and dependent indicators, prediction of behavioral changes and determination of generalized quality control indicators in accordance with ISO requirements. It should be noted that some research has been done in this work. But this work is mainly devoted to determining the correlation coefficients of performance indicators and conducting correlation analysis. In fact, in accordance with the requirements of ISO 9000 standard, the analysis and modeling of changes in railway transport performance indicators should be carried out systematically in the following two directions:

1) Analyzing the data of an indicator for gross errors in data labels (e.g., several times the average value) and correcting these values. Using indicator values without correction can lead to miscalculations and conclusions.

2) Conducting correlation and regression analysis of various indicators of transportation works (volumetric indicators, quality indicators, railroad condition, financial and economic indicators) to determine the impact of the main financial and economic indicators (transportation revenues, transportation costs, transportation expenses and labor productivity of employees engaged in transportation). In order to reduce their number and determine the main indicators, it is necessary to determine the dependent and independent indicators. Finding regression equations of dependence of the main financial and economic indicators on various indicators of transport works in order to identify changes in the main performance indicators and prevent possible deviations of the work process from the norm, optimization of values and, ultimately, the construction of quality control maps.

Improvement of the mechanism of railway transport management is inextricably linked to the improvement of the scientific level of statistical research.

To modernize the railway transport, to increase its efficiency, to develop measures to improve the planning and management of the transport process, to evaluate objectively the activity of its subdivisions and to characterize their development, reliable, timely and deep analytical statistical data are required. Obtaining of such data and their analysis is the main task of statistical authorities, presented in this figure, is to lay the foundations of ongoing economic and social processes in all spheres of activity of the railway network.

RESULT

The main task of railway transport statistics is further improvement of the system of railway transport statistics, development of statistical (reporting) indicators and methodology of analysis of the activity of branch railway transport and its subdivisions.

Table 1 Wagon utilization indicators in 2015-2021 for JSC "Railways of Uzbekistan"

Indicators	2015	2016	2017	2018	2019	2020	2021
Cargo turnover	18898,2	19026	20828,7	20975,9	17674,6	22993,5	25277,9
growth (decline) rate,%	100	100,7	109,5	100,7	84,3	130,1	109,9
Unloading	3650	3634	3608	3742	3883	3906	3943
growth (decline) rate,%	100	99,6	99,3	103,7	103,8	100,6	100,9
Working fleet, wagons	19368	20368	20894	20385	19248	20035	18678
growth (decline) rate,%	100	105,2	102,6	97,6	94,4	104,1	93,2
Average daily wagon productivity	975,7	934,1	996,8	1028,98	918,25	1147,6	1353,3
growth (decline) rate,%	100	95,7	106,7	103,2	89,2	125,0	117,9

NOVATEUR PUBLICATIONS
JournalNX- A Multidisciplinary Peer Reviewed Journal
ISSN No: 2581 - 4230
VOLUME 10, ISSUE 7, July - 2024

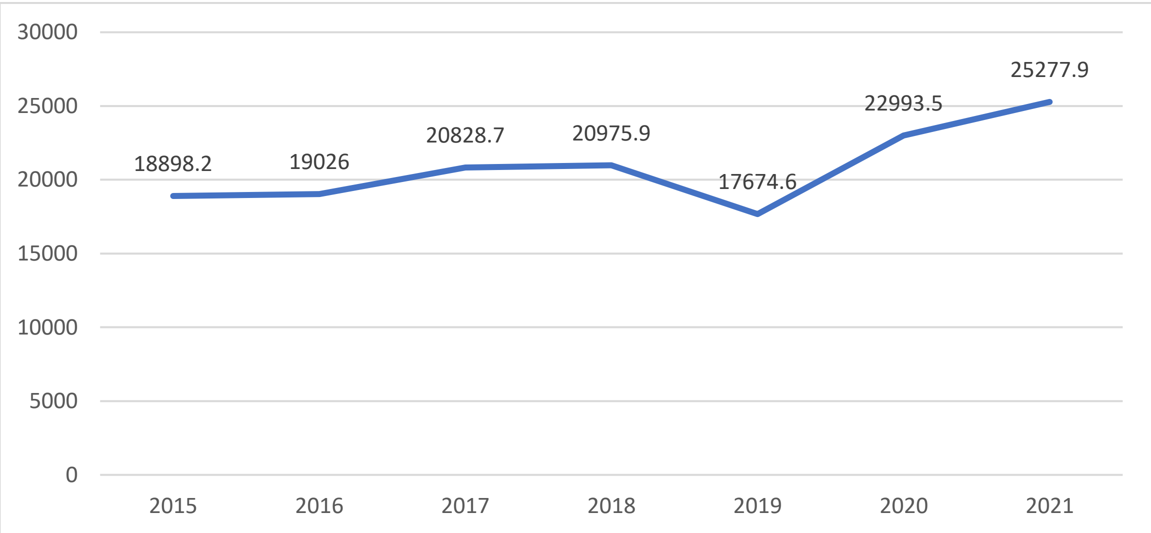
This table shows cargo turnover, unloading, operating fleet and average daily railcar productivity from 2015 to 2021. Cargo turnover in 2015 was 18898.2 million t-km, in 2016 -19026 million t-km, in 2017 -20828.7 million t-km, in 2018 -20975.9 million t-km, in 2019 -17674.6 million t-km, in 2020 -22993.5 million t-km and in 2021 25277.9 million t-km. From the data, it can be seen that the volume of cargo turnover has been increasing over the years, decreased in 2019, and increased sharply by 2020 (+5318.9 million t-km).

Unloading are 3650 in 2015, 3634 in 2016, 3608 in 2017, 3742 in 2018, 3883 in 2019, 3906 in 2020 and 3943 in 2021. By 2021, unloading have increased by 293(+8%) compared to 2015

The size of the working fleet was 19,368 units in 2015, 20,368 units in 2016, 20,894 units in 2017, 20,385 units in 2018, 19,248 units in 2019, 20,035 units in 2020 and 18,678 units in 2021. It can be seen that the 2021 figures show a decrease of 690(-3.6%) compared to the 2015 figures.

As for the volume of average daily carload turnover, the figures were 975.7 7 million.t-km.net in 2015, 934.1 million in 2016.t-km.net, 996.8 million in 2017. t-km.net, 1028.98 million in 2018.t-km.net, 918.25 million in 2019.t-km.net, 1147.6 million in 2020.t-km.net and 1353.3 million in 2021.t-km.net. From the table, we can see that the average daily railcar turnover has performed well over the past two years and has increased by 377.6 (38.7%) in 2021 compared to 2015. You can see the figures below in the graph.

Cargo turnover indicators serve as a basis for determining the need of the industry and railroads in rolling stock, analysis of quality indicators (cost, labor productivity, average transportation distance, profit margin, etc.). Freight turnover is used to determine the transportation component in the cost of production of certain sectors of the country's economy.



1-Figure 1: Dynamics of cargo turnover in “Railways of Uzbekistan”JSC

As can be seen from the data in the figure, the volume of cargo turnover in 2016 compared to 2015 was 127.8 (+0.7%) million tons-km, in 2017 compared to the previous year -1802.7 (+9.5%) million tons-km, in 2018 t-km, in 2018-147.2 (+0.7%) million t-km, in 2019 3301.3 (-15.7%) million t-km, in 2020-5318.9 (+30.1%) million t-km, and in 2021 an increase to 2284.4 (+9.9%) million t-km was achieved.

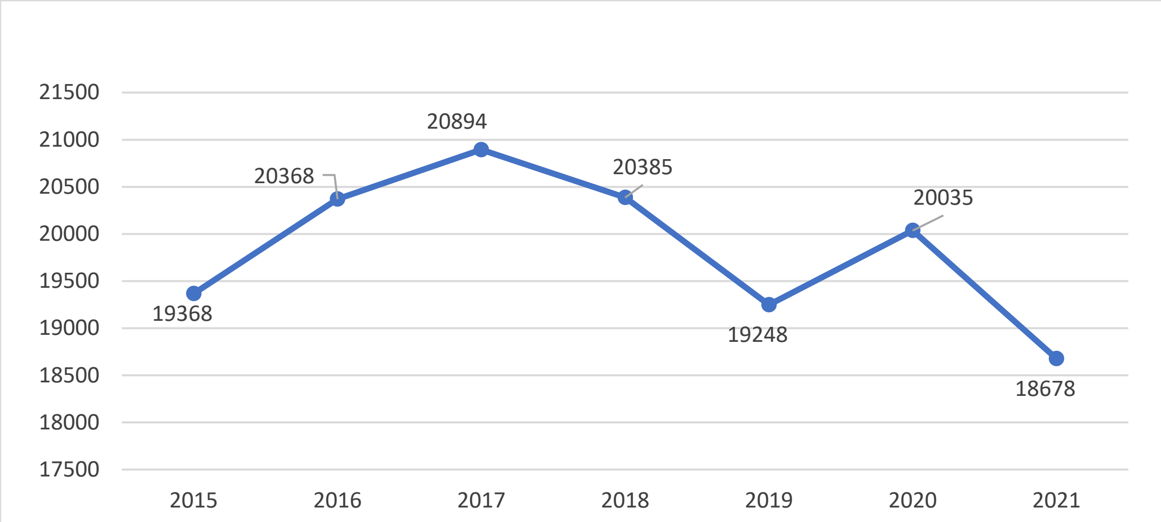


Figure 2: Dynamics of the working fleet of "Railways of Uzbekistan"JSC

Thus, looking at the 2015-2021 figures for the operating fleet as a base year of 2015, there is an increase of 1,000 (+5.2%) in 2016 over 2015, 1,526 (+7.8%) in 2017, 1,017 (+5.2%) in 2018, -120 (-0.62%) in 2019, 667 (3.4%) in 2020, and -690 (3.5%) in 2021.

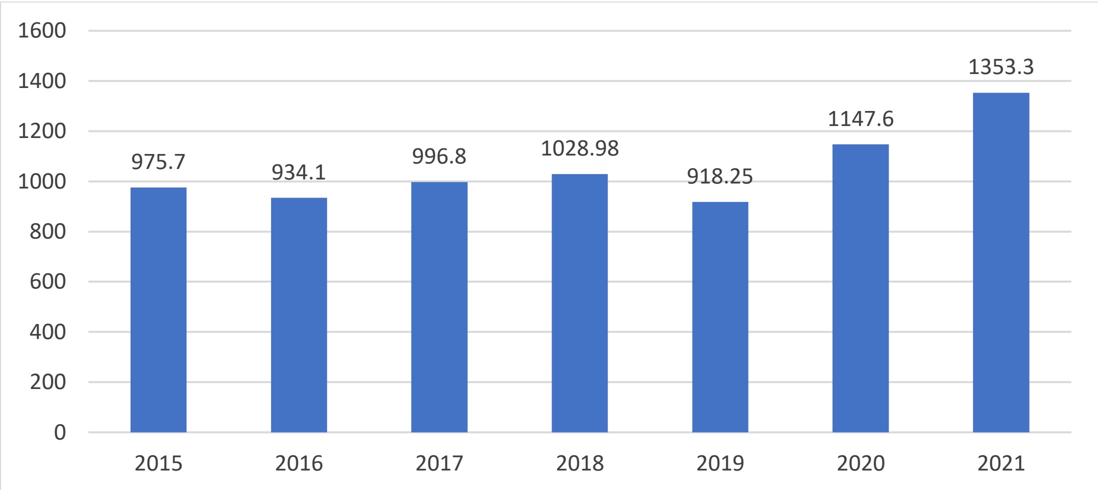


Figure 3. Dynamics of Wagon productivity in the average day by JSC "Railways of Uzbekistan"

The figure shows the average daily railcar throughput from 2015 to 2021. Based on the figures shown, in 2015 975.7 million.t-km.netto ni, 934.1 million in 2016.t-km.netto, 996.8 million in 2017.t-km.netto was 1028.98 in 2018, 918.25 in 2019 , 1147.6 in 2020 and 1353.3 in 2021. Overall, the average daily railcar throughput in 2021 compared to 2015 was 377.6 (38.7%) million.t-km.netto-increase achieved.

DISCUSSION

The above examples further confirm that one of the main requirements of ISO 9000 standard is the importance of quality data recording over other requirements defined by proper quality data recording, internal verification, analysis, correction and preventive measures. In the second stage of modeling, a multivariate correlation and regression model is built.

Model development and study of economic processes the following steps should be performed according to:

1. selection of the main factors;
2. estimation of the regression function;
3. checking the adequacy of the model;
4. economic interpretation;
5. prediction of unknown values depends on the variable.

Let's consider in detail the content of some stages.

Selection of the main factors is the basis for building a multifactor correlation and regression model. Many factors are inconvenient to analyze, and the model will not be stable. Multiple factors are also bad. This can lead to decision-making errors when analyzing the model. Therefore, a more rational list of factors should be chosen. Multicollinearity factors are analyzed.

Multicollinearity is a pairwise correlation of the relationship between factors. If there is a pairwise correlation coefficient $x_{ij} \geq$ 0,70-0,80, there is a multiple linear relationship. Pairwise correlation coefficients are used to select the excluded variables. Experience shows that if $|x_{ij}| \geq$0,70-0,80, one of the variables can be excluded, but which variable to exclude from the analysis is decided based on the control of enterprise level factors.

Usually this factor remains in the model, it is possible to develop a measure, in the planned year will provide improvement in the value of the factor. The procedure for selecting the main factors includes the following steps.

1.Multicollinearity and factor analysis to eliminate it. Here the values of pairwise correlation coefficients r_{ij} between factors x_i andx_j are analyzed.

2- Analyzing the affinity relationship of factors with dependent variable (x) and (y). Factors for r_{xy} ≈0, i.e., not related to Y, should be excluded first. Factors with the smallest r_{xy} value can potentially be excluded from the model. The question of their final exclusion is decided in the process of analyzing other statistical features.

Steps 1, 2, 3 of the "correlation" and "regression" functions can be implemented using the built-in Excel system.

The resulting regression equation is used in forecasting and optimization. The forecast is obtained by substituting the numerical values of factors into the regression. It should be emphasized that the forecasting of regression results is better subject to meaningful interpretation than simple extrapolation of trends, as the nature of the phenomenon under study is more fully taken into account.

On the basis of the above, a multifactor correlation-regression model of dependence of the financial and economic indicator "income from transportation" on some volumetric, qualitative and financial and economic indicators of the operational work of the railroad was obtained. The following indicators were taken as factors: total freight loading (thousand tons), freight turnover (mln. tkm.), average daily mileage of the freight car fleet (km), downtime of the freight car under one freight operation (h), downtime of the freight car at one technical station (h), average gross train weight in freight traffic, all types of traction, (t), average daily productivity of the locomotive in freight traffic, (ths. tkm. gross). tkm.

gross), cost of transportation (kop. per 10 per 1,000 tkm), average number of employees (thousand people).

As a result of calculating pairwise correlation dependence using the built-in function "Correlation" of Excel program and analyzing for multicollinearity (due to the high

The following factors were discarded: idle time of a freight car at one technical station (h), average daily mileage of a freight car in the freight fleet (km), average daily productivity of a locomotive in freight traffic (thousand gross tons), total cargo loading (thousand tons). In view of the high correlation between the cost of transportation and the average train weight in freight traffic (rij=0,9377) we leave the average train weight, as it is easier to manage at the road level than the cost, although the correlation coefficient of cost and income is slightly higher (0,94) than the correlation coefficient of average train weight and income (0,938). This results in a correlation table (Table 2) for the remaining factors.

As a result of Excel regression calculation we obtain a model in the form of

$Y_d - 4775{,}5 + 0{,}07x_1 - 20{,}89x_2 + 1{,}945x_3 - 15{,}16x_4$,

where factors: $x_1$freight turnover (mln. tkm.), x_2 downtime of a freight car under one freight operation (h), x_3 average gross train weight in freight traffic, all types of traction, (t), x_4 average number of employees (thousand people).

Similarly, the dependence of the cost of production (Yc) on the average daily mileage of the freight car fleet (x_1), number of employees (x_2) and freight turnover (x_3) was obtained as follows

$$Y_c = 50{,}74 + 1{,}51x_1 - 7{,}89x_2 + 0{,}003x_3$$

In this case, as a result of multicollinearity analysis, such factors as total freight loading (thousand tons), freight car downtime under one freight operation (h), freight car downtime at one technical station (h), average gross train weight in freight traffic were discarded,

all types of traction, (t), average daily productivity of locomotive in freight traffic, (thousand gross tons), revenue from transportation (mln.sum.).

Table 2 Correlation table for the main factors

Indicators	Total incomer	Cargo turnover	Downtime of a wagon under one cargo operation.	Average train weight	Number of employees of the main activity.
Total incomer	1				
Cargo turnover	0,551734	1			
Downtime of a wagon under one cargo operation	-0,67206	-0,44438	1		
Average train weight	0,938273	0,453895	-0,57159	1	
Number of employees of the main activity	-0,58793	-0,07378	0,259283	-0,63541	1

Similarly to the previous one, we analyzed the dependence of labor productivity of employees engaged in transportation (ths.

tkm) on volumetric and qualitative indicators of operational work (total freight loading, freight turnover, average daily mileage of freight car fleet, freight car downtime under one freight operation, freight car downtime at one technical station, average gross train weight in freight traffic, all types of traction, average daily productivity of locomotive in freight traffic) and financial and economic indicators (income from transportation, expenses from transportation, profit (loss) from transportation, cost of transportation, average number of employees). Interestingly, after analyzing the factors for multicollinearity and analyzing the closeness of the relationship between the factors (x) and the dependent variable (uproductivity), two correlation and regression models were obtained for consideration (taking into account the adjustment of one of the values of freight turnover mentioned above).

$$\mathrm{Y_p} = 19{,}91 + 0{,}00256\mathrm{x}_1 + 0{,}0258\mathrm{x}_2,$$

where x_1 - average monthly salary, x_2 - cargo turnover, or

$$\mathrm{Y_p} = 192{,}89 + 0{,}071\mathrm{x}_1 - 0{,}021\mathrm{x}_2,$$

bunda x_1 — yuk tashishda poyezdning yalpi oʻrtacha ogʻirlik, x_2 — yuk aylanmasi.

The explanation is that the pairwise correlation between average monthly wages and average train weight is significant. All other indicators are discarded because they either have a high correlation with the indicators average monthly wage, average gross train weight in freight traffic, freight turnover, or a low correlation with productivity.

CONCLUSION

In conclusion it should be noted that the application of methods of correlation and regression analysis allows to build models of dependencies of the main financial and economic indicators on the main factors of volumetric, qualitative and financial and economic indicators of operational work. The conducted analysis will allow to reduce the number of main indicators of railroad operation, and the obtained regression equations can be applied in forecasting and optimization of transportation operation indicators.

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