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PROBLEMS OF ASSESSING THE LEVEL OF COMPETITIVENESS OF INNOVATION-ORIENTED ENTERPRISES BASED ON A STATISTICAL APPROACH

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ПРОБЛЕМИ ОЦІНЮВАННЯ РІВНЯ КОНКУРЕНТОСПРОМОЖНОСТІ ІННОВАЦІЙНО-ОРІЄНТОВАНИХ ПІДПРИЄМСТВ НА ОСНОВІ СТАТИСТИЧНОГО ПІДХОДУ

The article considers the problem of assessing the competitiveness of innovation-oriented enterprises based on statistical analysis of financial and economic indicators. The aim of the article is to assess the competitiveness of innovation-oriented enterprises using a comprehensive statistical approach. Achieving this goal involves the analysis of enterprise performance data through a system of quantitative indicators that reflect solvency, operational efficiency, profitability, and growth potential. These indicators serve as the basis for evaluating the current ability of enterprises to generate and maintain competitive advantages in a dynamic market environment. The empirical part of the study is based on data from five innovation-oriented enterprises operating in high-tech and knowledge-intensive sectors. For the period 2014–2024, key financial and economic indicators were collected and processed, and an integral competitiveness indicator was calculated using the composite indexing method. This allowed for the ranking and comparative evaluation of the enterprises in the sample. Among the key analytical challenges identified in the study, the limitations of traditional statistical methods in assessing the competitiveness of innovation-oriented enterprises are particularly emphasized. In particular, the absence of stable linear relationships between the time series of indicators reduces the applicability of linear trend analysis, regression models, or correlation-based methods. The high variability and irregularity of development trajectories make it difficult to predict future competitiveness using classical approaches. Furthermore, the heterogeneity of the sample – in terms of scale, market niche, and innovation strategies – prevents the formulation of universal development scenarios or typical behavior patterns. The results obtained confirm the necessity of rethinking the existing tools for competitiveness assessment and adopting alternative, more flexible statistical methods. These methods should account for the multidimensional, non-linear, and often non-uniform nature of competitiveness formation in innovation-oriented enterprises.

У статті розглянуто проблему оцінювання конкурентоспроможності інноваційно-орієнтованих підприємств на основі статистичного аналізу фінансово-економічних показників. Метою статті є оцінювання конкурентоспроможності інноваційно-орієнтованих підприємств із використанням комплексного статистичного підходу. Досягнення цієї мети передбачає аналіз даних про результати діяльності підприємств за допомогою системи кількісних показників, які відображають платоспроможність, операційну ефективність, прибутковість та потенціал зростання. Ці показники слугують основою для формування уявлення про поточну здатність підприємств генерувати та підтримувати конкурентні переваги в умовах динамічного ринкового середовища. Емпіричну частину дослідження побудовано на прикладі п'яти інноваційно активних підприємств, що функціонують у наукоємних та високотехнологічних секторах. Для періоду 2014–2024 рр. зібрано та опрацьовано ключові фінансово-економічні показники, на основі яких здійснено розрахунок інтегрального показника конкурентоспроможності з використанням методу композитного індексування. Серед основних аналітичних викликів, виявлених у ході дослідження, особливо виокремлено обмеження традиційних статистичних методів при оцінюванні конкурентоспроможності інноваційно-орієнтованих підприємств. Відсутність стабільних лінійних залежностей між часовими рядами показників знижує ефективність використання методів лінійного трендового аналізу, регресійного моделювання або кореляційних оцінок. Висока варіативність та нерівномірність траєкторій розвитку підприємств ускладнює побудову достовірних прогнозів на основі класичних підходів. Додаткову складність становить неоднорідність вибірки підприємств за масштабом, ринковою спеціалізацією та інноваційною стратегією, що ускладнює побудову типових сценаріїв розвитку. Отримані результати підтверджують необхідність перегляду існуючих методичних підходів до оцінювання конкурентоспроможності та впровадження

альтернативних, більш гнучких статистичних методів, здатних враховувати багатовимірність, нелінійність та нерівномірність процесів формування конкурентних переваг у часі.

Keywords: *competitiveness, innovation-oriented enterprises, statistical approach, statistical methods, regression analysis, indicators, dynamics, forecast, ranking.*

Ключові слова: *конкурентоспроможність, інноваційно-орієнтовані підприємства, статистичний підхід, статистичні методи, регресійний аналіз, показники, динаміка, прогноз, рейтинг.*

Problem statement. In today's world of economic globalization, accelerated digitalization, and the growing role of knowledge as a key production resource, the innovative activity of enterprises is becoming a determining factor in their competitiveness. Increased competition in both domestic and foreign markets, as well as the need for constant updating of products, technologies, and business models, raise the issue of effectively measuring the competitive advantages of innovation-oriented enterprises.

However, in practice, the process of assessing their competitiveness faces a number of problems: the lack of a unified methodology, the complexity of measuring intangible assets, innovation potential, and innovation performance, the heterogeneity of data sources, and the lack of representative information. Standard approaches, which focus primarily on financial indicators, do not take into account the specifics of innovative development and do not allow for the identification of underlying trends in the strengthening or loss of an enterprise's competitive position in the innovation sphere. In this regard, there is a need to introduce statistically sound approaches to assessing competitiveness that combine objectivity, accuracy, adaptability to a dynamic environment, and meet the requirements of scientific validity. Such an approach should be based on modern methods of statistical analysis that allow for a systematic assessment of both

external and internal factors of competitiveness, in particular those related to innovative activity.

Despite the existence of a strong theoretical basis, the question of choosing an assessment method for enterprises, in whose activities a significant number of processes can be reliably assessed using quantitative parameters, remains open, due to the specificity of the documentation used, since it is difficult to obtain an analytical picture of the current situation. When processing data from such business entities, there is a problem of using financial reporting data to forecast the level of competitiveness in the short and long term, especially when attempting to apply a comprehensive approach to assessment. Special approaches must also be applied to the analysis of innovation-oriented enterprises, since the number of security documents is often used for their analysis, but the duration of obtaining each such document can take up to several years, which will also affect the relevance of data on the current formation of competitive advantages.

Analysis of recent research and publications. Methodological aspects of assessing the competitiveness of an enterprise are the subject of research by many scientists [6-9; 11; 15]. The assessment of corporate competitiveness is typically conducted from multiple dimensions.

Many scholars have used financial indicators to evaluate competitiveness, with common dimensions including profitability, solvency, operational efficiency, and sustainability. Liu H., Wu S., Zhong C. and Liu Y. [10] found that profitability and operational efficiency are key determinants of corporate competitiveness through an analysis of financial data from China's manufacturing enterprises. However, this study did not fully account for the impact of external market conditions, potentially leading to an overemphasis on financial metrics. In addition to financial perspectives, strategic choices are also crucial factors influencing corporate competitiveness.

Wang F. and Huang Z. examined the IT industry and argued that technological innovation, market segmentation, and brand development are essential to enhancing competitiveness. However, this research is limited to the IT

sector, and its findings may not be applicable to other industries, particularly those that do not prioritize technological innovation. Furthermore, market positioning and brand influence have always been central to many studies.

Zhang S., van Doorn J. and Leeftang P.S.H. [16] explored China's consumer goods industry, highlighting the importance of brand value and market share in driving corporate competitiveness. Although this study provides valuable insights for the consumer goods industry, its applicability to other industries may be limited. Numerous studies indicate that the assessment of corporate competitiveness involves various dimensions such as financial performance, strategic positioning, brand building, and sustainability [10; 15-16].

Each study has its own focus and limitations, reflecting the complexity of the field. Therefore, our research will focus on evaluating corporate competitiveness from four dimensions: profitability, solvency, operational efficiency, and growth potential. We aim to use this framework to conduct a comprehensive evaluation of the financial stability, market operational efficiency, debt management, and long-term sustainability of enterprises. Through a comparative analysis of relevant financial data from 2014 to 2024, this paper systematically observes the competitive potential of the sample enterprises over the past decade, achieving a comprehensive evaluation of their overall strength. This multidimensional approach not only reveals the current competitive advantages of the enterprises but also helps to identify potential risks and areas for improvement, providing clear direction for future development. Ultimately, the findings will provide valuable data support and practical insights for strategic decision-making within the enterprises.

The purpose of the article. The purpose of the article is to assess the competitiveness of innovation-oriented enterprises based on a statistical approach. Achieving this goal involves analysing enterprise data using quantitative indicators, which can be used to form an understanding of the current ability of enterprises to create competitive advantages.

Main findings. Five innovation-active companies were selected for further analysis: BOE Technology Group Co., Ltd (BOE) [2]; BYD Company Limited (BYD) [3]; East Money Information Co., Ltd. (East Money) [4]; Midea Group Co., Ltd (Midea) [12]; TCL Technology Group Corp. (TCL) [13].

Based on the analysis of annual reports of these companies, key aspects of their activities that determine their competitiveness were examined, in particular: solvency, operational efficiency, profitability, and growth potential. Each aspect was assessed using several quantitative indicators that have analytical and predictive value. Table 1 shows the structure of the analysis.

Table 1. Summary table of enterprise performance aspects analysis

Performance aspect	Indicator	Importance for competitiveness assessment	Calculation formula
Solvency	Current ratio	Indicates short-term liquidity and financial risk	<i>Current assets / Current liabilities</i>
	Debt-to-asset ratio	Reflects the level of financial leverage and ability to self-finance	<i>Total liabilities / Total assets</i>
Operational efficiency	Accounts receivable turnover	Measures the speed of receivables collection and cash flow efficiency	<i>Revenue / Average accounts receivable</i>
	Inventory turnover	Indicates efficiency of inventory management and asset liquidity	<i>Cost of Goods Sold / Average Inventory</i>
	Total asset turnover	Shows how efficiently assets are used to generate revenue	<i>Revenue / Total assets</i>
Profitability	Operating profit margin	Reflects profitability of core operations	<i>Operating profit / Revenue</i>
	Return on total assets (ROA)	Measures how efficiently assets generate net income	<i>Net income / Total assets</i>
Growth potential	Operating revenue growth rate	Indicates the pace of revenue expansion	$((Revenue_t - Revenue_{t-1}) / Revenue_{t-1}) \times 100\%$
	Total asset growth rate	Shows dynamics of asset base expansion	$((Assets_t - Assets_{t-1}) / Assets_{t-1}) \times 100\%$

Source: completed by authors

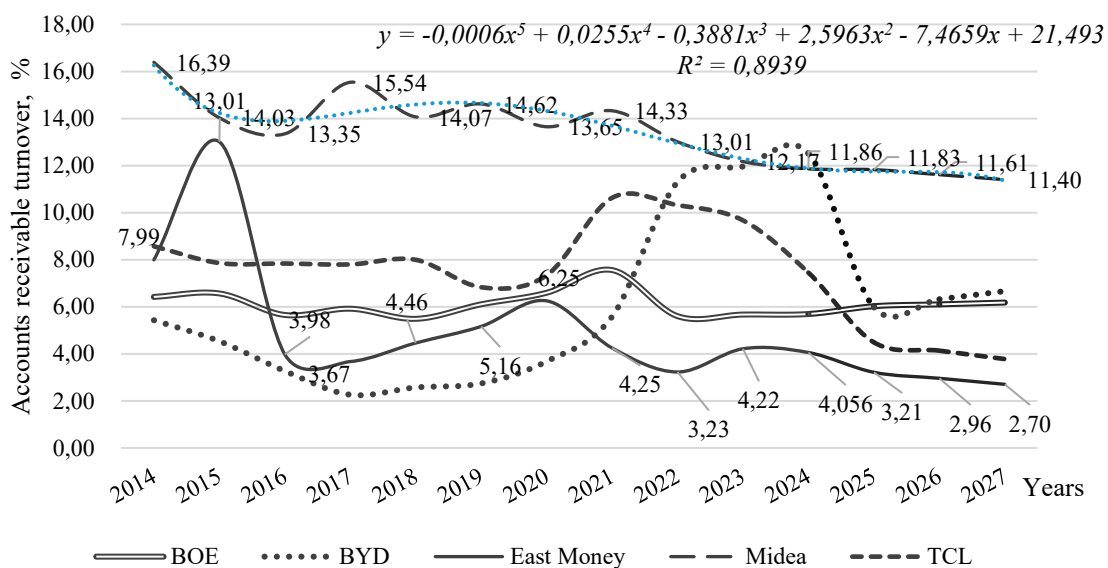


Fig. 1. Dynamics and forecast of accounts receivable turnover for five innovation-oriented enterprises for 2024-2027, %

Source: completed by authors based on [5; 14]

Figure 1 illustrates the change in accounts receivable turnover at five innovation-oriented companies for the period 2014–2024 and forecast values until 2027. The visualisation shows significant differentiation in both the levels of the indicator and its trajectory of change. BYD and Midea are characterised by relatively high efficiency in managing accounts receivable, while BOE and East Money show consistently low values for this indicator. The forecast curves do not confirm the existence of monotonic or linear trends – the forms of polynomial regressions indicate the presence of complex, unstable dynamics.

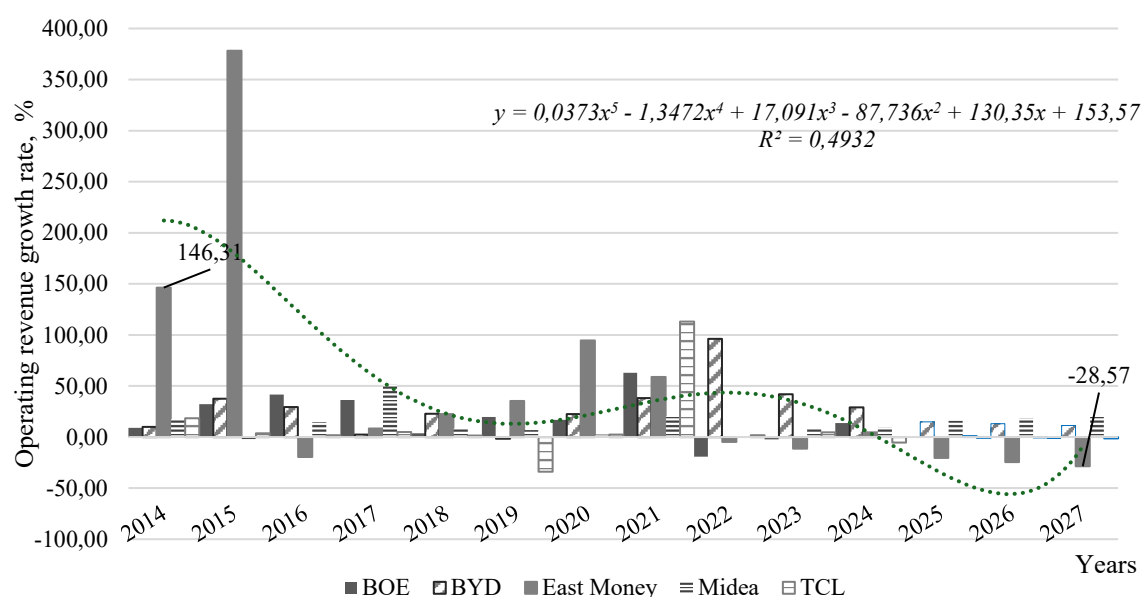


Fig. 2. Dynamics and forecast of operating revenue growth rate for five innovation-oriented enterprises for 2024-2027, %

Source: completed by authors based on [5; 14]

Figure 2 reflects fluctuations in the annual growth rate of income from core activities, which is an integral indicator of a company's development. The dynamics of individual companies show both a phase of decline (e.g., BOE and East Money) and a phase of intensive growth (e.g., BYD), indicating a high degree of variability. The forecast values are distinctly uneven, and the trajectories of change are polynomial functions with several local extrema, which excludes the possibility of describing the data using standard trend or linear models.

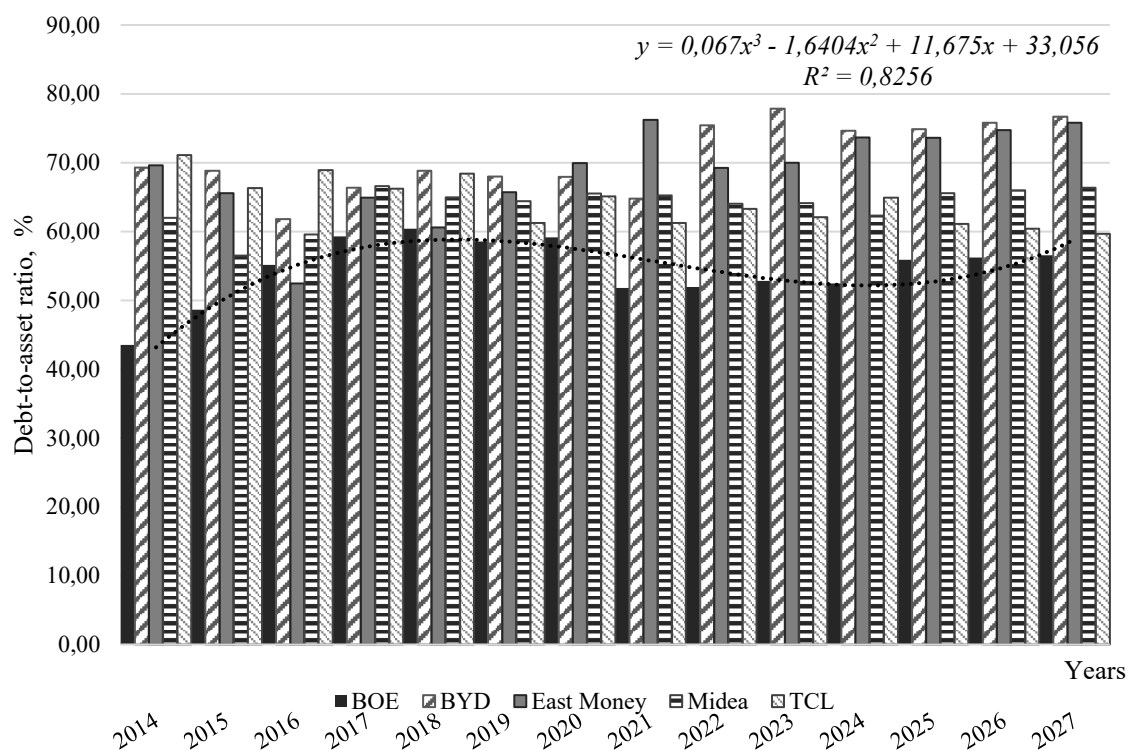


Fig. 3. Dynamics and forecast of debt-to-asset ratio for five innovation-oriented enterprises for 2024-2027, %

Source: completed by authors based on [5; 14]

Considering Figure 3, it is possible to assume that different enterprises demonstrate different strategic approaches to financing: BYD is characterised by a gradual increase in borrowed capital, while BOE maintains a consistently low level of financial leverage. The forecast curves are distinctly non-linear, with bends and inflection points, indicating a complex transformation of the capital structure over time.

The visualization results presented in Figures 1–3 indicate the absence of stable monotonic trends and linear dependencies both in terms of time and in inter-company comparisons. The dynamics of key competitiveness indicators are non-linear, variable and structurally heterogeneous, which makes it impossible to effectively apply traditional statistical analysis tools, in particular correlation and regression models. The trend lines determined using the Excel software environment are polynomials of the third to fifth degrees, which only confirms the

heterogeneity of the data. Given that the use of polynomials higher than the second degree to describe economic trends is not appropriate, it should be assumed that there are no clear trends that would make it possible to obtain adequate forecasts of enterprises' activities in the long term.

In this context, there is a need to use alternative, flexible methodological approaches, in particular: composite indexing methods considering weighting coefficients; cluster analysis to identify groups of enterprises by type of dynamics; non-parametric statistical methods that are not based on the assumption of linearity or normality of distribution.

Therefore, studying the competitiveness of innovation-oriented enterprises requires a multi-criteria approach that considers the complexity of the relationships between indicators, the dynamic influence of the external environment, and the specifics of industry strategies. Such an approach can provide a more relevant and adaptive assessment of competitive potential in the modern economy.

According to the general methodology chosen for further research, first, we perform a weighted average calculation of each company's data over the past 10 years to obtain a single value for each company. Then, for each primary dimension, the scores are calculated by multiplying each secondary indicator by its corresponding weight (see Table 2, formulas (1-4)).

After calculating the scores for each primary dimension, we further multiply each primary dimension score by its respective weight to derive the final composite score for each company. According to the Celtic Model, the weights for the primary dimensions are allocated as follows: profitability indicator – 35%, solvency indicator – 25%, operational efficiency indicator – 25%, and growth potential indicator – 15%.

Table 2. Summary table of competitiveness indicators calculation

№	Complex indicator	Formula	Explanation
1	Profitability indicator	$P = 0,5 * OPM + 0,5 * RTA$ (1)	P – a complex profitability indicator; OPM – operating profit margin; RTA – return on total assets.
2	Solvency indicator	$S = 0,5 * DAR + 0,5 * CR$ (2)	S – a complex solvency indicator; DAR – debt-to-asset ratio; CR – current ratio.
3	Operational efficiency indicator	$OE = 0,33 * IT + 0,33 * ART + 0,34 * TAT$ (3)	OE – a complex operational efficiency indicator; IT – inventory turnover; ART - accounts receivable turnover; TAT – total asset turnover.
4	Growth potential indicator	$GP = 0,5 * CORG + 0,5 * TAG$ (4)	GP – growth potential; CORG – core operating revenue growth rate; TAG - total asset growth rate.

Source: completed by authors

Therefore, we measure competitiveness for the five companies using the following formula:

$$CS = 0,35 \cdot P + 0,25 \cdot S + 0,25 \cdot OE + 0,15 \cdot GP, \quad (5)$$

where

CS – comprehensive competitiveness score; P - profitability score; S - solvency score; OE - operational efficiency score; GP - growth potential score.

By substituting the specific values into this formula, we obtain the final scores and rankings of the five companies, as shown in Table 3.

Table 3. Ranking of sample enterprises based on competitiveness indicators

Company Name	P	OE	S	GP	CS	Rank
Midea	0,024	1,735	0,233	0,007	2,000	1
TCL	0,011	1,425	0,215	0,018	1,669	2
BOE	0,011	1,051	0,299	0,016	1,375	3
East Money	0,226	0,622	0,268	0,039	1,154	4
BYD	0,021	0,837	0,199	0,038	1,095	5

Source: completed by authors

The analysis of profitability, operational efficiency, solvency and growth potential showed that Midea ranks first in the overall assessment. BYD, on the other hand, ranks last in the overall assessment. Taking into account weaknesses

such as relatively low operational efficiency will contribute to a more rapid strengthening of this company's competitive potential.

Based on the ratings obtained, we can conclude that the companies analyzed have significant untapped potential, especially in terms of financial stability and resource optimization. Therefore, further research will focus on studying the competitive reserves of each company by identifying untapped potential and areas for improvement, which will form the basis for further strategic optimization of their activities.

Conclusions. A study of the quantitative performance indicators of innovation-oriented enterprises showed that none of these enterprises has an absolute advantage that would determine a leading competitive position in the market. Midea's relative leadership is due to the fact that this company is characterized by stable operational efficiency indicators and a balanced financial structure, but even under these conditions, there is no dynamic growth. At the same time, despite its relatively low performance indicators, BYD stands out for its high growth potential, which in the strategic perspective may contribute to the expansion of its activities and sustainable economic development. Thus, competitiveness is a multidimensional and dynamic characteristic of an enterprise, which is quite difficult to reduce to a single aggregate indicator. Nevertheless, a significant number of existing studies highlight precisely such approaches aimed at aggregate calculations and additive models.

Among the key analytical challenges identified in the study, it is worth highlighting the limitations of traditional statistical methods in assessing the competitiveness of innovation-oriented enterprises. First, the absence of linear dependencies between time series of indicators makes it impossible to use linear trend or correlation analysis methods to draw general conclusions. Most indicators have non-linear, oscillatory or multi-phase dynamics that cannot be adequately modelled using classical methods.

Secondly, differences in the time horizons for the formation of various competitive advantages complicate direct comparisons between enterprises. For

example, solvency can change quickly, while the effects of innovative investments show up a few years later. This creates asynchrony in the dynamics of indicators, which reduces the usefulness of comparing companies at the same time using static indicators. In this context, it is promising to transition to adaptive statistical approaches that involve the use of: dynamic panel models capable of accounting for the temporal unevenness of effects; cluster analysis, which allows enterprises to be grouped not by performance levels, but by the similarity of their trajectories of change; composite indexing methods that combine multiple criteria, taking into account their weight and impact in the context of industry specifics.

Further improvement of the methodology for statistical assessment of competitiveness requires the development of flexible, multi-level and time-sensitive models that will ensure a correct comparison of enterprises in a dynamic environment. Thus, competitiveness assessment should be based on a comprehensive, adaptive and situationally sensitive methodology that takes into account not only financial parameters, but also strategies, industry dynamics, innovation activity and the external environment.

A promising area for further research is the identification of internal reserves of competitiveness of enterprises by identifying unrealised potential and areas for improvement, which will form the basis for subsequent strategic optimisation.

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