Matrix-vector approach to assessing the competitiveness of logistics enterprises in the context of economic security and information risks

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Abstract
In modern conditions, logistics companies face a number of challenges, among which information risks and economic security play a critical role. Insufficient level of digital protection or dependence on unstable IT infrastructures can undermine the competitiveness of companies regardless of their financial potential. The proposed matrix-vector approach allows for an integrated assessment of competitiveness with the inclusion of indicators of information resilience of the enterprise. The article presents a matrix-vector approach to assessing the competitiveness of logistics enterprises, which combines the analysis of quantitative indicators of company performance and the statistical determination of their significance. The main stages of the methodology are described: formation of the initial data matrix, selection of the reference vector, calculation of weight coefficients through correlation analysis, construction of a matrix of deviations from the reference, calculation of rating indicators (B_i) and final rating (L_i). An example of a calculation based on data from four hypothetical logistics enterprises is given, and the results are illustrated in the form of a rating graph. It is demonstrated that the use of this approach contributes to increasing the objectivity of assessing competitiveness and, accordingly, the sustainability of enterprises in the context of economic security and information risks.

Keywords
competitiveness, logistics enterprise, economic security, matrix-vector method, information risks, sustainable development, automation of logistics processes, profitable enterprise, information stability

1. Introduction

Modern logistics companies operate in an environment of high competition and rapid technological change. Digital transformation opens up new opportunities, but at the same time increases vulnerability to information risks, which can negatively affect the economic security of companies.

Competition stimulates enterprises to implement effective solutions and technologies, therefore, assessing their competitiveness is an important condition for economic development. Modern logistics enterprises operate in a complex environment of acute challenges (military, economic and information), which makes their economic security a priority. Therefore, ensuring the stable functioning of logistics companies and minimizing risks in the process of information management and transmission becomes urgent [1].

Scientists note that in conditions of instability it is important to implement security-oriented management strategies, since information uncertainty can reduce the effectiveness of decision-making and lead to losses [2, 3]. In this context, modelling competitiveness, taking into account information risks

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contributes to the economic security of logistics entities.

Traditional methods of assessing the competitiveness of enterprises, considered in many scientific publications [4, 5, 6] as well as [7, 8, 9, 10, 11, 12, 13], often ignore the interrelationship of indicators and do not take into account their importance. The matrix-vector approach to assessing competitiveness combines the use of matrices of financial and economic indicators with vector operations on them, which ensures the derivation of the rating of enterprises according to a unified and statistically sound scheme [14, 15]. Matrix methods are generally based on the analysis of tables with a system of indicators, but do not themselves take into account the significance of individual factors. The proposed approach uses the calculation of weighting coefficients using correlation analysis, which increases the reliability of the assessment and reduces the subjectivity of the ranking procedure of the enterprises under research.

2. Literature review

There are many approaches to assessing the competitiveness of companies in scientific literature. In particular, matrix methods (e.g., SWOT, BCG matrix, portfolio models) are widely used, which provide clarity and simplicity of assessment. Typically, matrix approaches allow you to visualize the strengths and weaknesses of an enterprise, but do not provide clear recommendations regarding the importance of indicators and the causes of competitive situations. At the same time, some research focus on practical aspects of increasing competitiveness, in particular through the analysis of internal resources and functional components of the enterprise. The scientific publication [16] revealed the influence of logistics components on the level of competitiveness of enterprises and highlighted relevant logistics components for increasing the level of competitiveness of enterprises in terms of production, marketing and financial potential.

A comprehensive analysis of competitiveness requires taking into account both economic indicators and external risks. Accordingly, modern literature focuses on combining traditional competitiveness measurements with risk management. Thus, in the context of logistics enterprises, various types of risks are considered - from technological to informational. O. Yaremenko and S. Matyukh in their work [17] emphasize that the main goal of the risk management system is to ensure maximum stability of the enterprise, limiting the impact of threats to an acceptable level. On the other hand, the lack of a single methodological basis for assessing information risks creates fragmentation in approaches to assessing competitiveness in conditions of information instability.

Information risks of the logistics process are associated with the unreliability of data on the movement of goods and the market, which can lead to incorrect management decisions. Scientists O. Vashkiv, O. Sobko and S. Smereka [18] presented a methodology for comprehensive assessment of the competitiveness of an enterprise, based on a holistic five-level hierarchical system of factors by T. Kono. This approach expands the possibilities of analyzing an enterprise's competitiveness by focusing on its most important components, including the market share occupied by the enterprise, its innovative potential, production and sales capacities, strategy, and main performance results.

The fundamental research of I. Kryvovyazyuk, S. Smerichevskyi and Y. Kulik [19] proposes a solution to the scientific and applied problem, which consists in deepening the theoretical and methodological provisions of risk management, aimed at increasing the level of efficiency and substantiating the directions of implementing risk management of the logistics system of enterprises. The enterprise under the influence of the external and internal environment, in the context of investment and security aspects, as well as the development of effective measures to prevent the risks of unstable activity [20, 21].

The approach that formalizes all available indicators into a matrix and introduces statistically sound weighting coefficients allows to partially compensate for the lack of information and focus on the interdependencies of key factors. Thus, the literature emphasizes the need to combine methods of competitiveness analysis with risk management tools of logistics systems.

3. Methodology

The model of integrated assessment of the competitiveness of logistics enterprises should take into account the following components:

- financial stability, i.e. the ability of the enterprise to withstand financial risks and provide stable profits.
- technological level of the enterprise – the degree of implementation of digital technologies and process automation.
- cybersecurity – the availability of effective information protection systems and information risk management.
- customer orientation – the level of customer satisfaction and the ability to adapt services to their needs.

Each of the above indicators is assessed using the corresponding indicators, which allows you to obtain a comprehensive picture of the competitiveness of the enterprise.

The research proposes the use of a matrix-vector approach to assessing the competitiveness of logistics enterprises, taking into account economic security factors. The methodology is based on an objective analysis of indicators that reflect the use of the company's potential, financial stability, and market efficiency.

The essence of the matrix-vector method of assessing the competitiveness of logistics enterprises lies in the sequence of the following stages:

3.1. Formation of the initial matrix of indicators

First, me build a matrix of type:

$$A = |a_{ij}|\,;\; i = \overline{1,n};\; j = \overline{1,m}, \tag{1}$$

where:

n – is a number of logistics enterprises;

m – number of indicators covering financial efficiency, logistical performance and information security;

a_{ij} – value of the j-the indicator for the i-th enterprise.

The indicators that make up the matrix are relative values and express an assessment of the use of the company's potential. The structure of indicators may include:

- Financial ratios (profitability, liquidity, turnover).
- Volume of logistics services provided.
- Number of detected cyber incidents (inverted scale).
- Availability of certified information security systems.
- Frequency of information system audits.
- Level of automation of logistics operations.

In the proposed methodology, profitability indicators and financial ratios are consistent with the standard financial statements of the enterprise. In addition, a vector of logistics services sales volumes (target variable) is fixed, which is used to assess the significance of the indicators.

The assessment of competitiveness based on the above indicators is based on a comprehensive, multidimensional approach and eliminates subjectivity, as it takes into account the real situation of all competing logistics companies.

If the change in all indicators towards an increase is considered a positive phenomenon, then to assess competitiveness it is proposed to use the values of the Euclidean norms of vectors:

$$N_i = \left|\overline{A_i}\right| = \sqrt{\sum_{j=1}^{m} a_{ij}^2}. \tag{2}$$

Thus, it is possible to obtain generalized characteristics of all vectors and compare each of them with the normative (reference). The most competitive enterprise is the one whose Euclidean vector coefficient is the highest.

But the Euclidean norm of a vector cannot always serve as a sufficient and comprehensive characteristic of a company's competitiveness. Among the competitive indicators, it is also necessary to highlight the level of co-direction of each of the vectors $\overline{A}$ and the reference vector $\overline{A_{ij}}$. Such an estimate can be the angle α between the vectors, which is found from the formula:

$$\cos\alpha = \frac{\overline{A_0} \cdot \overline{A_i}}{\left|\overline{A_0}\right| \cdot \left|\overline{A_i}\right|}, \tag{3}$$

where $\overline{A_0} \cdot \overline{A_i}$ – the dot product of vectors.

The less if the α, the closer is the value of $\cos\alpha$ to 1. So, if the vectors are directed in the same direction, then $\cos\alpha = 1$. This indicator can be used to judge the degree to which a logistics company's activities comply with the requirements of the standard or reference value.

If the subordination of Euclidean norms and co-direction indicators is not the same, then to identify the rating position it is proposed to use the distance value between points A_i (actual value of the indicator) and A_0 (reference value of the indicator).

3.2. Definition of the reference vector

To the matrix A an additional column with reference (optimal) values for each indicator is added a_{0j} The benchmark can be chosen as the industry average or the best achieved value in the sample. Benchmark vector A_0 is formed based on the maximum values for positive indicators and the minimum values for risk indicators. For example, maximum profitability is positive, and the minimum number of cyber incidents is also positive. In our example, the benchmark is chosen as the maximum values of indicators among all logistics enterprises, since higher profitability or liquidity is a positive aspect.

3.3. Calculation of the weighting factors K_j

For further calculations for each indicator, it is necessary to enter correction weight coefficients. The calculation of correction coefficients is carried out based on correlation analysis methods. This allows us to quantitatively assess the relationships between each group of calculated indicators and a value that would comprehensively characterize the economic potential of the enterprise. Such an indicator could be the volume of sales of services (products). Weighting factor R_j is calculated using the following formula:

$$K_j = \upsilon_j \times \mu_j, \tag{4}$$

where υ_j is the correlation coefficient, μ_j – reliability criterion of the correlation coefficient. The correlation coefficient is calculated using the following formula:

$$\upsilon_j = \frac{\sum_{i=1}^{n} (x_i - \overline{x})(y_i - \overline{y})}{\sqrt{\sum_{i=1}^{n} (x_i - \overline{x})^2 \sum_{i=1}^{n} (y_i - \overline{y})^2}}. \tag{5}$$

The reliability criterion of the correlation coefficient is calculated as follows

$$\mu_j = \frac{|\upsilon_j|}{\sigma_\upsilon}, \tag{6}$$

where σ_υ is the average error of the correlation coefficient.

$$\sigma_\upsilon = \frac{1 - \upsilon^2}{\sqrt{n-1}}. \tag{7}$$

Thus, indicators with a high correlation with sales volume receive greater weight. In a practical example, the results of calculating weight coefficients K_j is given below.

3.4. Construction of the deviation matrix

A matrix R of deviations is created, where the elements are the distances r_{ij} between points A_i and A_0:

$r_{ij} = a_{0j} - a_{ij}$, if the change a_{ij} in the larger direction is considered a positive phenomenon.

$r_{ij} = a_{ij} - a_{0j}$, if the change a_{ij} to a lesser extent is considered a positive phenomenon.

The less r_{ij}, the better the i-th enterprise is characterized by the j-th indicator. The matrix of deviations from the standard is given Table 3.

3.5. Calculation of the final rating indicators

A total competitiveness indicator is calculated for each enterprise B_i:

$$B_i = \sqrt{\sum \left(\frac{r_{ij}}{K_j}\right)^2}. \tag{8}$$

A smaller value B_i indicates a smaller deviation from the standard and, accordingly, higher competitiveness. The final rating (L_i) of each enterprise is calculated using the formula:

$$L_i = \frac{1}{B_i}. \tag{9}$$

As a result, the company with the smallest B_i receives the largest L_i and the highest rank. Thus, the ranking is determined by the L_i, indicators and the place in the ranking is formed by the decrease of L_i. Enterprises with the highest L_i value demonstrate a high level of competitiveness while simultaneously having a low level of information risks and economic stability. This method allows not only to see the "strong" sides of companies, but also to identify specific areas of vulnerability, particularly in the field of digital security.

The proposed method eliminates subjectivity and allows for a multidimensional objective assessment of the competitive positions of logistics companies in the digital environment, taking into account information risks and financial efficiency.

Let us give a practical example of calculating the competitiveness of logistics enterprises. Let us consider conditional data for 4 enterprises operating in the logistics industry (Table 1). Due to the intensive digitalization of logistics processes and increased vulnerability to cyber threats, an effective assessment of an enterprise's competitiveness must take into account not only financial and operational metrics, but also indicators of information security and digital resilience. To this end, the study proposes

Table 1
Indicators for Assessing the Competitiveness of Logistics Enterprises

Indicator	Enterprise				Reference vector
	1	2	3	4	
Volume of logistics services sales, thousand UAH	3104	3540	5307	6920	
1. Return on assets	0,045	0,05	0,105	0,103	0,105
2. Profitability of fixed assets	0,11	0,14	0,172	0,184	0,184
3. Profitability of implemented logistics services (by sales profit)	0,013	0,069	0,094	0,095	0,095
4. Profitability of implemented logistics services (by operating profit)	0,014	0,115	0,147	0,158	0,158
5. Profitability of logistics services provided (by net profit)	0,019	0,084	0,063	0,065	0,084
6. Current asset coverage ratio	0,195	0,193	0,197	0,2	0,2
7. Financial stability ratio	0,796	0,843	0,9	0,85	0,9
8. Absolute liquidity ratio	0,23	0,204	0,35	0,293	0,35
9. Information stability coefficient	0,62	0,586	0,59	0,71	0,71
10. IT infrastructure security factor	0,48	0,35	0,46	0,47	0,48

expanding the traditional matrix of indicators by adding an information security block. Each of the indicators in this block is normalized and interpreted as digital security coefficients, which are analogues of financial coefficients and can be included in the matrix along with financial ones.

Analysis of the data in Table 1 allows us to state that the market leader in most indicators – in particular sales volumes, profitability and information stability – is logistics enterprise 4. At the same time, it should pay attention to strengthening IT security, where it is inferior to other Enterprises. Enterprise 3 demonstrates the best level of financial stability and liquidity, but needs to improve profitability, which indicates the need to update its operating strategy. Enterprise 2 has a strong position in terms of net income and profitability but needs to strengthen its IT infrastructure and information resilience. Enterprise 1 has a high level of IT security but overall is characterized by the lowest level of profitability and market activity, which requires strategic transformation. There is a two-way relationship between innovation and sustainable development. On the one hand, economic, social and environmental factors improve as a result of intensified innovation. On the other hand, these changes lead to the accumulation of funds, knowledge, and skills to spread innovation processes in the country [22].

The obtained in Table 1 indicators are relative financial and economic values, on the basis of which calculations were made according to the presented methodology. First, the correlations of each indicator with the volume of logistics services were calculated and the weighting coefficients K_j were determined (Table 2).

The results of the interim calculations (Table 2) demonstrate that financial indicators, especially the profitability of fixed assets and assets, remain the main criteria for competitiveness. Digital security has not yet become a full-fledged "strength", but it already records a positive dependence, especially on the information resilience indicator. To build a competitive rating, it is advisable to take a financial and digital balance, where each group of indicators will have a separate weight in the final calculation. Table 3 shows a matrix of deviations of indicators from the standard.

Analysis of key deviations from the reference indicators (Table 3) shows that enterprise 4 has minimal or zero deviations for most indicators, which indicates its highest compliance with the reference values. This confirms its leading position in competitiveness. Enterprise 3 also shows low deviations, especially in financial indicators, but has some minor lags in digital security and profitability in terms of net profit. Enterprise 2 is characterized by a medium level of deviations, with noticeable lags in IT security, information resilience and liquidity. Enterprise 1 demonstrates the highest deviations in all indicators, especially in terms of profitability and digital security, indicating the lowest level of competitiveness

Table 2
Results of Intermediate Calculations for Weight Coefficients K_j

Indicator	Indicators a_{ij} by enterprises 1	2	3	4	$\overline{x} \times \overline{y}$	υ_j	μ_j	K_j
Volume of logistics services sales (thousand UAH)	3104	3540	5307	6920	4717,75			
1. Return on assets	0,045	0,05	0,105	0,103	0,07575	0,91578	9,830794	9,00284
2. Profitability of fixed assets	0,11	0,14	0,172	0,184	0,1515	0,938382	13,60804	12,76954
3. Profitability of implemented logistics services (by sales profit)	0,013	0,069	0,094	0,095	0,06775	0,804673	3,953853	3,18156
4. Profitability of implemented logistics services (by operating profit)	0,014	0,115	0,147	0,158	0,1085	0,803085	3,917653	3,146206
5. Profitability of logistics services provided (by net profit)	0,019	0,084	0,063	0,065	0,05775	0,350836	0,692959	0,243115
6. Current asset coverage ratio	0,195	0,193	0,197	0,2	0,19625	0,927768	11,54021	10,70663
7. Financial stability ratio	0,796	0,843	0,9	0,85	0,84725	0,558697	1,406818	0,785985
8. Absolute liquidity ratio	0,230	0,293	0,350	0,204	0,26925	0,69778	2,35547	1,643602
9. Information stability coefficient	0,62	0,586	0,59	0,71	0,6265	0,728125	2,684244	1,954465
10. IT infrastructure security factor	0,480	0,350	0,420	0,144	0,44	0,37525	0,75648	0,283872

among the analysed companies.

Using formulas 2, 3 and 9, the competitiveness indicators of logistics enterprises were calculated, and the results are presented in Table 4.

The calculated indicators clearly identify enterprise 4 as the most competitive, with high efficiency and digital resilience. Enterprise 2, although it has strengths, needs systematic improvement in the structure of indicators and consistency with critical parameters.

The rating of logistics enterprises by L_i indicator is graphically depicted in Figure 1.

From the calculations obtained it is clear that the highest rating (L_i) was received by enterprise 4, and the lowest by enterprise 2 (Table 4, Figure 1). This means that enterprise 4 deviates the least from the reference values and is the most competitive among the analysed ones. Enterprise 2, on the contrary, has significantly larger deviations of indicators (the largest is B_i) and takes the last place. A practical example demonstrates that differences in financial ratios significantly affect the rating: for example, higher profitability and liquidity of enterprise 4 ensured its leadership, despite a slightly smaller sales volume compared to enterprise 2. Thus, the matrix-vector method provided a consistent assessment procedure: first, all logistics enterprises were standardized according to the standard, then, taking into account the correlation with sales volume, the relative weights of each indicator were determined, and finally, the weighted deviations were summed to form a rating.

One of the characteristics of competitiveness is the stability of the enterprise. Stability, in turn, depends on the dynamics of indicators characterizing the work of the enterprise over certain periods of time. The state of enterprises can be characterized as stable development, relative stability, instability. The

Table 3
Matrix of Deviations from Reference Indicators for Assessing Competitiveness

Indicator	Enterprise			
	1	2	3	4
1. Return on assets	0,06	0,055	0	0,002
2. Profitability of fixed assets	0,074	0,044	0,012	0
3. Profitability of implemented logistics services (by sales profit)	0,082	0,026	0,001	0
4. Profitability of implemented logistics services (by operating profit)	0,144	0,043	0,011	0
5. Profitability of logistics services provided (by net profit)	0,065	0	0,021	0,019
6. Current asset coverage ratio	0,005	0,007	0,003	0
7. Financial stability ratio	0,104	0,057	0	0,05
8. Absolute liquidity ratio	0,12	0,146	0	0,057
9. Information stability coefficient	0,09	0,124	0,12	0
10. IT infrastructure security factor	0	0,13	0,02	0,01

Table 4
Competitiveness Indicators of Logistics Enterprises

Enterprise	Competitiveness indicators			
	$\|N_i\|$/place in the rating	$\cos \alpha_i$/place in the rating	B_i/place in the rating	L_i/place in the rating
1	1,16/3	0,986/4	0,315/3	3,174/3
2	1,14/4	0,992/3	0,477/4	2,098/4
3	1,27/2	0,997/2	0,127/2	7,855/2
4	1,29/1	0,998/1	0,112/1	8,909/1

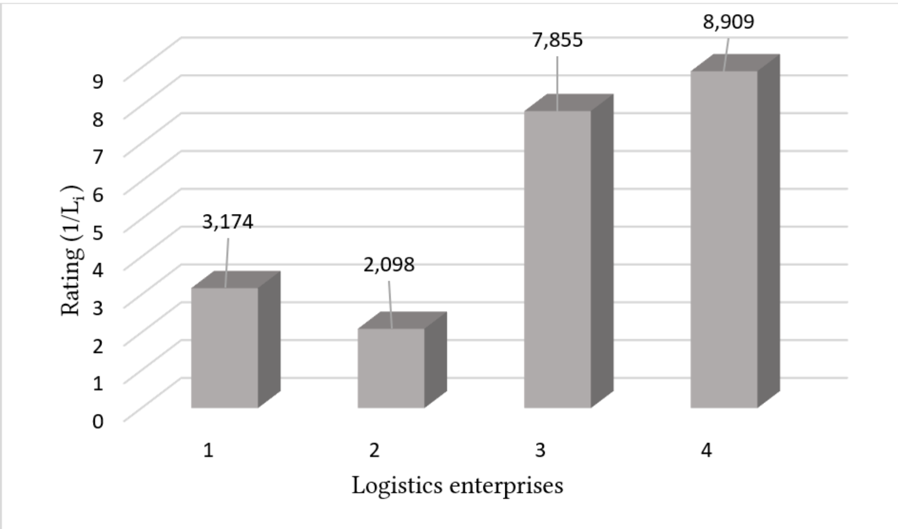

Figure 1: Rating of logistics enterprises.

first will be characterized by the fact that the change in all indicators for certain periods is characterized positively. It is known that the level of indicators is a rather dynamic characteristic with an irregular order of fluctuations relative to the average level. The greater the magnitude of the fluctuation, the less the activity of the logistics enterprise can be considered satisfactory and the more the results of the enterprise are at risk. The degree of fluctuation of indicators is proposed to be assessed by the standard

Table 5
Calculation of the Risk Indicators for a Logistics Enterprise 1

Indicator	a_{ij01}	a_{ij02}	a_{ij03}	σ	$\overline{a_j}$	$\left(\frac{\sigma}{\overline{a_j}} \times K_j\right)^2$
1. Return on assets	0,0430	0,0440	0,0450	0,0008	0,044	0,02791
2. Profitability of fixed assets	0,1140	0,1090	0,1100	0,0022	0,111	0,06176
3. Profitability of implemented logistics services (by sales profit)	0,0139	0,0130	0,0131	0,0004	0,013327	0,00943
4. Profitability of implemented logistics services (by operating profit)	0,0142	0,0133	0,0135	0,0004	0,013636	0,00755
5. Profitability of logistics services provided (by net profit)	0,0099	0,0093	0,0094	0,0003	0,009545	0,00005
6. Current asset coverage ratio	0,1890	0,1930	0,1950	0,0025	0,192333	0,01928
7. Financial stability ratio	0,5170	0,5420	0,7960	0,1260	0,618333	0,02567
8. Absolute liquidity ratio	0,1800	0,2000	0,2300	0,0205	0,203333	0,02759
9. Information stability coefficient	0,4800	0,5900	0,6200	0,0602	0,563333	0,04360
10. IT infrastructure security factor	0,3900	0,4500	0,4800	0,0374	0,44	0,00058
Total						*0,223*
The amount of risk						*0,473*

deviation of individual indicators for each year from the average level:

$$\sigma = \sqrt{\frac{\sum (a_j - \overline{a})^2}{m}}, \tag{10}$$

where m is the number of periods. The generalizing characteristic of risk is the magnitude:

$$P = \sqrt{\sum \left(\frac{\sigma}{\overline{a_j}} \times K_j\right)^2}. \tag{11}$$

When $P_i < 0.3$, the situation should be considered relatively stable, and when $K_j >= 0.3$, it should be considered unstable.

Based on the financial and economic indicators of the activities of logistics enterprises, considered in dynamics (for example, over three years), the standard deviation and risk indicators for the logistics enterprise were calculated (Table 5).

Therefore, P is a generalizing risk characteristic for logistics enterprise 1 is 0,473, i.e. the situation should be considered unstable.

Table 6 presents calculations of risk indicators for logistics enterprises 2, 3 and 4.

Analysis of the data in Tables 5 and 6 allows us to conclude that the most unstable in terms of financial and economic indicators is logistics enterprise 2, for which the generalized risk characteristic is 0.580, which indicates high variability of indicators and increased unpredictability of financial results. Logistics enterprise 1, although demonstrating some stability of individual indicators, in particular IT

Table 6
Calculation of the Risk Indicators for Logistics Enterprises 2, 3 and 4

Indi-cator	Enterprise 2			Enterprise 3			Enterprise 4		
	σ	$\overline{a_j}$	$\left(\frac{\sigma}{\overline{a_j}} \times K_j\right)^2$	σ	$\overline{a_j}$	$\left(\frac{\sigma}{\overline{a_j}} \times K_j\right)^2$	σ	$\overline{a_j}$	$\left(\frac{\sigma}{\overline{a_j}} \times K_j\right)^2$
1	2,89E-06	0,048	0,10305	6,67E-07	0,106	0,00481	6,67E-07	0,102	0,00519
2	6,67E-07	0,139	0,00563	9,56E-06	0,176333	0,05011	1,72E-07	0,1837	0,00083
3	2,37E-05	0,062	0,06193	1,03E-05	0,0925	0,01217	1,15E-05	0,0928	0,01355
4	4,92E-07	0,114	0,00037	2,52E-06	0,1448	0,00119	4,54E-05	0,1485	0,02040
5	0,0012	0,034	0,06143	0,0006	0,0274	0,04988	6,68E-05	0,0763	0,00068
6	4,67E-06	0,192	0,01451	1,09E-05	0,1933	0,03339	6,89E-06	0,1977	0,02021
7	0,006878	0,734	0,00789	0,011742	0,753	0,01279	0,007398	0,7363	0,00843
8	7,47E-05	0,582	0,00084	8,89E-05	0,5833	0,00100	0,0002	0,6933	0,00124
9	0,0038	0,403	0,00189	0,0026	0,44	0,00108	0,0028	0,443333	0,00113
10	0,0011	0,1947	0,07914	6,67E-05	0,34	0,00156	0,0004	0,321	0,01071
	Total		*0,337*	*Total*		*0,168*	*Total*		*0,082*
	The amount of risk		*0,580*	*The amount of risk*		*0,41*	*The amount of risk*		*0,287*

security and profitability of net profit, also has a high risk overall (0.473), which indicates unstable development and the need to strengthen financial fundamentals. Enterprise 3 has an average risk level (0.41), and although it demonstrates better stability in indicators such as absolute liquidity and operating profitability, it still needs to optimize internal processes and reduce profitability fluctuations. The most stable and predictable is logistics enterprise 4, with the lowest risk value of 0.287, which is an optimal indicator for planning and strategic management. This company demonstrates the smallest deviations in most key financial parameters, in particular, return on fixed assets, financial stability and IT infrastructure security.

Figure 2 presents a comparative diagram of the risk index for the four analyzed logistics enterprises.

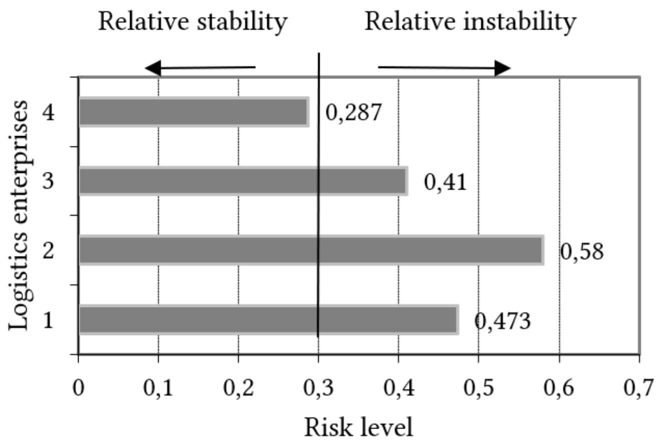

Figure 2: Risk level for logistics companies.

The proposed approach has a number of advantages. First, the combination of matrix formalization with vector operations allows us to reflect competitiveness in the form of a systematized model, which reduces the subjectivity of the assessment. The use of statistically sound weighting coefficients K_j ensures that key financial indicators receive due significance. For example, those profitability indicators that are closely related to the volume of sales of logistics services automatically have a stronger influence on the final rating. Thus, priority is given to objectively important factors of activity. The use of digital tools in management allows to find an individual approach to each client, which increases customer satisfaction and loyalty. This approach helps to increase sales and reduce customer losses [23].

Secondly, this method increases economic security: a comprehensive analysis based on many interdependent indicators minimizes the risk of obtaining erroneous estimates in the event of partial loss of information. Since the success criteria of a logistics enterprise are formed on the basis of official reporting data, and the weights of indicators are calculated formally, the risk of exposure to information threats (inaccurate or missing data) is reduced. At the same time, the methodology allows you to adapt to changes in the external environment: if necessary, the reference vector and correlations can be updated under new market conditions.

On the other hand, the disadvantage is the need for large amounts of input information and additional calculations (correlation analysis), which may complicate the application of the method for small enterprises. However, for large logistics operators, these resources are justified by the increased accuracy of the assessment. Overall, the proposed matrix-vector approach proved to be relevant for assessing competitiveness in the context of economic security and can complement existing risk management systems in logistics.

4. Conclusions

The use of the matrix-vector method allows us to build an objective and representative model of the competitiveness of logistics enterprises. This approach allows us to take into account the impact of each financial indicator in proportion to its significance, reducing the impact of "subjective" assessments. The results of applied calculations confirm that the methodology provides a clear rating that reflects the real differences between enterprises. In the context of economic security, this method helps reduce information risks, as it is based on known statistical data and formal relationships.

Among the advantages, the possibility of rapid update of the assessment when market conditions change is emphasized. In addition, the method can be applied even in an unstable information environment. It is recommended to use this approach for comprehensive analyses of the competitiveness of logistics enterprises, especially in cases where high reliability of the assessment is required in conditions of high uncertainty.

Declaration on Generative AI

The authors have not employed any Generative AI tools.

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