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Threshold Values of Functional-Integrative Indicators as an Early-Warning Tool for the Economic Security of Railway Enterprises

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Abstract:
The thesis justifies normal, pre-crisis and crisis threshold values for 25 functional-integrative indicators of the economic security of railway transport enterprises, grouped into five blocks. Unlike financial ratios, the indicators capture threats inside the operating architecture before they reach financial statements. The approach is tested on data from Uzbekistan Railways JSC for 2020–2025.

Keywords: Economic security; railway transport; early warning; threshold values; functional indicators; wagon turnaround.

Introduction

ПОРОГОВЫЕ ЗНАЧЕНИЯ ФУНКЦИОНАЛЬНО-ИНТЕГРАТИВНЫХ ПОКАЗАТЕЛЕЙ КАК ИНСТРУМЕНТ РАННЕГО ПРЕДУПРЕЖДЕНИЯ ДЛЯ ЭКОНОМИЧЕСКОЙ БЕЗОПАСНОСТИ ЖЕЛЕЗНОДОРОЖНЫХ ПРЕДПРИЯТИЙ

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Аннотация:
В тезисе обосновываются нормативные, предкризисные и кризисные пороговые значения для 25 функционально-интегративных показателей экономической безопасности предприятий железнодорожного транспорта, сгруппированных в пять блоков. В отличие от финансовых коэффициентов, данные показатели позволяют выявлять угрозы внутри операционной структуры до того, как они находят отражение в финансовой отчетности. Подход апробирован на данных АО «Узбекистон темир йуллари» за 2020–2025 годы.

Ключевые слова: Экономическая безопасность; железнодорожный транспорт; раннее предупреждение; пороговые значения; функциональные показатели; оборот вагона.

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ТЕМИР ЙЎЛ КОРХОНАЛАРИНИНГ ИҚТИСОДИЙ ХАВФСИЗЛИГИ УЧУН ЭРТА ОГОҲЛАНТИРИШ ВОСИТАСИ СИФАТИДА ФУНКЦИОНАЛ-ИНТЕГРАТИВ КЎРСАТКИЧЛАРНИНГ ЧЕГАРАВИЙ ҚИЙМАТЛАРИ

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Аннотация
Тезисда бешта блокка гуруҳланган темир йўл транспорти корхоналарининг иқтисодий хавфсизлигини ифодаловчи 25 та функционал-интегратив кўрсаткич учун меъёрий, инқирозолди ва инқироз ҳолатларига мос чегаравий қийматлар асослаб берилган. Молиявий коэффициентлардан фарқли равишда, мазкур кўрсаткичлар таҳдидларни молиявий ҳисоботларда акс эттирилишидан олдин корхонанинг операцион тузилмасида аниқлаш имконини беради. Ёндашув 2020–2025 йиллар учун «Ўзбекистон темир йўллари» АЖ маълумотлари асосида синовдан ўтказилган.

Калит сўзлар: иқтисодий хавфсизлик; темир йўл транспорти; эрта огоҳлантириш; чегаравий қийматлар; функционал кўрсаткичлар; вагон айланмаси.

Relevance

Economic security assessments of railway enterprises still rely mainly on liquidity, profitability and leverage ratios [1; 2]. These indicators record the financial footprint of a problem rather than its origin. In railway systems, economic erosion begins in the operating architecture. Locomotive cycles lengthen, wagons wait at technical stations, headways shrink and maintenance intervals shorten well before any deterioration becomes visible on the balance sheet. At Uzbekistan Railways JSC, for example, the current liquidity ratio stayed within 1.19–1.22 in 2020–2025, while in 2023 expenses grew by 16.9% against revenue growth of 6.1%, and asset turnover fell from 0.66 to 0.60 in 2023–2025. A conventional assessment therefore signals stability exactly when functional pressure is building up.

The threshold approach to economic security [1] and the signal approach to early warning [3] provide the logic needed here: an indicator crossing a predefined boundary is treated as a leading signal of crisis. Existing threshold systems, however, are designed for national or regional economies and use financial or macroeconomic indicators. They do not treat time, circulation and traffic rhythm as economic categories, even though these are decisive in railways, where freight in transit represents frozen capital [4].

Aim and methods

The aim of the study is to build a railway-specific indicator system and to justify threshold values that detect economic security threats at the functional stage. The methods include systems and functional analysis, comparative analysis of practice in Japan, Germany, France, China and Russia, expert evaluation, and index-based assessment. The empirical base is the financial and operating data of Uzbekistan Railways JSC for 2020–2025 [5].

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Results

A system of 25 functional-integrative indicators is proposed, grouped into five blocks. These are (1) locomotive circulation stability; (2) wagon turnaround and resource velocity; (3) infrastructure pressure and traffic rhythm; (4) operating costs and functional pressure; and (5) tariff–investment consistency and technological stability. For each indicator three boundaries are justified: normal, pre-crisis and crisis. The key indicators are shown in the table.

Table 1 Key functional-integrative indicators and their threshold values

Indicator	Unit	Normal	Pre-crisis	Crisis
Locomotive-cycle deformation index	coef.	≤ 0.25	0.26–0.45	> 0.45
Locomotive load pressure index	%	≤ 75	76–90	> 90
Functional locomotive idle pressure	%	≤ 8	9–16	> 16
Resource-flow continuity index	coef.	≥ 0.90	0.75–0.89	< 0.75
Wagon turnaround pressure index	days	≤ 4.0	4.1–6.0	> 6.0
Infrastructure density pressure index	coef.	≤ 0.55	0.56–0.75	> 0.75
Headway deterioration	min	≤ 12	13–20	> 20
Operating energy pressure coefficient	coef.	≤ 0.22	0.23–0.40	> 0.40
Maintenance-cycle erosion index	coef.	≤ 0.18	0.19–0.35	> 0.35
Tariff-signal transformation coefficient	coef.	≥ 0.85	0.65–0.84	< 0.65
Investment renewal gap index	coef.	≤ 0.20	0.21–0.40	> 0.40
Capital renewal rate	%	≥ 12	6–11	< 6

Source: developed by the author (the full system contains 25 indicators).

The boundaries are not purely statistical intervals. Each one marks a qualitative change in the underlying economics. Beyond a locomotive-cycle deformation index of 0.45, traffic rhythm loses internal synchronisation, reserve locomotives are drawn in, maintenance cycles shorten and operating pressure grows cumulatively rather than linearly. Below an infrastructure density index of 0.55, delays are absorbed within the system; above it, they become an independent source of operating pressure. This is consistent with international evidence that network sensitivity to delays rises sharply once capacity utilisation exceeds 80–85%. A tariff-signal transformation coefficient below 0.85 means that part of the tariff revenue is absorbed by accumulated operating pressure instead of funding technological renewal.

To make heterogeneous indicators comparable, each is normalised by a dynamic function that combines the deviation from the norm, signal delay τ and risk elasticity β:

$$Z_i(t) = [(x_i(t) - x_i^n) / (x_i^c - x_i^n)] \cdot (1 + \lambda_i\tau_i) / (1 + e^{-\beta_-\{i}\Delta x_i\}) \quad (1)$$

where x_i^n and x_i^c are the normal and crisis thresholds and λ_i is the delay sensitivity. The sigmoid denominator ensures that the risk score grows in steps rather than linearly as an indicator approaches the crisis boundary. This turns a binary threshold breach into a continuous, delay-sensitive signal.

Applying the thresholds to Uzbekistan Railways JSC yields practically relevant warnings that financial ratios miss. Average wagon turnaround (3.84–3.90 days) still lies in the normal zone, but only 0.10 days (2.5%) remain before the boundary. Locomotive productivity rose by 18.2% in 2021–2025 while wagon productivity rose by only 5.9%, indicating growing locomotive load

without a matching acceleration of wagon circulation. The domestic tariff index was held at 26.7 in 2021–2024 and the transit index was cut from 29.1 to 25.5 in 2025. This signals that tariff revenue is not being converted into infrastructure renewal, which moves the tariff-signal indicator towards the pre-crisis zone.

The threshold system has been adopted by Uzbekistan Railways JSC. Estimates indicate that it increases the speed of detecting functional breaks by 20–25% and shortens the time needed to take preventive decisions by 15–18%.

Conclusions

Threshold values defined in time and movement units (days, minutes, cycle deformation) allow railway enterprises to detect economic security threats at the functional stage, before they become financial losses. It is recommended (1) to run monthly functional monitoring against these thresholds alongside financial reporting; (2) to integrate the indicators into a single digital dispatching and data platform; and (3) to differentiate the thresholds by corridor and cargo type in further research.

References

1. Ekonomicheskaya bezopasnost' Rossii: obshchiy kurs / ed. by V.K. Senchagov. – 2nd ed. – Moscow: Delo, 2005. – 896 p. (in Russian)
2. Altman E.I. Financial ratios, discriminant analysis and the prediction of corporate bankruptcy // The Journal of Finance. – 1968. – Vol. 23, No. 4. – P. 589–609.
3. Kaminsky G., Lizondo S., Reinhart C.M. Leading indicators of currency crises // IMF Staff Papers. – 1998. – Vol. 45, No. 1. – P. 1–48.
4. Lapidus B.M., Macheret D.A. Makroekonomicheskoe znachenie transporta: sushchnostnyy analiz // Ekonomika zheleznykh dorog. – 2011. – No. 1. – P. 13–19. (in Russian)
5. Uzbekistan Railways JSC. Official website. – URL: https://railway.uz.