Heuristic Approaches to Studying the Dynamics of Economic Development for Resource Allocation in Crisis Management

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Abstract

Economic systems operating under high uncertainty, particularly during wartime disruptions, require robust analytical and forecasting instruments to support objective and timely resource allocation decisions within crisis management. This study aims to improve the methodological approaches and analytical toolkit for forecasting and analysing the dynamics of economic development in order to substantiate resource allocation decisions at the level of an economic entity. The research is based on statistical data describing the performance of the analysed object over the pre-war and wartime period of 2006–2024. The methodological framework integrates principles of systems analysis, multivariate statistical techniques for data collection, structuring and processing, expert judgement, and heuristic reasoning to establish the system–logical relationships among the parameters used to construct the initial analytical database. Expert assessments and a set of coefficients (indicators) were developed to operationalise the taxonomic method, enabling the calculation of an integral criterion of economic development. Furthermore, a correlation–regression forecasting model was developed to quantify the strength of relationships among factors and to rank their significance in explaining variations in the economic development index. The findings demonstrate that the proposed modelling framework provides a consistent analytical basis for forecasting economic development dynamics as a function of internal changes in liquidity, solvency, profitability and financial stability indicators, thereby increasing the objectivity and resilience of managerial decisions on resource allocation. The study contributes to the literature by advancing heuristic and data-driven approaches to modelling economic development dynamics under crisis conditions, with particular emphasis on the integration of taxonomic analysis, expert-based indicator construction, and econometric forecasting. The proposed tools may be applied in the practice of crisis management to enhance decision-making in resource distribution and may serve as a foundation for further research incorporating stochastic components and scenario-based analysis.

Key words

forecasting, analysis, economic development, crisis, taxonomy, model, resources.

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Introduction

Assessing the current state and prospects of Ukraine's European integration, it should be acknowledged that the sustainable development of the national economy largely depends on the depth of structural transformations in the economic and technological sphere, the rationality of regional and sectoral division of labour, and the level of human capital capacity (Rohoza et al., 2019). Under conditions of expanding external economic relations and intensifying competition, issues related to improving the effectiveness of economic systems management and ensuring their adaptability to a changing environment become particularly relevant.

The utilisation and enhancement of the potential of economic entities is primarily oriented towards stimulating not only high-technology, export-oriented production, but also the modernisation of industrial sectors in general, taking into account the influence of external environmental factors in both the operational and strategic horizons. In this context, the development of management systems, the application of innovative big data analytical instruments under the digital transformation of the economy, as well as business process optimisation, are considered key elements in strengthening the competitiveness and economic security of business entities. These circumstances determine the necessity of continuous scholarly reflection and further improvement of analytical and forecasting methods employed within management systems.

Accordingly, the role of systemic analysis principles increases in addressing research and forecasting tasks related to the dynamics of socio-economic processes, as well as in substantiating managerial decisions. Contemporary development of systemic analysis implies its rational integration with heuristic hypotheses, enabling the combination of human expert capabilities with advanced computational tools. The scholarly literature emphasises the importance of heuristic approaches grounded in professional intuition, experience, and expert knowledge, which is particularly critical for solving tasks characterised by goal ambiguity and inconsistency, uncertainty, and incompleteness and inaccuracy of initial information. Heuristic methods make it possible to complement missing data through the formulation of well-grounded hypotheses, thereby enabling solutions to a wide range of systemic tasks, including the analysis and forecasting of critical and emergency situations in technological, environmental, and socio-economic processes. A practical instrument for addressing such tasks is the use of expert knowledge to establish priorities, assess influencing factors, and anticipate possible scenarios of future developments.

The relevance of investigating heuristic approaches to forecasting and analysing the dynamics of economic development in the context of substantiating resource allocation decisions is explained by the fact that the effective functioning of economic systems under turbulence and high uncertainty largely depends on the reliability of development forecasts. In the presence of military risks and systemic shocks, the need increases for instruments that enhance the validity and resilience of managerial decisions related to the distribution of scarce resources. Within this study, a methodological approach is proposed that combines expert assessments in constructing a system of parameters (indicators) reflecting the interrelations of key financial and economic performance measures with the development of an economic-mathematical forecasting model based on correlation–regression analysis. The application of this integrated toolkit enables the identification of the strength and direction of factor impacts on the economic development index of the analysed entity, thereby improving the quality of managerial decision-making.

Additionally, it should be noted that under a market economy, further intensified by the heightened uncertainty of wartime conditions, the analysis of performance outcomes and their forecasting require a comprehensive application of methods for modelling the dynamics of economic development. Addressing this task is complicated by the instability of both the external and internal environment, which necessitated the examination of an extended retrospective period covering both pre-war and wartime stages (2006–2024). This made it possible to form the initial data matrix and to calculate the integrated Economic Development Index of the analysed economic entity.

The structure of the article comprises several interconnected sections. The Literature Review analyses contemporary scholarly approaches to examining economic development dynamics and substantiating resource allocation decisions under uncertainty; the identified research gaps provided the basis for formulating the aim and objectives of the present study. The Methodology section outlines the logic of the proposed methodological toolkit, including the justification of the indicator system and the sequence of applying expert judgement, the taxonomic approach, and correlation–regression modelling. The Research Results section presents the outcomes of calculating the integrated Economic Development Index, assessing the influence of key factors, and forecasting the development dynamics of the object under study. The Discussion section interprets the obtained results, specifies the study limitations, and considers possible avenues for addressing them. Finally, the Conclusions section summarises the main findings, outlines practical implications, and identifies directions for further research aimed at advancing the proposed approach.

1. Literature review

Within the scope of this study, approaches to revealing the essence of heuristic methods for forecasting and analysing the dynamics of economic development are examined in the context of substantiating resource allocation decisions under crisis management conditions. The application of heuristic approaches in managing growth and development processes of economic entities remains a methodologically complex task due to the multifactorial nature of socio-economic systems, the inherent contradictions in management objectives, the incompleteness and inaccuracy of initial information, as well as the turbulence of the external environment. This актуализes the need to systematise research addressing the role of innovative and technological development in shaping economic process transformations, as well as to identify effective methods for the formation and evaluation of managerial decisions, including project-based approaches.

Contemporary research on the management of complex socio-economic systems demonstrates a steady trend towards expanding the methodological toolkit applied for diagnosis, forecasting, and substantiation of managerial decision-making. In particular, a number of studies emphasise the importance of developing indicator systems and determining threshold values of security-related parameters, which provides the basis for strategic planning under uncertainty and crisis challenges (Kharazishvili & Kwilinski, 2022; Kharazishvili et al., 2025a, 2025b). Overall, the existing scientific literature outlines several key research streams that are directly relevant to the topic of this article.

Heuristic methods are commonly interpreted as an analytical toolkit aimed at obtaining well-grounded decisions in weakly structured situations where the construction of a strict deterministic model is infeasible or where complete baseline data are unavailable. Methodologically, the heuristic approach implies the active use of expert knowledge, iterative refinement procedures, and flexible combinations of formalised and non-formalised methods. Management research highlights that under uncertainty the effectiveness of decision-making increases when methods of systemic analysis are rationally integrated with heuristic assumptions.

A comparison between idiographic and nomothetic approaches to scientific inquiry in management confirms the necessity of combined research strategies that simultaneously account for the unique features of an object and identify patterns of a more general nature (Dzwigol, 2022). In the context of enterprise development, the application of iterative signal processing and forecasting procedures is of particular importance, enabling anticipatory management of industrial enterprise development (Kamińska, 2018). Consequently, heuristic approaches provide a methodological foundation for forming decisions under conditions of incomplete information and high environmental dynamism.

A distinct strand of the literature is associated with the development and advancement of time-series forecasting methods, including cases with seasonality, trends, and instability in indicator behaviour. Classical exponential smoothing models are regarded as fundamental instruments for forecasting seasonal components and trends, maintaining their relevance both for applied tasks and as a baseline level for model comparison (Holt, 2004). At the same time, contemporary studies increasingly focus on the robustness of forecasts under abrupt deviations and large forecast errors, which is particularly typical of crisis periods (Castle et al., 2025).

A substantial body of research has evolved around integrating econometric approaches with deep learning methods in order to improve the predictive accuracy of financial and economic indicators. In particular, comparisons between deep learning and econometric techniques in forecasting daily returns demonstrate the potential of machine learning when the forecasting problem is correctly specified and appropriate evaluation criteria are applied (Berger, 2026). This has contributed to the formation of a methodological basis for constructing forecasting models of economic development dynamics using historical data while explicitly accounting for instability factors.

Research on the application of artificial neural networks (ANNs) in forecasting and managerial decision support represents one of the most rapidly developing directions. Early studies demonstrated the value of neural network models for forecasting and decision-making tasks, highlighting their advantages in capturing non-linearities and complex dependencies (Hill et al., 1994). Subsequently, the state of the art in ANN-based forecasting was synthesised, including a systematic discussion of architectures, training procedures, and practical limitations of implementation (Zhang et al., 1998).

In contemporary practice, artificial intelligence (AI) and machine learning methods are also applied to assess resource security and the sustainability of enterprise functioning. In particular, modelling enterprise resource security using ANNs demonstrates the feasibility of integrating digital methods into managerial analytics of resources and risks (Pankova et al., 2023). Studies forecasting entrepreneurial and employability opportunities based on the analysis of government financial parameters likewise confirm the relevance of AI-based approaches for examining the development dynamics of socio-economic systems (Gherbi et al., 2024). Under post-crisis recovery conditions and in ensuring supply chain resilience, particular attention is paid to machine learning methods as instruments for strengthening resilience and accelerating the recovery of operational processes (Sakthi Balan et al., 2025; Salamian et al., 2024).

A significant group of studies focuses on the construction of indicator systems and the methodology for determining threshold values of security-related parameters, enabling the quantitative assessment of stability and admissible operational boundaries of socio-economic systems. The methodology for identifying threshold values of national security indicators using AI methods enhances the formalisation of expert assessments and improves the reproducibility of results (Kharazishvili & Kwilinski, 2022). The expansion of indicator systems for the environmental component of sustainable development in the security dimension provides an analytical basis for integrated assessment of systemic changes and risk monitoring (Kharazishvili et al., 2025b).

Within the analysis of macro-level factors, particular interest is associated with studies that quantitatively assess the impact of innovation-driven supply factors on economic growth and innovation-development security, demonstrating both the magnitude of effects and their significance for ensuring resilience (Kharazishvili et al., 2025a). Related research emphasises the non-linear nature of the impact of digital technological development on CO_2 reduction, thereby confirming the need to account for non-linearities and structural shifts when modelling development dynamics (Kwilinski, 2024). In a broader context, the integration of AI into the analysis of energy-system security highlights paradoxical and non-linear development patterns under sustainability conditions (Kwilinski, 2025).

Resource allocation issues are addressed in contemporary literature as a key element for enhancing efficiency and ensuring sustainable development, particularly under external shocks. Empirical research on resource allocation efficiency in infrastructure projects confirms that the effectiveness of economic development largely depends on the quality of coordination of investment flows and managerial mechanisms for allocating scarce resources (Bu et al., 2021). At the enterprise level, a systemic understanding of linkages between operational processes and financial outcomes becomes essential, as it strengthens economic sustainability and supports managerial decision-making oriented towards long-term performance (Jin et al., 2017).

From the perspective of organisational sustainability under external disturbances, the challenge of resource management becomes increasingly salient as a determinant of adaptation and competitiveness preservation. Specifically, evidence on the influence of external shocks on organisational resources indicates that development resilience largely depends on a firm's ability to transform innovation and digital competences into actionable managerial solutions (Soluk, 2022). Under post-crisis recovery conditions and supply chain disruptions, the role of data-driven analytical instruments increases, as they support resilience maintenance, risk assessment, and enhanced effectiveness of process recovery (Salamian et al., 2024; Sakthi Balan et al., 2025). This reinforces the need to develop methodological tools capable of integrating resource assessment, development dynamics, and external environmental uncertainty.

The substantiation of resource allocation decisions is closely linked to project-oriented development management logic and the formation of competitive business models. Studies on growth strategies and competitive advantage demonstrate that innovativeness in marketing and business plans determines the quality of managerial decisions regarding development directions and resource distribution (Vaníčková & Szczepańska-Woszczyna, 2020). Similarly, business model development in retail is considered a process in which resource allocation across model components requires systematic optimisation and adaptive management (Kita et al., 2023).

Further advancement of this problem field is associated with rethinking sustainable growth models in the context of the circular economy. A review of methodologies for assessing circular economy business models emphasises that life-cycle and life-cycle-based approaches expand the toolkit for evaluating decision consequences and refining the efficiency criteria for resource allocation (Filippi et al., 2025). However, the majority of the reviewed studies predominantly focus on institutional or applied aspects of project and business model management, whereas the methodological integration of indicator-based assessments of economic development with forecasting models designed to support resource allocation under crisis conditions remains insufficiently addressed.

For the construction of integrated indices of economic development, the advancement of multidimensional analysis and observation classification methodology is of substantial importance, as it enables the systematisation of indicators and the formation of a robust informational basis for analytical calculations. Classical approaches to multidimensional classification emphasise the significance of appropriate feature selection, normalisation procedures, and data aggregation techniques when constructing composite indicators (Aivazian et al., 1974). These methodological principles provide the foundation for the subsequent application of taxonomic methods and the development of economic development indices based on an indicator system.

At the same time, in practice the formation of the indicator base requires a heuristic component–namely, expert-driven specification of the indicator set and their weights, ensuring the substantive interpretability of the resulting integrated criterion. This approach is consistent with studies focused on determining threshold values of security-related indicators and constructing indicator systems that reflect the complex nature of sustainable development and economic security (Kharazishvili & Kwilinski, 2022; Kharazishvili et al., 2025b).

Contemporary research on uncertainty in resource management tasks demonstrates significant progress in optimisation methods that incorporate interval, fuzzy, stochastic, and probabilistic constraints. One approach to decision formation in weakly structured conditions involves the application of selection criteria oriented towards minimising time, maximising income, or other target performance measures, which implies formulating an optimisation problem and selecting an appropriate mathematical form of the objective function. Under high uncertainty, hybrid formalisations are frequently employed, combining probabilistic elements with heuristic criteria.

A representative example is the use of the Hurwicz criterion in two-stage resource management planning models, which enables risk and uncertainty to be incorporated into managerial decision-making (Zeng et al., 2014). Interval double-sided chance-constrained modelling approaches are likewise applied to assess development sustainability under uncertainty and to support decision-making based on spatial analysis (Jia et al., 2020). Despite the substantial methodological value of these studies, most contributions are oriented towards sector-specific tasks (in particular, natural resource management), whereas methodologically comparable logic for substantiating resource allocation decisions in relation to the economic development of business entities remains insufficiently elaborated.

An additional methodological dimension of the problem under consideration is associated with the selection of statistical and modelling tools that ensure the validity of interpreting relationships between latent and observed variables. In forecasting and socio-economic analysis research, the choice between alternative approaches to structural modelling–particularly covariance-based structural equation modelling (CB-SEM) and partial least squares structural equation modelling (PLS-SEM)–remains subject to discussion. Comparative analyses of these methods demonstrate differences in underlying assumptions, data requirements, and the admissibility of their application to socio-economic research and technological forecasting tasks, thereby establishing a methodological basis for the justified selection of tools when constructing analytical and forecasting models (Dash & Paul, 2021). This is particularly relevant for tasks aimed at developing robust managerial decisions under uncertainty, where it is necessary to align measurement quality, information completeness, and method applicability to empirical datasets.

From a methodological perspective, it is important to emphasise that heuristics as a research principle are widely applied not only in economics and management, but also across applied disciplines where process formalisation is constrained by dynamic complexity and multiple limitations. The use of heuristic reasoning as a means of simplifying and interpreting complex patterns is demonstrated in a number of fundamental works, in which heuristics serve as a basis for constructing explanatory models and formulating hypotheses in the analysis of complex processes (Hassani, 2017). Similarly, in engineering problems of trajectory planning and the optimisation of system development management, heuristics-oriented approaches are employed that combine formal dynamic models with empirically grounded rules to achieve objectives under resource and power constraints (Ordonez et al., 2025). Accordingly, the heuristic approach may be regarded as an interdisciplinary methodological resource relevant to crisis management and decision support under conditions of limited data availability and high turbulence.

In parallel, a research stream is developing that focuses on universal algorithmic instruments and data structures that enable scalable solutions for information processing and the design of analytical procedures. Considering heuristics as part of algorithmic support and decision-making procedures confirms the applicability of heuristic design principles to modelling and forecasting tasks, where computational complexity and the processing of large data volumes constitute critical constraints (Wiener, 2022). This aspect becomes particularly important when integrating expert assessments, multidimensional indicators, and econometric procedures within a unified analytical mechanism designed to support resource allocation decisions.

A research stream substantively close to the topic of this article concerns the efficiency and determinants of sustainable productivity, particularly in the context of "green" total factor productivity. Identifying key drivers and quantitatively assessing the determinants of efficiency confirms the importance of multifactor analysis, which is methodologically consistent with the logic of correlation–regression modelling and ranking factors by the strength of their effects on the outcome development indicator (Xu et al., 2024). Accordingly, these studies provide both empirical and methodological foundations for refining procedures used to evaluate factor impacts on an integrated Economic Development Index in tasks aimed at substantiating resource allocation decisions.

Overall, the literature review indicates that contemporary research offers a broad spectrum of tools for modelling, forecasting, and optimising decisions under risk and uncertainty, including structural modelling approaches, interdisciplinary heuristic principles, and multifactor efficiency assessment. However, existing approaches generally do not provide a coherent methodological integration of (i) expert-based indicator formation, (ii) construction of an integrated development index (particularly of a taxonomic nature), and (iii) econometric modelling of influencing factors within a unified logic of substantiating managerial decisions on resource allocation in crisis management. This limitation strengthens the relevance of developing the integrated heuristic–analytical toolkit proposed in this article.

The synthesis of the reviewed literature makes it possible to identify several research gaps that remain relevant in the field. First, despite substantial progress in forecasting and modelling socio-economic dynamics–including both classical smoothing methods and contemporary econometric and deep learning approaches (Holt, 2004; Berger, 2026; Castle et al., 2025)–the practical integration of forecasting procedures with economic development indicator systems directly oriented towards resource allocation tasks and the robustness of managerial decisions under crisis conditions remains insufficiently explored.

Second, studies on artificial intelligence and neural-network forecasting confirm their capability to detect non-linearities and complex relationships in data (Hill et al., 1994; Zhang et al., 1998; Pankova et al., 2023). Nevertheless, the academic literature provides limited comprehensive methodological solutions that combine expert-driven indicator construction, the calculation of an integrated development criterion (including multidimensional aggregation), and subsequent econometric modelling of factor influences within the decision-support logic for resource allocation management. Moreover, the problem of selecting and aligning appropriate analytical instruments–including the comparability of measurement models, the validity of relationship estimation, and data requirements–remains debatable and requires further methodological justification (Dash & Paul, 2021).

hird, studies addressing resource allocation efficiency, project-based approaches, and business model development provide a substantial contribution to understanding organisational and institutional mechanisms of growth and competitiveness (Bu et al., 2021; Jin et al., 2017; Vaníčková & Szczepańska-Woszczyna, 2020; Kita et al., 2023; Filippi et al., 2025), while also confirming the role of the factor structure of efficiency and the determinants of sustainable development (Xu et al., 2024). However, these studies generally do not offer a universal integrated instrument that simultaneously combines heuristic principles of parameter formation, indicator-based taxonomic assessment of economic development dynamics, and formalised forecasting of influencing factors to support resource allocation decisions in crisis management.

In addition, although heuristic reasoning is widely applied in interdisciplinary tasks related to complex system management and decision optimisation (Hassani, 2017; Ordonez et al., 2025), and is also regarded as an important element of algorithmic design and computational implementation of analytical procedures (Wiener, 2022), its integration into economic-mathematical models for resource decision-making under high uncertainty remains methodologically insufficiently developed.

Therefore, despite the substantial number of studies addressing individual aspects of forecasting, indicator-based analysis, and the substantiation of managerial decisions, the research field continues to lack a comprehensive heuristic–analytical toolkit ensuring coherent integration of the following components: (1) expert-driven construction of an indicator system reflecting key characteristics of the socio-economic system's functioning; (2) calculation of an integrated Economic Development Index based on a taxonomic approach and multidimensional aggregation procedures; (3) development of correlation–regression models for quantitative assessment of factor impacts and forecasting of development dynamics; and (4) utilisation of the obtained estimates and forecasts as a formalised basis for substantiating resource allocation decisions under adaptive and crisis management conditions. The absence of a methodologically consistent integration of these elements reduces the reproducibility of analytical procedures and limits the practical applicability of individual methods in managerial decision-making under high uncertainty and environmental turbulence.

The identified research limitations determined the aim of the present study, which consists in improving approaches and instruments for forecasting and analysing the dynamics of economic development in order to substantiate resource allocation decisions in the management of an economic entity, taking into account the analysis and synthesis of the initial conditions of the socio-economic system, as well as the uncertainty of dynamic equations arising from disturbances in its functioning under high instability of the external and internal environment. Particular attention is devoted to adapting both the proposed and existing methods to enhance forecasting accuracy and strengthen the robustness of managerial decisions through the integration of stochastic elements and the application of scenario analysis.

2. Methodology

In the analytical procedures, the objects under study (such as enterprises) were conceptualised as multidimensional entities. Therefore, the following were employed to examine and assess their processes: methods of multivariate analysis; principles of systems analysis; multivariate statistical approaches for designing optimal plans for the collection, systematisation, and processing of multidimensional statistical data aimed at identifying the nature and structure of interrelationships among the components of the multidimensional system under investigation in order to support the allocation and use of development resources; expert knowledge and judgement; and heuristic approaches. The integration of these capabilities was aimed at developing heuristic approaches to forecasting and analysing the dynamics of economic development for substantiating resource-allocation decisions, based on a rational combination of systems analysis principles, expert judgement, modern computational tools, and multivariate analytical methods. This also justifies the application of the taxonomy method of comparative multivariate analysis, which provides a basis for the systematisation of complex systems with a hierarchical structure.

To develop heuristic approaches to forecasting and analysing the dynamics of economic development for substantiating resource-allocation decisions in the management of operational activity and economic development processes (which may be regarded as innovation-oriented), the objectives of the entity (enterprise) should be divided into several directions that, by their nature, comprise both external and internal dimensions. The management tasks of the analysed enterprise included those related to: (i) information and analytical support for managerial decision-making; (ii) working capital formation and renewal of fixed assets; (iii) diagnosing the growth of net revenue; (iv) monitoring inventories of finished goods; (v) asset growth; (vi) changes in current assets, accounts payable, and non-current assets; (vii) the relationship between income growth and the growth rate of expenses; (viii) working capital turnover; (ix) settlements with debtors/accounts receivable; (x) growth of liabilities; and (xi) growth of production inventories.

For a comprehensive assessment and diagnostics, heuristic-type approaches were proposed, implying a combined use of expert elicitation and the taxonomy method. This combination enabled the determination of an integral criterion referred to as the enterprise's economic development index, based on the results of the analysis of the economic object over the period 2006–2024. In other words, by constructing a system of heuristic approaches for the effective study, analysis, and utilisation of information and financial resources, as well as liabilities–which constitutes one of the necessary conditions for successful operation and development in a competitive environment–the study addressed the following objectives in solving the tasks of forecasting and analysing the economic development dynamics of the investigated entity:

– to structure the research tasks in accordance with a systems approach to the development and application of heuristic-type procedures;
– to elicit expert assessments based on specialists' experience;
– to identify and form a system of coefficients (indicators) for constructing the baseline dataset required for the taxonomy method;
– to conduct a taxonomic analysis in order to determine the integral criterion of economic development;

– to substantiate the system-logical relationships among the analysed parameters for calculating the baseline dataset for the taxonomy-based assessment of development;
– to develop a correlation–regression forecasting model of development;
– to assess the strength of relationships among the variables included in the developed correlation–regression model to substantiate resource-allocation decisions by ranking the factors according to their contribution to the economic development index of the investigated entity.

Within the proposed research approach, both theoretical–methodological foundations and applied analytical issues required thorough conceptualisation and resolution in order to enable forecasting of the enterprise's economic development dynamics. In the course of the study, it was considered appropriate to develop a system of coefficients, the number and content of which were determined on the basis of expert assessments. The primary purpose of these coefficients was to characterise the relationships among the key financial and economic indicators of the analysed entity over time. This provided a general methodological and analytical basis for constructing economic and mathematical models using correlation–regression analysis, aimed at identifying the specific effects of individual factors on the economic development index of the enterprise and applying the obtained forecasting results in managerial decision-making, with due regard to the relevant components of the socio-economic system.

However, the ambiguity and inherent risk associated with the mutual influence of socio-economic factors on the economic processes of the analysed entity necessitate the use of a systems approach when developing forecasting frameworks. The complexity of forecasting the development of a socio-economic system (the object of study) is manifested in the impossibility of unambiguously defining inputs and outputs, as the system's response is not necessarily directly linked to an initial stimulus; rather, the system may influence its subsequent changes. In economic systems, the resulting output is affected by factors determined by the internal state of the system, which may be partially unobservable, indicating that system behaviour cannot be explained solely as a reaction to an external input.

Accordingly, when designing approaches to forecasting and analysing the dynamics of economic development for substantiating resource-allocation decisions in management, it is also necessary to account for the fact that a structurally balanced system activates self-organisation mechanisms that enhance its economic resilience. Depending on the selected analytical framework, this may serve as a basis for economic stabilisation of the entity through structural harmonisation associated with the redistribution of the relative influence (weights) of structural elements characterised by different spatio-temporal localisation. Such processes affect the maintenance of a balanced state and may require additional mobilisation and redistribution of resources, as well as material and information costs. This, in turn, necessitates the use of economic and mathematical tools to substantiate the allocation of resources among subsystems when forecasting the development trajectory of the business entity.

The development of an economic entity requires forecasting approaches, analysis of the dynamics of economic development, and substantiation of managerial decisions regarding resource allocation under dynamic and internally contradictory operating conditions. Analytical and information support aimed at achieving forecasting objectives is closely linked to managerial decision-making processes based on diagnostics, assessment of the analytical capacity, forecasting, and planning. The experience of previous studies in the analytical and information dimension of diagnostics and decision-making was used to formulate tasks for experts in order to achieve development forecasting objectives. This made it possible to structure and systematise functional tasks, according to their purpose, into information-related, diagnostic, analytical, forecasting, planning, and decision-making categories. In addition, by applying the principles and approaches of systems analysis to construct the baseline dataset required for conducting a taxonomy-based assessment of economic development, the object of analysis was conceptualised as a system comprising a set of interrelated processes. The outcomes of this approach provided a new interpretative basis through structural analysis, expressed as the relationships between the dynamics of key financial and economic indicators of the socio-economic system's functioning across time and space. Elaboration of the methodological relationships between the dynamics of the elements of the socio-economic system, using statistical performance data for the analysed reporting periods, enables the identification of regularities in resource allocation patterns within anti-crisis management.

The selection of components for the integral indicator required for the taxonomy method was based on the principles of systematicity, comprehensiveness, adequacy, and objectivity. This ensures the identification and evaluation of the influence arising from interrelations among operational parameters on the economic development dynamics, taking into account trends in liquidity, solvency, profitability, and financial stability of the socio-economic system. To this end, approaches to the development of the socio-economic system in accordance with market requirements were analysed. Expert assessments were formed by identifying early manifestations of insufficient provision of material resources within operational turnover, the emergence and deepening of liquidity crisis symptoms, and the need to implement adequate measures to restore liquidity in settlements with debtors/accounts receivable. In this way, factors acting as stabilisers or destabilisers were distinguished across different stages of the socio-economic system's life cycle.

The development of the socio-economic system in accordance with market needs can be traced using the lead–lag coefficient comparing the growth rate of net revenue with the growth rate of finished goods inventories. The emergence of stagnant (slow-moving) products is primarily driven by the mismatch between expanding production volumes and the growth rate of the sales market, which may result from inconsistencies in product assortment, pricing, and quality; a decline in consumers' effective demand; loss of market niches due to competitive pressures; or economically unjustified over-procurement under constrained sales opportunities for various reasons.

At the onset of a liquidity crisis, overproduction becomes a characteristic phenomenon. It initially manifests itself as a more intensive increase in finished goods (merchandise) inventories relative to the growth rate of sales revenue, i.e.:

$$g_I > g_R > 100\% \tag{1}$$

where g_I denotes the growth rate of inventories of finished goods and/or merchandise; g_R denotes the growth rate of sales revenue.

This relationship results from production growth exceeding the growth in sales volumes. In practical terms, this implies that the economic system "produces for stock" due to shortcomings in marketing policy and demand assessment. If appropriate measures aimed at eliminating the causes of sales difficulties are not undertaken at this stage, the decline in the growth rate of net sales revenue gradually transforms into an absolute reduction. At the same time, the tendency for inventories to increase may persist, or their decline may remain insufficiently pronounced.

Such features are typical for the escalation stage of the liquidity crisis and can be formalised as follows:

$$g_I > 100\% > g_R \text{ or } 100\% > g_I > g_R \tag{2}$$

provided that

$$1 > K_{R/I} = \frac{g_R}{g_I} > 0.5 \tag{3}$$

where $K_{R/I}$ is the lead–lag coefficient comparing sales revenue growth to inventory growth.

A further state of this criterion at the stage of crisis unfolding is the situation in which the inventory growth rate exceeds the growth rate of sales revenue by more than two times, i.e.:

$$K_{R/I} = \frac{g_R}{g_I} < 0.5 \tag{4}$$

The onset of a liquidity crisis is characterised by inventory congestion and the attainment of the peak phase of the overproduction crisis. Quantitatively, these phenomena are reflected in a high proportion of stagnant (slow-moving) products (exceeding 50%), as well as in a ratio of the growth rate of sold output to the growth rate of produced output that is below unity. The stabilisation of the overproduction crisis should be achieved through reducing finished goods inventories by entering new sales markets, partial write-offs, reprocessing, utilisation, and other measures. At the same time, re-profiling activities should be implemented in order to align the financial and production potential of the socio-economic system with market demand. As a consequence of such measures, inventories of finished goods (merchandise) decrease while sales volumes increase, which can be formalised by the following condition:

$$K_{R/I} = \frac{g_R}{g_I} > 1 \tag{5}$$

Once an optimal level of inventory is reached–serving as a sales reserve to support stable growth in sales volume–the liquidity crisis may be considered eliminated. Such a state of the socio-economic system is characterised by the following inequality:

$$g_R > g_P > g_I > 100\% \tag{6}$$

where g_P denotes the growth rate of produced output.

Early manifestations of insufficient provision of material resources in operational turnover include: first, a situation in which the growth of current assets due to the prolongation of the production cycle exceeds the growth rate of output; and second, a tendency towards a reduction in working capital resources, primarily in the component of production inventories, even under conditions of increasing work-in-progress. At the same time, at the onset stage of a liquidity crisis, a slowdown in the growth of business activity is observed, which, in the absence of adequate preventive measures, subsequently transforms into a declining trend. Thus, the stage of liquidity crisis build-up is characterised by the following inequality:

$$g_P < g_{WCm} < 100\% \tag{7}$$

where g_{WCm} denotes the growth rate of material working capital.

This comparison indicates that the intensity of the downward dynamics of business activity exceeds the rate of reduction in working capital funds. Moreover, within the latter, not only production inventories but also work-in-progress are reduced. Depending on the duration of the production process, output may temporarily be maintained due to the completion of existing work-in-progress. In the absence of, or with only negligible reserves of, this buffer, output volumes will decline.

It should be noted that at this stage an alternative scenario of liquidity crisis development is possible: while production inventories and/or livestock for fattening decrease, work-in-progress may increase substantially due to shortages of specific types of raw materials or inputs (spare parts, components, semi-finished products, etc.) required to complete production. In such a case, a reduction in business activity will also be observed. Nevertheless, in both scenarios, the above inequality remains valid.

A deepening of the liquidity crisis is reflected in the following relationship between the growth rate of business activity (output) and the dynamics of material working capital:

$$K_{P/WCm} = \frac{g_P}{g_{WCm}} < 0.5 \quad (8)$$

where $K_{P/WCm}$ is the lead–lag coefficient comparing the growth rate of business activity to the relative change in material working capital resources. If the intensity of decline in business activity exceeds the reduction in material working capital by more than a factor of two, the socio-economic system is considered to be at the crisis unfolding stage.

Insufficient provision of operational turnover with the minimum required normative level of inventories characterises the peak stage of the liquidity crisis. This state is evidenced by negligible remaining inventories or their complete absence, lack of work-in-progress, and either incomplete capacity utilisation or full production shutdown, as well as a significant contraction of business activity.

The stabilisation of a liquidity crisis begins with a slowdown in the contraction of material resources in operational turnover and business activity, or with an increase in the latter, i.e.:

$$100\% > g_P > g_{WCm} \text{ or } g_P > 100\% > g_{WCm} \quad (9)$$

As a consequence, an optimal relationship emerges between the rate of change in business activity and material resources in turnover, exceeding unity. This constitutes a basis for restoring the replenishment of the material working-capital base of operations. At this stage, an increase in production output is not a necessary condition; however, such a state of the socio-economic system should not persist for a prolonged period. It may be considered a temporary phenomenon associated with an "injection" of working capital at the initial stage of restoring operational turnover. Subsequently, the following inequality should hold:

$$g_P > g_{WCm} > 100\% \quad (10)$$

This indicates efficient utilisation of the resources invested in operational turnover and corresponds to the features of liquidity crisis elimination.

A key component of an enterprise's current assets is funds tied up in settlements with debtors (accounts receivable). The degree of their mobility determines the enterprise's ability to settle with creditors, affects the volume of net cash flow, and influences the overall liquidity of assets. The examination of the quality of this resource group was therefore selected as the next criterion for assessing a liquidity crisis. It involves identifying the preconditions for the emergence and dynamics of accounts receivable balances that are not repaid within the contractual timeframe (overdue receivables).

An indicator of the onset stage of a liquidity crisis may be defined by the following inequality:

$$g_{AR} > g_R > 100\% \quad (11)$$

where g_{AR} denotes the growth rate of accounts receivable. This implies that the prerequisite for the accumulation of overdue debtor obligations is the fact that the growth of total receivables from customers and clients exceeds the growth in net sales revenue. A decline in net sales revenue is also a plausible scenario. The economic logic of this relationship is that, when accounts receivable grow at a higher rate than sales, the share of trade credit provided increases. This leads to greater dependence of the socio-economic system's functioning on the financial condition of its debtors, while an unjustified expansion of sales through deferred payments reduces the current liquidity of working capital as a whole. Moreover, total receivables increase, thereby raising the potential volume of overdue debt.

The build-up stage of the liquidity crisis is characterised by the fulfilment of one of the following two inequalities:

$$g_R < g_{AR} < 100\% \text{ or } g_{AR} > 100\% > g_R \tag{12}$$

provided that

$$0.5 < K_{R/AR} = \frac{g_R}{g_{AR}} < 1 \tag{13}$$

where $K_{R/AR}$ is the lead–lag coefficient of net sales revenue growth relative to the change in accounts receivable. A common condition in both cases is a reduction in sales revenue. The difference lies in whether accounts receivable increase or decrease simultaneously. A more intensive contraction of sales relative to the decline in receivables is explained by the existence of a persistent (structurally stable) outstanding debt volume, which reduces the mobility of this resource group.

If the first case is characterised by a relative synchrony between fluctuations in sales and debtor obligations, the second variant is less favourable for the enterprise. Specifically, a reduction in net sales revenue accompanied by an increase in accounts receivable indicates a decline in the liquidity of current settlements due to a high share of unpaid deliveries within total shipments, alongside chronic non-payment of debts accumulated in previous periods.

An intensive divergence between the growth dynamics of sales revenue and accounts receivable leads to a relationship in which the lead–lag coefficient falls below 0.5, i.e.:

$$K_{R/AR} = \frac{g_R}{g_{AR}} < 0.5 \tag{14}$$

Such a state of the socio-economic system corresponds to the unfolding stage of the liquidity crisis. If the enterprise does not take active measures to halt the development of the liquidity crisis, mere observation results in the concentration of a dominant share of working capital in overdue accounts receivable (exceeding 50%). Consequently, the liquidity crisis materialises with a characteristic deterioration in the quality of funds tied up in settlements with debtors, as these resources cannot be released into circulation in a timely manner. For a more comprehensive understanding of the reasons for such a situation, it is important to assess the effectiveness of the enterprise's legal claim and litigation management procedures.

The effectiveness of preventive and corrective measures aimed at avoiding liquidity deterioration or restoring the liquidity of funds in receivables may be assessed using the lead–lag coefficient comparing the growth rate of sales revenue with the dynamics of accounts receivable. Specifically, if the following condition holds:

$$K_{R/AR} = \frac{g_R}{g_{AR}} > 1 \tag{15}$$

The transition of the liquidity crisis to the stabilisation (abating) stage is considered complete. It should be noted that this relationship may remain valid even when sales revenue decreases, provided that the decline in accounts receivable is more intensive. This implies that the principal instrument for overcoming this type of crisis is the intensification of debt restructuring efforts and the active management of debtor obligations.

A necessary condition for the lead–lag coefficient is that the following relationship holds:

$$K_{R/AR} = \frac{g_R}{g_{AR}} > 1 \tag{16}$$

which is ensured by satisfying the inequality:

$$g_R > 100\% > g_{AR} \quad (17)$$

This inequality should be maintained until overdue debts are fully eliminated from the accounts receivable structure. Thereafter, the socio-economic system enters the stage of liquidity crisis elimination, which is characterised by the fulfilment of the following condition:

$$g_R > g_{AR} > 100\% \quad (18)$$

At this stage, strict compliance with settlement quality control requirements is essential in order to ensure timely identification of problematic debts and to monitor the causes of accounts receivable growth. When the socio-economic system is at the liquidity crisis elimination stage, an increase in debtor obligations is admissible as a natural outcome of sales market diversification.

A negative phenomenon in the functioning of a socio-economic system is a tendency towards resource contraction, as this indicates the emergence of preconditions for operational decline. Therefore, it is necessary to monitor the dynamics of total assets simultaneously with changes in net sales revenue. The first stage of a liquidity crisis is accompanied by a slowdown in the growth of resources or their decline. Typical causes include depreciation of fixed assets in the absence of their expanded reproduction, depletion of working capital due to inventory consumption without regular replenishment, breaches of contractual obligations by suppliers and customers, and similar factors. At the same time, sales revenue may still display positive dynamics; however, when comparing consecutive growth rates, a substantial deceleration in growth intensity becomes evident. Gradually, this dynamic transforms into a decline in net sales revenue while the tendency towards contraction in the book value of assets persists. These characteristics are typical of an economic system operating at the stage of liquidity crisis build-up.

Changes in this criterion throughout the liquidity crisis cycle may be described through the following inequalities:

1) Stage of emergence:

$$g_R > g_A > 100\% \text{ or } g_A < 100\% < g_R \quad (19)$$

provided that

$$K^R_{acc/dec} < 1 \text{ and } K^A_{acc/dec} < 1 \quad (20)$$

where g_A – growth rate of the enterprise's total assets; $K^R_{acc/dec}$ – coefficient of acceleration (deceleration) of the growth rate of sales revenue; $K^A_{acc/dec}$ – coefficient of acceleration (deceleration) of the growth rate of the book value of assets (balance-sheet value).

2) Stage of escalation:

$$g_A < g_R < 100\% \quad (21)$$

The deepening of the crisis process manifests itself in the fact that the decline in sales revenue becomes more intensive than the reduction in assets, i.e.:

$$100\% > g_A > g_R \quad (22)$$

In this case, it is necessary to calculate the coefficient of lead/lag of the sales revenue growth rate relative to the asset growth rate. Under the specified conditions, its value is lower than 1 but not below 0.5. Within this interval, the liquidity crisis enters the escalation phase, namely:

$$0.5 < K_{R/A} = \frac{g_R}{g_A} < 1 \quad (23)$$

where g_R – growth rate of sales revenue; g_A – growth rate of total assets; $K_{R/A}$ – lead/lag coefficient of sales revenue growth relative to asset growth.

A prolonged persistence of the downward trend in resources, accompanied by a simultaneous contraction in the scale of activity, results in the onset of a liquidity crisis. Such a state of the socio-economic system is characterised by the simultaneous fulfilment of the following inequalities:

$$K_{R/A} < 0.5 \quad (24)$$

which corresponds to

$$100\% > g_A > g_R \quad (25)$$

An indicator of the stabilisation stage of a liquidity crisis is the formation of a positive resource dynamics under accelerated growth in sales revenue, i.e.:

$$0.5 < K_{R/A} < 1 \quad (26)$$

which is achieved when either

$$g_A > g_R > 100\%, \text{ or } g_A > 100\% > g_R \quad (27)$$

Depending on the intensity with which the results of anti-crisis measures manifest themselves, the recovery of the growth trend in business activity may precede the restoration of asset growth. In such a case, the stabilisation stage of the liquidity crisis is described by the following inequalities:

$$g_R > 100\% > g_A \quad (28)$$

given that

$$K^R_{acc/dec} > 1 \quad (29)$$

Provided that resource growth is restored alongside stable expansion of business activity

$$K^R_{acc/dec} > 1, K^A_{acc/dec} > 1 \quad (30)$$

the following inequality holds:

$$g_R > g_A > 100\% \quad (31)$$

which indicates the elimination of the liquidity crisis.

The overall level of solvency of a socio-economic system is characterised by the value of the coverage ratio. This indicator reflects the extent to which current liabilities can be settled using current assets, as well as the proportion of current assets that remains available to ensure the continued functioning of the socio-economic system. The recommended benchmark value of the coverage ratio is set at 1.5. A value below this threshold is considered one of the key signs of critical insolvency. Accordingly, we propose to treat the current liquidity ratio as a criterion for assessing the solvency crisis. The initial stage of a solvency crisis is characterised by a decline in the coverage ratio, driven by a faster increase in current liabilities relative to the growth of current assets:

$$100\% < T_{CA} < T_{CL} \tag{32}$$

given that

$$K_{cov} > 1.5 \tag{33}$$

where K_{cov} – coverage ratio (current ratio); T_{CA} – growth rate of current assets; T_{CL} – growth rate of current liabilities.

A further decline in the overall solvency level below the threshold value, caused by a reduction in current assets and an increase in current liabilities (or their less intensive decrease), corresponds to the stage of crisis escalation. Thus, the condition

$$K_{cov} < 1.5 \tag{34}$$

holds when:

$$0.5 < K_{CA/CL} = \frac{T_{CA}}{T_{CL}} < 1 \tag{35}$$

as a result of either:

$$T_{CL} > 100\% > T_{CA},\text{ or } 100\% > T_{CL} > T_{CA} \tag{36}$$

where $K_{CA/CL}$ – lead–lag coefficient reflecting the relative change in current assets compared with the change in current liabilities; T_{CA} – growth rate of current assets; T_{CL} – growth rate of current liabilities; K_{cov} – coverage ratio (current ratio).

An acceleration in the development of the solvency crisis is characterised by a coverage ratio below 1, indicating that current assets are insufficient to settle current liabilities. In such a situation, settlements are typically ensured through partial disposal of fixed assets and other non-current assets. A distinctive feature of this stage is a sharp contraction in current assets accompanied by a slow decline in current liabilities or, even worse, the persistence of their growth. Therefore, the transition of the solvency crisis to the escalation stage is evidenced by the following inequalities:

$$K_{cov} < 1.0 \text{ when } K_{CA/CL} < 0.5 \tag{37}$$

If the above trends continue to develop without obstruction, they create grounds for initiating bankruptcy proceedings in the form of overdue accounts payable. This legitimately indicates the onset of a solvency crisis. It is important to note that overdue accounts payable may arise at any value of the coverage ratio. However, this does not imply that being at the escalation or unfolding stage of a solvency crisis necessarily leads to formal (legal) bankruptcy. Therefore, the solvency position of an economic system should be recognised as unsatisfactory specifically at the stage when the crisis actually materialises. The implementation of measures approved by the court or through pre-trial restructuring (sanation) will primarily be aimed at satisfying creditors' claims. Hence, the stabilisation stage of the solvency crisis is characterised by an increase in the coverage ratio. A necessary condition for securing this positive trend is:

$$K_{CA/CL} > 1.0 \tag{38}$$

which is achieved when one of the following inequalities holds:

$$100\% > T_{CA} > T_{CL} \text{ or } T_{CL} < 100\% < T_{CA} \tag{39}$$

where $K_{CA/CL}$ – lead–lag coefficient reflecting the relative change in current assets compared with the change in current liabilities; T_{CA} – growth rate of current assets; T_{CL} – growth rate of current liabilities; the value 100% corresponds to a zero-growth threshold.

The repayment process of overdue accounts payable begins at the stabilisation stage of the solvency crisis; however, it may not be completed simultaneously with this stage and may therefore extend into part of the crisis elimination stage. The transition to this stage is characterised by the following inequality:

$$T_{CA} > T_{CL} > 100\% \tag{40}$$

Nevertheless, the mandatory conditions for overcoming the solvency crisis are: (i) the absence of overdue liabilities to creditors; (ii) the coverage ratio (current ratio) being within the range of normative values, where the lower bound is the regulatory threshold of 1.5, while the upper bound is the normal current liquidity ratio (K_N), which is determined either individually or, alternatively, the optimal limit of 2 established by international standards may be applied. Hence, the condition is:

$$1.5 \leq K_{cov} \leq K_N \tag{41}$$

Compliance with the upper bound is justified by the fact that an excessively high level of overall solvency is not necessarily accompanied by an adequate level of liquidity of working (current) resources. For example, the economically unjustified growth of current assets driven by excessive inventories of finished goods or merchandise that are not in demand in the market, or by unreasonably large volumes of trade credit under a non-payment crisis, is particularly problematic. In such circumstances, a seemingly sufficient volume of working resources may prove to be illiquid, which, in turn, results in the inability of the socio-economic system to fulfil its obligations in practice without disrupting the normal operating cycle. This condition is consistent with the requirement to maintain a rational structure of resources, which is defined as an indicator of liquidity crisis elimination, and its implementation is associated with the transition of the solvency crisis to the stabilisation stage.

A sign of growing problems in the area of payment discipline with creditors is an increase in the amount of creditor indebtedness while net sales revenue decreases or grows less intensively. This is explained by the fact that the emergence of a solvency crisis occurs simultaneously with the escalation of the liquidity crisis, the common feature of which is a reduction in revenue or a slowdown in its growth. At the initial stage of the solvency crisis, the following inequalities are typical:

$$g_R < 100\% < g_{CL} \text{ or } g_{CL} > g_R > 100\% \tag{42}$$

provided that

$$0.5 < K_{R/CL} = \frac{g_R}{g_{CL}} < 1 \tag{43}$$

where g_{CL} – growth rate of accounts payable (creditor indebtedness); $K_{R/CL}$ – lead–lag coefficient reflecting the growth rate of net sales revenue relative to the growth rate of accounts payable.

This indicates that, in the course of business operations, the enterprise does not ensure effective use of the resources attracted from creditors, which results in a gradual expansion of the “debt trap.”

The escalation of the solvency crisis is accompanied by a transition from a slowdown in revenue growth to a downward trend in revenue, while accounts payable continue to increase steadily. The simultaneous impact of these factors causes a substantial imbalance between the growth rate of net sales revenue and the growth rate of accounts payable. If

$$K_{R/CL} < 0.5 \tag{44}$$

i.e., when the revenue growth rate is two times lower than the growth rate of accounts payable, the economic system is assessed as being at the stage of escalation of the solvency crisis.

An indicator of a further deterioration in payment discipline with creditors is the situation where the growth rate of overdue accounts payable exceeds the relative change in total accounts payable, while revenue from sales decreases:

$$g_R < 100\% < g_{CL} < g_{CL}^{OD} \text{ or } g_R < g_{CL} < 100\% < g_{CL}^{OD} \tag{45}$$

provided that

$$0.5 < K_{CL/CL^{OD}} = \frac{g_{CL}}{g_{CL}^{OD}} \tag{46}$$

where g_{CL}^{OD} – growth rate of overdue accounts payable; $K_{CL/CL^{OD}}$ – lead–lag coefficient reflecting the growth rate of total accounts payable relative to the growth rate of overdue accounts payable.

The essence of this relationship is that, by analysing only the dynamics of the total amount of accounts payable, it is impossible to draw a positive conclusion, because within its structure an intensive transformation of previously accumulated current payables into overdue liabilities takes place as contractual payment deadlines become due. Such a situation provokes a decline in business activity, which first of all is manifested through a reduction in sales revenue.

At the peak of the adverse relationship between the growth rate of accounts payable and the growth rate of overdue accounts payable, the lead–lag coefficient falls below 0.5. If, in addition, the structure of accounts payable includes overdue debts in an amount sufficient to initiate bankruptcy proceedings, the socio-economic system is assessed as having entered the stage of solvency crisis onset.

An improvement in the quality of settlements with creditors can be traced through a downward trend in overdue accounts payable, even if the total amount of accounts payable continues to grow. However, to draw a positive conclusion, an increase in net sales revenue is a mandatory condition. Thus, the stage of stabilisation of the solvency crisis is indicated by the fulfilment of the following conditions:

$$K_{R/CL} > 1 \text{ when } g_{CL}^{OD} < 100\% \tag{47}$$

where $K_{R/CL}$ – lead–lag coefficient reflecting the relative change in net sales revenue compared with accounts payable.

The full repayment of overdue debt obligations is completed only at the stage of elimination of the solvency crisis. An additional condition is the validity of one of the following inequalities:

$$g_R > g_{CL} > 100\% \text{ or } g_R > 100\% > g_{CL} \tag{48}$$

These inequalities reflect the activation of business turnover, which is manifested in a higher intensity of revenue growth compared with the growth rate of resources attracted from creditors. This means that the role of own financial resources increases in financing current operations, while the use of borrowed funds ensures a sufficient level of operational efficiency required for timely settlements with creditors.

One of the key characteristics of economic development is the profitability factor. It is a summarising indicator that reflects the final performance result and allows assessment of both absolute and relative efficiency. The presence of profit ensures compliance with the fundamental principles of business activity–self-sufficiency and self-financing. Therefore, the consequences of a profitability crisis affect reproduction processes and the resource potential of the socio-economic system.

A slowdown in turnover results in the formation of additional funds involved in circulation, the source of which–under low profitability–are creditors' resources. Consequently, liabilities and costs increase with each operating cycle, which leads to a decline in solvency and a decrease in profitability.

The escalation of a profitability crisis is characterised by a reduction in the amount of funds released from circulation or, conversely, by the emergence (increase) of additionally attracted funds, accompanied by a slowdown in their turnover:

$$K_{acc/dec} = \frac{g_{P1}^{T}}{g_{P0}^{T}} < 1 \tag{49}$$

where $K_{acc/dec}$ – coefficient reflecting acceleration/deceleration of working-capital turnover; g_{P1}^{T}– growth rate of the working-capital turnover period in period 1; g_{P0}^{T} – growth rate of the working-capital turnover period in period 0 (base period).

An increase in the turnover period of working capital leads to a decrease in revenue, whereas additional external financing results in rising costs. As a consequence, gross profit decreases to a level that is insufficient to cover other operating costs. Thus, operating losses occur:

$$OP_0 > 0;\ OP_1 < 0 \tag{50}$$

where OP_0 – operating profit in the base period; OP_1 – operating profit in the subsequent period.

At the stage of escalation of the profitability crisis, gross losses are formed while the following trends persist:

$$g_{GL} > 100\%, K_{acc/dec} < 1, g_{OL} > 100\% \tag{51}$$

where g_{GL} – growth rate of gross losses; $K_{acc/dec}$ – coefficient of acceleration/deceleration of working-capital turnover; g_{OL} – growth rate of operating losses;

provided that:

$$g_{T}^{WC} < 100\% \tag{52}$$

Second, an acceleration of working-capital turnover occurs due to a more intensive reduction in its average balance compared to the rate of revenue decline, namely:

$$K_{acc/dec} > 1 \tag{53}$$

as a result of:

$$1 > K_{Q/acc} = \frac{g_{Q1}}{g_{Q0}} > K_{OA/acc} = \frac{g_{OA1}}{g_{OA0}} \tag{54}$$

where $K_{acc/dec}$ – coefficient of acceleration/deceleration of working-capital turnover; $K_{Q/acc}$ – coefficient of acceleration/deceleration of the revenue growth rate; g_{Q1}, g_{Q0} – growth rates of revenue in the current and base periods, respectively; g_{OA1}, g_{OA0} – growth rates of average working-capital balances in the current and base periods, respectively.

Stage of stabilisation of the profitability crisis is characterised by:
a) overcoming the gross loss threshold;
b) recovery of growth in net sales revenue and, on this basis, an increase in the turnover ratio of current assets even if their amount decreases:

$$g_R > 100\% \text{ due to } K_{R/CA} \tag{55}$$

where g_R – growth rate of net sales revenue; $K_{R/CA}$ – lead–lag coefficient reflecting the ratio of the growth rate of net sales revenue to the growth rate of current assets;

c) formation of the amount of funds released from circulation;
d) reduction of operating losses or reaching the operating break-even point.
Elimination of the profitability crisis has the following features:
a) growth of gross profit and operating profit;
b) acceleration of current assets turnover under:

$$K_{R/CA} > 1 \tag{56}$$

c) increase in the amount of current assets released from circulation.
We characterise the stages of the profitability crisis based on the dynamics of the enterprise's net profit (loss). If, in the reporting period compared with the base period, a decrease in net profit is observed, it may be concluded that prerequisites for the development of a profitability crisis have emerged. The reasons for the reduction in net profit consist in either a higher growth rate of total expenses compared with total revenues, or a more intensive decline in the latter. Thus, the inequality

$$T_{pNP} < 100\% \tag{57}$$

is determined by the condition when

$$T_{pE} > T_{pR} > 100\% \text{ or } 100\% > T_{pE} > T_{pR} \tag{58}$$

where T_{pNP} is the growth rate of net profit; T_{pE} is the growth rate of total expenses; and T_{pR} is the growth rate of total revenues. The described changes are accompanied by a slowdown in the growth of retained earnings.

A characteristic feature of the development of a profitability crisis is the emergence of losses. The stage of crisis escalation is determined by a transition from a decreasing profitability trend to loss-making performance. If, in the reporting period, the economic system operated with a profit, but in the subsequent period incurred a loss, this indicates that the crisis is escalating. It should be noted that at this stage the formation of losses is intensified due to a decline in total revenues, especially from the core activity. Therefore, the indicators of this stage are:

$$NP_0 > 0, L_1 < 0 \quad \text{under the condition} \quad T_{pE} > 100\% > T_{pR} \tag{59}$$

where NP_0 – is the amount of net profit in the base period; L_1 – is the amount of loss in the reporting period.

The unfolding of the profitability crisis is evidenced by an increase in the amount of loss resulting from the persistent maintenance of a negative difference in the intensity and directions of changes in expenses and revenues. When the lead–lag coefficient (reflecting the relative change in revenues compared with the change in expenses), $K_{B/B}^{R/E}$ is stably lower than 1, a growth in the amount of current losses is observed.

With a chronic nature of current loss-making activity, the resource and asset structure reflects an accumulated amount of uncovered losses. The cumulative growth of uncovered losses gradually exhausts equity and becomes the main factor leading to a deficit of net assets. Given the severe consequences of this phenomenon, the onset of the crisis should be associated with the very appearance of uncovered losses in the balance sheet. Their accumulation indicates a deepening profitability crisis and the socio-economic system approaching a loss of financial stability. Anti-crisis measures should therefore be aimed at mobilising internal resources in order to generate restructuring (rehabilitation) profit to cover balance-sheet losses.

A slowdown in growth or a decrease in the amount of uncovered losses indicates the easing (stabilisation) of the profitability crisis. This can be achieved through the generation of restructuring profit and/or the recovery of current profitability, provided that

$$K_{B/B}^{R/E} = \frac{T_{pR}}{T_{pE}} > 1 \tag{60}$$

The complete elimination of uncovered losses from the balance sheet, ensured by a sustained increase in net profit based on higher growth rates of total revenues compared with the intensity of expense growth (or even through cost savings), implies the overcoming of the profitability crisis.

Among the first manifestations of the threat of losing financial stability is a decrease in the investment ratio due to a slowdown in growth or a reduction in equity compared with the intensity of the increase in non-current assets. The fulfilment of the inequalities

$$K_{inv} > 1, \text{ but } T_{p\ inv} < 100\% \tag{61}$$

under either

$$100\% < T_{p\ EC} < T_{p\ NCA} \text{ or } T_{p\ NCA} > 100\% > T_{p\ EC} \tag{62}$$

where K_{inv} – investment ratio (investment coefficient); $T_{p\ inv}$ – growth rate of the investment ratio; $T_{p\ EC}$ – growth rate of equity; $T_{p\ NCA}$ – growth rate of non-current assets, characterises the emergence stage of the financial stability crisis.

As a result of the development of current loss-making activity formed at the stage of unfolding of the profitability crisis, equity decreases through a reduction in retained earnings. Consequently, factors causing a more intensive decline in the investment ratio are formed. At the stage of escalation of the threat of losing financial stability, the tendency of decreasing this indicator persists even when

$$K_{inv} > 1 \tag{63}$$

however, destructive processes deepen, generating its negative dynamics, namely:

$$T_{p\ EC} < T_{p\ NCA} < 100\% \tag{64}$$

Unimpeded development of these trends leads to

$$0 < K_{inv} < 1 \tag{65}$$

which reflects the phenomenon of a deficit of own working capital. The emergence of such trends takes place at the stage of unfolding of the financial stability crisis. At the same time, the speed of crisis tendencies increases. Their quantitative assessment may be performed using the lead–lag coefficient (advance/lag) of the equity growth rate relative to the growth rate of non-current assets, namely:

$$K_{B/B}^{EC/NCA} = \frac{T_{p\,EC}}{T_{p\,NCA}} < 1 \quad (66)$$

where $K_{B/B}^{EC/NCA}$ – lead–lag coefficient reflecting the relative change in equity compared with the change in non-current assets; $T_{p\,EC}$ – growth rate of equity; $T_{p\,NCA}$ – growth rate of non-current assets.

The acquisition of a negative value by the investment ratio, accompanied by a tendency toward its increase, corresponds to the stage of the onset of a threat to financial sustainability, as it indicates the emergence of a deep disturbance in financial equilibrium, under which the enterprise has no net assets. At this stage, the development of the crisis imbalance may be caused by one of the following inequalities:

$$T_{p\,EC}^{DEF} > T_{p\,NCA} > 100\% \ \text{ or } \ T_{p\,EC}^{DEF} > 100\% > T_{p\,NCA} \quad (67)$$

where $T_{p\,EC}^{DEF}$ denotes the growth rate of the deficit of equity.

Overcoming the crisis of financial sustainability is a long-term process. Its catalyst can only be the mobilisation of internal resources. Therefore, the enterprise's rehabilitation capacity in fact represents a combination of production, financial, and marketing potential, which should be utilised to enable the enterprise to overcome the crisis while preserving the owners' capital and ensuring economic independence. Signs of stabilisation of the financial sustainability crisis include a decrease in the absolute value of the negative investment ratio, followed by reaching a positive value and restoring its upward trend based on:

$$K_{B/B}^{EC/NCA} = \frac{T_{p\,EC}}{T_{p\,NCA}} > 1 \quad (68)$$

An indicator of the complete elimination of the threat of losing the owners' capital is maintaining the investment ratio within the optimal range (above 1) with stable growth of its value as a result of:

$$T_{p\,EC} > T_{p\,NCA} > 100\% \ \text{ or } \ T_{p\,EC} > 100\% > T_{p\,NCA} \quad (69)$$

The study of the interrelationship between trends in profitability development, self-financing, and the value of equity makes it possible to differentiate the stages of the development of a financial sustainability crisis. The enterprise's financial result obtained in the current period determines the amount of increase or decrease in retained earnings in the balance sheet. In the case of chronic current losses, a tendency toward a decline in retained earnings is formed; when this trend transforms into the accumulation of uncovered losses, it causes a reduction in the company's own working capital, followed by the emergence of its deficit. An uncontrolled crisis process ultimately leads to the loss of the invested capital by the owners. This occurs when the amount of liabilities exceeds the value of assets, which indicates a legitimate transfer to creditors of decisive voting power in determining the future fate of the debtor.

As a criterion for assessing the threat of loss of financial sustainability, we choose the liabilities concentration ratio. The economic meaning of this indicator reflects the share of borrowed capital in the total value of funding sources used to form the assets. The optimal value of this ratio should be lower than 0.5; that is, the share of liabilities in the total amount of capital should not exceed 50%. As its value increases, the risk of the economic system losing financial autonomy in resolving key operational and strategic issues also increases.

Prerequisites for the emergence of a financial sustainability crisis include a more intensive growth of capital formed from borrowed sources compared with the rate of increase in the value of the enterprise's assets. The value of the liabilities concentration ratio remains within the normative range ($K_{conc} < 0.5$), but it demonstrates an upward trend ($T_{p\,conc} > 100\%$) under the influence of the condition:

$$T_{p\,L} > T_{p\,A} > 100\% \tag{70}$$

where $T_{p\,L}$ – growth rate of liabilities (total obligations); $T_{p\,A}$ – growth rate of total assets.

Long-term persistence of this condition leads to exceeding the optimal level of the liabilities concentration ratio, i.e.,

$$1 > K_{conc} > 0.5 \tag{71}$$

which indicates that the crisis development is entering the escalation stage. It should be noted that a temporary reason for an increase in the concentration ratio at the early stages of the financial sustainability crisis may also be the following relationship:

$$100\% > T_{p\,L} > T_{p\,A} \tag{72}$$

The threat of losing financial stability is intensified by a reduction in assets under the conditions of stable growth in borrowed capital. If the inequality

$$T_{pA} < 100\% < T_{pZOB} \tag{73}$$

where T_{pA} – growth rate of total assets; T_{pZOB} – growth rate of total liabilities (obligations), holds, and the value of the liabilities concentration coefficient remains within the range from 0.5 to 1, then the socio-economic system is at the stage of crisis escalation. Reaching a critical value of the liabilities concentration coefficient–above 1–while maintaining a tendency to further increase, characterises the peak of the threat of losing financial stability. This is because the excess of liabilities over the value of assets indicates an insufficient amount of the latter to cover the total indebtedness.

The reduction and return of the share of liabilities to the interval from 50% to 100% is achieved by establishing the lead–lag coefficient (advance/lag) of the asset growth rate compared to the growth rate of liabilities at a level above 1, i.e.,

$$K_{B/B}^{A/ZOB} = \frac{T_{pA}}{T_{pZOB}} > 1 \tag{74}$$

where $K_{B/B}^{A/ZOB}$ – lead–lag coefficient reflecting the relative change in assets compared with the change in liabilities.

These conditions characterise the stage of stabilisation of the financial stability crisis: maintaining the inequality

$$K_{B/B}^{A/ZOB} > 1 \tag{75}$$

while the liabilities concentration coefficient reaches a value below 0.5 indicates the elimination of the threat of owners losing their capital and the preservation of the economic independence of the socio-economic system.

In addition, defining the analysed object as a system enabled the experts to identify a set of interrelated elements and the characteristics that should be included in the database for applying the taxonomy method. Therefore, a systemic and logical relationship among the studied parameters was constructed, and a system of coefficients was developed to calculate the initial database for the comprehensive taxonomy approach. Based on expert judgement, ten coefficients were selected; these coefficients describe the relationships between key financial and economic indicators of the object of analysis over time (in dynamics). A pivotal element in forming the initial database for analytical research using the taxonomy method was the lead–lag coefficient, which, by its purpose, characterises the ratio between the rates of change of two indicators. The choice of this methodological instrument is justified by the fact that it allows determining the extent to which one indicator changes faster or slower than another (Table 1).

Table 1. System of Coefficients for Calculating the Initial Database for Analytical Research Using the Taxonomy Method.

Name of the lead–lag coefficient	**Symbol**
Lead–lag coefficient of the growth rate of net revenue compared to the growth rate of closing inventory of finished goods and commodities	K_1
Lead–lag coefficient of the growth rate of net revenue from sales relative to the growth rate of resources	K_2
Lead–lag coefficient of the growth rate of current assets compared to the growth rate of current liabilities	K_3
Lead–lag coefficient of the growth rate of net revenue from sales compared to the growth rate of accounts payable	K_4
Lead–lag coefficient of the growth rate of equity compared to the growth rate of non-current assets	K_5
Lead–lag coefficient of the growth rate of income compared to the growth rate of expenses	K_6
Coefficient of acceleration (deceleration) of working capital turnover	K_7
Lead–lag coefficient of the growth rate of net revenue from sales compared to the relative change in the amount of funds in settlements with debtors (accounts receivable)	K_8
Lead–lag coefficient of the growth rate of assets compared to the growth rate of liabilities	K_9
Lead–lag coefficient of the growth rate of net revenue from sales relative to the growth rate of inventories	K_{10}

Source: Developed by the authors.

To ensure a systematic analysis and a deeper understanding of theoretical and methodological approaches as well as applied issues related to analysing the activity of the object under study–which provides the basis for forecasting the dynamics of its economic development–the economic meaning of each lead–lag coefficient reflecting the relationship between key financial and economic indicators of the object of analysis over time (K_1–K_{10}) was characterised.

Coefficient K_1 reflects the relationship between the growth rate of net revenue and the growth rate of inventory balances of finished goods and commodities. If the actual value of this indicator exceeds 1, it indicates that the expansion of production corresponds to market demand, as stockpiling in warehouses is not observed. Conversely, when this coefficient is below 1, it signals a disruption in the sales of finished products. This may occur due to various reasons, such as the narrowing or loss of a market niche, displacement by competitors, production disruptions, termination of supply contracts, customer refusals, etc.

Coefficient K_2 characterises the relationship between the growth rate of net revenue from sales and the growth rate of resources. If this coefficient exceeds 1, the enterprise's development is considered to have a positive dynamic. This is explained by the fact that net revenue represents the primary internal source for capital replenishment and asset expansion. If external financial sources begin to dominate in enterprise activity, this trend becomes unfavourable for financial independence when the coefficient falls below 1–especially when net revenue decreases while assets increase, which may result from the accumulation of liabilities to creditors.

Coefficient K_3 reflects the relationship between the growth rate of current assets and the growth rate of current liabilities. Accelerated growth of current assets compared to current liabilities indicates a tendency to form, maintain and/or restore the enterprise's solvency. In the opposite case, it becomes the fundamental prerequisite for a solvency crisis. When the coefficient exceeds 1, the enterprise's development is recognised as positive, since the turnover of working capital ensures repayment of debt obligations to creditors attracted into business activity. If the amount of funds advanced into circulation decreases, it will no longer ensure full settlement of current creditor claims, resulting in the formation of overdue accounts payable.

Coefficient K_4 further specifies the dynamic state of solvency through the relationship between the growth rate of net revenue from sales and the growth rate of accounts payable. If the coefficient value is below 1, this indicates the deepening of the problem of untimely debt repayment to creditors and an increase in the overdue portion of liabilities. Conversely, a value above the threshold of 1 indicates stable solvency or its recovery. If the coefficient fluctuates, this implies that anti-crisis measures are being implemented; however, their unstable effectiveness generates a volatile trajectory of coefficient K_4.

Coefficient K_5 provides insight into the dynamics of formation or depletion of the internal source of self-financing, namely own working capital. Its formation is ensured when the growth rate of equity exceeds the growth rate of non-current assets. If the opposite tendency is observed, manifested in the sustained situation where $K_5 < 1$, the business is approaching a deficit of own working capital or already increasing it. The availability and stable growth of own working capital is an essential feature of a financially stable enterprise over time and one that is resilient to external threats.

Coefficient K_6 is a key instrument for identifying the underlying causes of profitability in one business and losses in another. One of the earliest indications that an enterprise is moving into a loss-making zone is a faster acceleration of costs relative to the intensity of revenue growth. When the value of K_6 falls below 1, this means that revenues are still increasing, yet at a slower rate than the relative increase in costs. If this transition of K_6 below the threshold of 1 is identified in a timely manner, the enterprise gains time to determine the drivers and prerequisites of emerging unprofitability.

Coefficient K_7 characterises the ability of a business to "generate" profit or, alternatively, reveals the reasons for the accumulation of losses. Each operating cycle should yield profit; the greater the number of turnover cycles, the higher the total profit. However, if managerial miscalculations occur–for example, in pricing–then losses may accumulate even under accelerated turnover of working capital. Hence, working capital turnover acts as a catalyst either for business profitability or, conversely, for loss-making activity.

Coefficient K_8 represents the lead/lag coefficient of the growth rate of net revenue from sales compared with the relative change in the amount of funds tied up in receivables. The calculation of K_8 is necessary to identify a potential threat of a liquidity crisis arising from a persistent increase in non-payments among consumers and counterparties. Once net revenue from sales begins to lag behind the expansion of receivables (in percentage-point terms), particular attention should be given to payment discipline through systematic monitoring and strengthened control over contractual compliance, enabling early identification of the causes of non-compliance. Conversely, when $K_8 > 1$, the dynamics of sales activity may be considered liquid and income-generating.

Coefficient K_9 and its estimation provide the basis for assessing progressive (when its value exceeds 1) or regressive (when $K9 < 1$) changes in the dynamics of a firm's financial stability. To ensure stable financial sustainability or to restore it, the growth rate of assets must outpace the growth rate of liabilities. Under the opposite trend, the enterprise's financial autonomy will be weakened over time, and if such a trend persists, financial sustainability may ultimately be lost.

Coefficient K_{10} reflects the enterprise's ability to ensure production rhythm and continuity. In the presence of idle capacity, supply chain disruptions, or miscalculations in raw-material logistics, the growth rate of net revenue from sales will lag behind the growth rate of production inventories. Stable and uninterrupted production is associated with $K_{10} > 1$, indicating the absence of excessive inventories that generate additional storage costs and quality deterioration over time, as well as the adequacy of production capacity to meet market demand.

In the course of the study and application of the proposed methodology, the authors used primary data (survey results) and secondary data (reporting databases for 2006–2024). Furthermore, the stages of generating the initial dataset and the sequential transformation of the initial data matrix were established to compute an aggregated indicator of the comprehensive assessment of the level of economic development of the analysed object (illustrated by "Dominik Co" LLC). The dynamics of this indicator within the firm's financial and economic cycle were examined using the taxonomic method, including the construction of a benchmark (reference) vector, calculation of distances to the benchmark, and derivation of an integral measure in the form of a taxonomic index of economic development. In addition, a correlation–regression model was proposed for forecasting the dynamics of economic development in the socio-economic system.

3. Research results

The difficulties associated with conducting economic research using statistical methods that rely on the distribution of a multidimensional random variable are primarily linked to the number of available observations contained in the dataset. In many cases, this number is insufficient for solving the problem of ordering multidimensional objects or processes relative to a predetermined benchmark (reference) vector. This circumstance substantiated the relevance of applying the taxonomic method (Wu, 2020).

The use of taxonomy provides opportunities to construct a generalised assessment of a complex object or process. Its application is also driven by the intrinsic complexity of the economic phenomena and processes under study, their multidimensional nature, and the ambiguity of causal relationships. The use of a system of heterogeneous indicators through their structuring and analytical interpretation for managerial decision-making is closely associated with taxonomy as a methodological approach. In particular, the taxonomic method offers a powerful set of systematisation algorithms and is capable of addressing the problem of evaluating the dynamics of economic development within a socio-economic system.

Accordingly, to achieve the research objective, the taxonomic method was employed. It is based on calculating the distance between the actual value of an indicator and its benchmark value, where the benchmark is defined as the maximum value within the time series for a stimulating factor and the minimum value within the time series for a destimulating factor.

At the initial stage, the proposed coefficients forming the analytical basis for the taxonomic study are calculated. Table 2 presents the computed indicators for the period 2006–2024, based on the case of "Dominik Co" LLC (hereinafter referred to as the object of analysis).

Table 2. Initial Data Matrix for Calculating the Economic Development Index of the Analysed Object ("Dominik Co" LLC) for 2006–2024.

As at 1 January	K_1	K_2	K_3	K_4	K_5	K_6	K_7	K_8	K_9	K_{10}
2006	1.0450	1.0526	1.1432	1.1521	1.0822	0.9791	0.9836	0.9908	1.1028	1.2489
2007	0.8847	0.9081	0.8603	0.7291	1.0578	0.9987	0.8374	0.7169	0.8065	0.7407
2008	1.2383	0.9485	0.7971	0.8765	0.8795	0.9867	1.1775	1.0147	0.8374	0.966
2009	1.1102	1.0657	1.2305	1.5583	1.0981	1.0096	1.0439	0.9768	1.1796	1.2457
2010	1.0173	0.8150	1.1259	0.7061	0.9803	1.0092	0.8201	0.8260	1.1824	0.8423
2011	2.7865	0.9246	0.798	0.7886	0.9942	0.9648	1.0388	0.8770	0.7689	0.9103
2012	2.6111	1.0168	1.0613	1.0300	1.1076	1.0100	1.0835	0.8831	1.0007	1.1538
2013	2.3188	0.9093	1.1532	1.1280	0.9801	1.0025	0.9885	0.9566	1.1859	0.8727
2014	9.3082	0.8905	1.1838	0.9462	1.0088	0.9868	0.9630	0.9460	1.2203	0.5675
2015	0.0063	1.0890	1.0560	1.0368	1.1453	1.0566	1.1019	1.4049	0.9784	1.1491
2016	1.4849	1.2336	1.3122	1.4444	1.3330	1.0159	1.0997	1.2662	1.1754	1.2997
2017	1.4696	0.9759	1.0960	1.0946	0.9578	0.9854	0.9042	0.8673	1.1215	0.7269

2018	1.703	0.9484	0.9156	1.0565	0.6964	0.9949	1.1560	1.1242	1.1146	1.5608
2019	1.1443	0.8281	1.4743	1.1917	1.1060	0.9810	0.6856	0.9982	1.3146	0.6963
2020	1.1902	0.8453	1.1858	0.8987	1.2488	1.0016	0.9545	0.8920	1.0854	1.0476
2021	1.5732	0.7865	0.6875	0.6083	0.7912	1.0251	1.1632	0.9063	0.8038	0.8708
2022	0.8632	1.2745	1.0668	1.3768	0.9458	0.8892	1.5153	0.9671	1.1145	0.9737
2023	1.4086	1.1112	1.6986	1.6324	1.3368	1.1437	0.7218	1.9638	1.4691	0.9067
2024	0.7771	1.0903	0.9131	0.9267	1.1794	0.9445	1.056	1.0203	0.8499	1.1199

Source: Developed by the authors.

Overall, the values of the selected set of coefficients over the period 2006–2024 demonstrate volatility and sample heterogeneity. Considered individually, none of these coefficients enables a comprehensive conclusion regarding the dynamics of the economic development of the analysed object. Therefore, there arises a need to derive a composite indicator that provides an integrated characterisation of the economic development dynamics of the analysed entity–namely, the Economic Development Index (illustrated using the case of "Dominik Co" LLC).

To address this objective, it is proposed to apply a taxonomic indicator, calculated using the classical taxonomy algorithm, which includes the following stages: (i) constructing the observation matrix; (ii) standardising the values of the observation matrix elements; (iii) identifying the benchmark (reference) vector; (iv) determining the distance between individual observations and the benchmark vector; and (v) calculating the taxonomic development coefficient. The approach to constructing the integral indicator on the basis of the taxonomic economic development index (K_i) relies on the application of the taxonomic method, which is grounded in distance-based procedures.

The results of applying the taxonomic method in accordance with the algorithm for calculating the integral indicator based on the determination of the taxonomic economic development index (K_i) are presented in Table 4. The data in this table constitute the observation matrix, which was standardised (a_{ij}) in order to convert the indicators into a common dimensionless scale. For this purpose, the following were computed: the mean value, variance, and standard deviation for each indicator in the initial dataset. Subsequently, a benchmark vector was constructed, the elements of which correspond to the indicator values presented in Table 3: P0 = (3.9923; 2.1807; 2.5616; 2.0570; 1.7880; 3.0372; 2.7549; 3.5044; 2.1704; 2.3678). In the subsequent stage of the research, the distances between individual observations and the benchmark (reference) vector (C_i0) were determined using the following formula:

$$C_{i0} = \sum(a_{ij} - a_{ideal})^2 \tag{76}$$

where C_{i0} – the distance between the i-th observation (object) and the ideal (benchmark) vector (reference point) in the taxonomic analysis (often interpreted as the Euclidean-type distance measure); a_{ij} – the standardised value of the j-th indicator for the i-th observation (object) in the observation matrix; a_{ideal} – the ideal (benchmark) value of the j-th indicator (i.e., the corresponding component of the ideal/reference vector).

The taxonomic index of economic development (Ki) was calculated according to the following procedure:

1. The average distance was determined as:

$$\overline{C_0} = \frac{1}{m}\sum_{i=1}^{m} C_{i0} \tag{77}$$

2. The standard deviation was calculated as:

$$S_0 = \sqrt{\frac{1}{m}\sum_{i=1}^{m}(C_{i0} - \overline{C_0})^2} \tag{78}$$

3. The critical (threshold) distance between the indicators and the benchmark (ideal) vector was defined as:

$$C_0 = \overline{C_0} + 2S_0 \tag{79}$$

4. The relative distance between the i-th observation and the benchmark vector was computed as:

$$d_i = \frac{C_{i0}}{C_0} \tag{80}$$

5. Finally, the taxonomic development index was obtained as:

$$K_i = 1 - d_i \tag{81}$$

where K_i – the taxonomic index of economic development for the *i-th* observation (object / year); m – the number of observations (objects, periods, years) included in the analysis; C_{i0} – the distance between the *i-th* observation and the benchmark (ideal) vector (reference point) in the multidimensional indicator space; $\overline{C}_0$ – the average (mean) distance across all observations; S_0 – the standard deviation of the distances C_{i0}, reflecting their dispersion; C_0 – the critical/threshold distance, calculated as the mean distance plus twice the standard deviation: $C_0 + 2S_0$; d_i – the relative (normalised) distance of the i-th observation from the benchmark: $\frac{C_{i0}}{C_0}$.

Table 3. Standardised Data Matrix with the Calculation of the Economic Development Index (K_i) for the Analysed Entity over 2006–2024 (case study of "Dominik Co" LLC).

As at 1 January	K_1	K_2	K_3	K_4	K_5	K_6	K_7	K_8	K_9	K_{10}	Cio	d_s	K_s
2006	-0.3935	0.5095	0.2141	0.3244	0.2068	-0.4235	-0.1757	-0.1529	0.1830	1.0631	8.5230	0.3160	0.684
2007	-0.4785	-0.5785	-0.9820	-1.2016	0.0550	-0.0119	-0.9815	-1.1825	-1.4246	-1.0624	11.1220	0.4120	0.5880
2008	-0.2909	-0.2743	-1.2492	-0.6699	-1.0524	-0.2634	0.8929	-0.0630	-1.2567	-0.1198	9.9710	0.3690	0.6310
2009	-0.3589	0.6081	0.5830	1.7897	0.3058	0.2181	0.1565	-0.2054	0.5997	1.0500	7.7620	0.2870	0.7130
2010	-0.4082	-1.2797	0.1408	-1.2846	-0.4261	0.2100	-1.0769	-0.7723	0.6148	-0.6375	10.2800	0.3810	0.6190
2011	0.5308	-0.4546	-1.2452	-0.9871	-0.3395	-0.7232	0.1283	-0.5808	-1.6282	-0.3531	10.3330	0.3830	0.6170
2012	0.4377	0.2400	-0.1321	-0.1163	0.3647	0.2264	0.3746	-0.5578	-0.3706	0.6653	8.3560	0.3090	0.6910
2013	0.2826	-0.5698	0.2561	0.2373	-0.4272	0.0695	-0.1488	-0.2816	0.6339	-0.5104	8.7800	0.3250	0.6750
2014	3.9923	-0.7116	0.3857	-0.4186	-0.2493	-0.2603	-0.2892	-0.3214	0.8208	-1.7867	8.7880	0.3250	0.6750
2015	-0.9447	0.7839	-0.1548	-0.0915	0.5986	1.2058	0.4763	1.4037	-0.4917	0.6456	7.9210	0.2930	0.7070
2016	-0.1600	1.8726	0.9283	1.3787	1.7643	0.3501	0.4639	0.8823	0.5772	1.2757	6.5990	0.2440	0.7560
2017	-0.1681	-0.0677	0.0144	0.1169	-0.5656	-0.2904	-0.6134	-0.6173	0.2848	-1.1202	9.6580	0.3580	0.6420
2018	-0.0442	-0.2755	-0.7481	-0.0205	-2.1895	-0.0907	0.7743	0.3486	0.2471	2.3678	8.9880	0.3330	0.6670
2019	-0.3408	-1.1815	1.6136	0.4672	0.3549	-0.3834	-1.8186	-0.1252	1.3324	-1.2482	9.7530	0.3610	0.6390
2020	-0.3164	-1.0514	0.3941	-0.5899	1.2419	0.0502	-0.3364	-0.5243	0.0889	0.2213	9.2010	0.3410	0.6590
2021	-0.1131	-1.4949	-1.7126	-1.6375	-1.6007	0.5432	0.8142	-0.4705	-1.4391	-0.5181	10.9960	0.4070	0.5930
2022	-0.4899	2.1808	-0.1090	1.1351	-0.6401	-2.3129	2.7549	-0.2421	0.2468	-0.0880	9.2930	0.3440	0.6560
2023	-0.2005	0.9508	2.5617	2.0570	1.7880	3.0372	-1.6190	3.5044	2.1704	-0.3679	6.7610	0.2500	0.7500
2024	-0.5357	0.7938	-0.7589	-0.4888	0.8103	-1.1508	0.2234	-0.0421	-1.1889	0.5235	9.5970	0.3550	0.6450
Ideal	3.9923	2.1808	2.5617	2.0570	1.7880	3.0372	2.7549	3.5044	2.1704	2.3678	x	x	x

Source: Developed by the authors.

As a result of successive transformations of the initial data matrix, a new aggregated indicator–the economic development index (K_i)–was obtained. This index enables a comprehensive assessment of the business activity cycle of the analysed entity by capturing periods of stability, volatility, decline, and growth over 2006–2024 (*Fig. 1*).

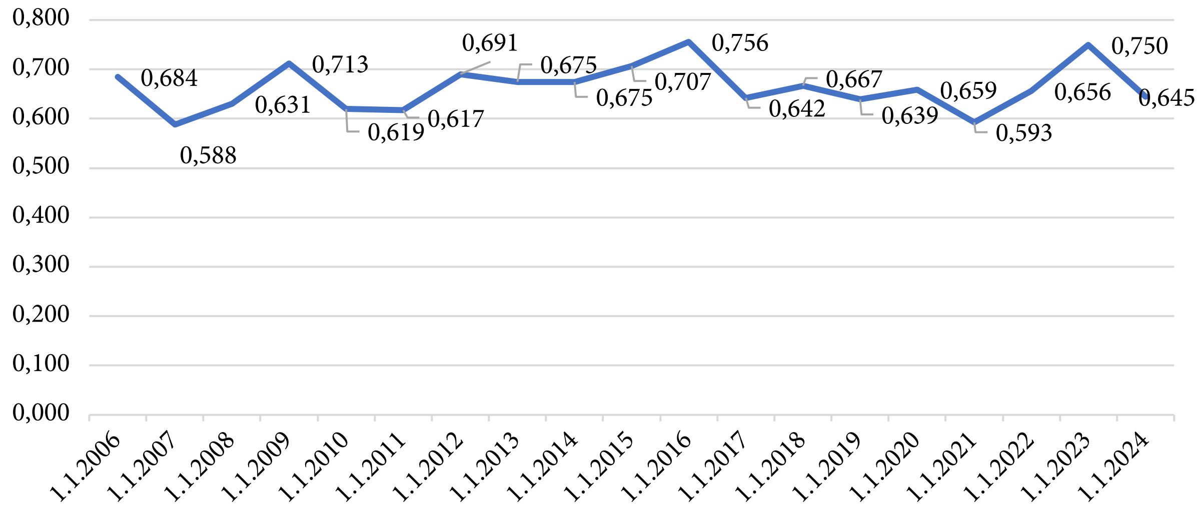

Figure 1. Title Dynamics of the economic development index of the analysed entity over 2006–2024 (case study of "Dominik Co" LLC).
Source: Developed by the authors.

For forecasting the dynamics of economic development, an economic–mathematical model was developed within the study using correlation and regression analysis. Its application and interpretation enable the estimation of the Economic Development Index and the assessment of factor impacts on the index for the analysed entity. In determining the relevance of heuristic methods, system analysis techniques, and expert judgement, the experts considered a set of critically important determinants required for constructing a multifactor model. This provided the basis for identifying the impact of four factors on the Economic Development Index (Y) of the analysed entity (using "Dominik Co" LLC as an example), which reflects the cyclical nature of business activity.

The selected factors represent indicators describing dynamics in liquidity, solvency, profitability, and financial sustainability, specifically the growth rates of: the autonomy ratio (X1), calculated as the ratio of equity to total capital and reflecting the firm's level of financial independence; the current solvency ratio (X2), computed as the ratio of current assets to current liabilities and characterising the enterprise's capacity to settle creditors' obligations in a timely manner; operating expenses (X3), i.e., the total costs directly associated with the core business activity–confectionery production; and the absolute liquidity ratio (X4), calculated as the ratio of cash and cash equivalents to total current liabilities and indicating the share of obligations that can be settled immediately.

In addition, an economic interpretation of the matrix of pairwise correlation coefficients was performed, which made it possible to identify factors that should not be simultaneously included in the model (Table 4).

Table 4. Matrix of Pairwise Correlation Coefficients.

Factors	X1i	X2i	X3i	X4i	Y
X1i	1.00000	0.71260	-0.21093	0.22630	0.56307
X2i	–	1.00000	-0.07597	0.52631	0.69065
X3i	–	–	1.00000	0.13864	0.37401
X4i	–	–	–	1.00000	0.69974
Y	–	–	–	–	1.00000

Source: Developed by the authors.

The obtained results indicate that the strongest relationship (0.71260) is observed between the levels of financial independence and solvency, which can be explained by the fact that both indicators are determined through the enterprise's liabilities ($X2_i$). The second and third positions in the ranking of importance are occupied by the two pairwise correlation coefficients between X4 and X2 and the economic development index (Y). This finding is substantiated by the core of financial and economic performance, which is fundamentally shaped by the firm's liquidity and solvency (Table 5).

Table 5. Strength and Direction of Relationships between Variables.

Pairwise correlation coefficient between variables	Interval of the absolute value of the pairwise correlation coefficient	Strength of relationship	Direction of relationship
r (X1, X2) = 0.71260	0.3<|rij|<0.8	Moderate relationship	Positive relationship
r (X1, X3) = -0.21093	0.1<|rij|<0.3	Weak relationship	Negative relationship
r (X1, X4) = 0.22630	0.1<|rij|<0.3	Weak relationship	Positive relationship
r (X1, Y) = 0.56307	0.3<|rij|<0.8	Moderate relationship	Positive relationship
r (X2, X3) = -0.07597	0.1>|rij|	Very weak relationship	Negative relationship
r (X2, X4) = 0.52631	0.3<|rij|<0.8	Moderate relationship	Positive relationship
r (X2, Y) = 0.69065	0.3<|rij|<0.8	Moderate relationship	Positive relationship
r (X3, X4) = 0.13864	0.1<|rij|<0.3	Weak relationship	Positive relationship
r (X3, Y) = 0.37401	0.3<|rij|<0.8	Weak relationship	Positive relationship
r (X4, Y) = 0.69974	0.3<|rij|<0.8	Moderate relationship	Positive relationship

Source: Developed by the authors.

Thus, the assessment of the strength of interrelationships among the explanatory variables allows us to conclude that the selected factors can be jointly included in a single model. As a result of the calculations, the multiple regression equation was estimated (Table 6).

Table 6. Parameters of the Correlation–Regression Model of Economic Development.

Model coefficients	Estimated coefficient values	Standard errors of coefficient estimates	t-statistic for model coefficients	Elasticity coefficients (Ki)
a0	-0.056405	0.195718	-0.2882	x
a1	0.519003	0.207761	2.4981	0.039
a2	0.037318	0.035312	1.0568	0.196
a3	0.120643	0.033395	3.6126	0.061
a4	0.016585	0.004996	3.3196	0.789

Source: Developed by the authors.

Accordingly, the correlation–regression model of economic development of the analysed economic entity is proposed in the following form:

$$Y = -0.056405 + 0.519003 \cdot X1 + 0.037318 \cdot X2 + 0.120643 \cdot X3 + 0.016585 \cdot X4 \quad (82)$$

In order to identify the factors exerting the greatest impact on the economic development index, the parameters of Equation (82) were interpreted as follows: ceteris paribus, an increase in the growth rate of the share of equity capital in total financial resources (X1) by one unit leads to an average increase in the economic development index (Y) by 0.519003; ceteris paribus, an increase in the growth rate of the current solvency ratio (X2) by one unit results in an average increase in the economic development index (Y) by 0.037318; ceteris paribus, an increase in the growth rate of operating expenditures–particularly their investment and innovation component (X3) by one unit contributes to an average increase in the economic development index (Y) by 0.120643; ceteris paribus, an increase in the growth rate of the share of highly liquid assets within the firm's current assets (X4) by one unit causes an average increase in the economic development index (Y) by 0.016585.

Since the explanatory variables included in Model (83) are expressed in different measurement units, a comparative assessment of their influence on the economic development index of the analysed entity requires normalisation of the regression coefficients. This is achieved through calculating the standardised beta coefficients (β_i), which reflect the relative contribution of each factor to the dependent variable:

$$b_i = \frac{a_i}{\overline{Y}}\overline{X_i}, \tag{83}$$

where a_i – the weight (regression) coefficient of the i-th explanatory variable X_i; $\overline{X_i}$ – the mean value of the i-th explanatory variable X_i; $\overline{Y}$ – the mean value of the dependent (result) variable.

After converting the regression coefficients into a comparable form, the regression equation was obtained in a standardised (normalised) form, which makes it possible to compare the strength of the factors' influence on the dependent (result) variable:

$$Y = 0.039 \cdot X1 + 0.196 \cdot X2 + 0.061 \cdot X3 + 0.789 \cdot X4 \tag{84}$$

The results of analysing Equation (84) provide grounds for determining the degree of influence of the selected factors on the economic development index of the analysed object. As a result, it was found that the share of highly liquid assets in working assets has the greatest influence on the economic development index of the analysed object, since the impact of this factor is seven times more significant than the influence of the other determinants. This conclusion is supported by the results of assessing the strength of the relationships between the factors included in the model (Table 6).

In order to assess the suitability of the model for forecasting the dynamics of the economic development index, a statistical evaluation of Model (8) was conducted using the data presented in Table 7.

Table 7. Parameters for Describing the Correlation–Regression Model.

Indicator	Value	Indicator	Value
Coefficient of determination	0.8322	Tabular value of the Fisher criterion	0.0702
Fisher criterion	17.36	Degrees of freedom	14.00

Source: Developed by the authors.

The value of the multiple coefficient of determination ($R^2 = 0.8322$) indicates that the dynamics of the economic development index are explained by the factors included in the model by 83.22%, while 16.77% is explained by other unaccounted determinants. According to the Fisher criterion, it can be stated that, with a probability of 0.99, the model is statistically reliable, since F = 17.36 exceeds the critical value Ftab = 0.0702. Therefore, it can be concluded that the proposed model is suitable for forecasting the dynamics of the economic development index of the analysed object by substituting probable values of the explanatory variables.

4. Discussion

This study proposes and validates an integrated heuristic–analytical framework for modelling, diagnosing, and forecasting the dynamics of economic development of a socio-economic system under crisis conditions. The approach combines heuristic structuring of diagnostic indicators (liquidity, solvency, profitability, and financial stability), taxonomic aggregation of multidimensional evidence into an integrated Economic Development Index, and an econometric correlation–regression model enabling quantitative identification of dominant endogenous drivers and forecasting of index trajectories.

A key methodological advantage of the proposed framework is its explicit recognition of uncertainty, incomplete observability, and imprecision of baseline information in turbulent environments. Under such conditions, heuristic methods within systemic analysis make it possible to incorporate expert knowledge, professional experience, and informed intuition, thereby compensating for missing or distorted information through economically meaningful heuristic hypotheses. This stance is consistent with broader methodological arguments emphasising the appropriateness of heuristics in complex systems where exact optimisation and fully formalised modelling are constrained by informational gaps and combinatorial complexity (Ordonez et al., 2025; Wiener, 2022). The present study extends this logic to crisis-driven socio-economic processes by formalising heuristics through indicator logic and subsequent quantitative modelling.

The constructed system of coefficients (K1–K10) operationalises the endogenous logic between liquidity, solvency, profitability, and financial stability and allows cyclical shifts between crisis and development stages to be captured as a structured trajectory. In contrast to conventional ratio analysis, which often interprets indicators in isolation, the proposed approach emphasises lead–lag relations and growth-rate comparisons, enabling the identification of internal dominants of development. The integrated index functions as a monocriterial instrument for complex analysis of system state dynamics along the time axis, aligning with classical ideas of synthesising multidimensional observations into interpretable composite measures (Aivazian et al., 1974; Wu, 2020).

Empirical results for "Dominik Co" LLC (2006–2024) confirm the diagnostic capacity of the index to reflect non-linear development trajectories, including crisis-related declines and recovery phases. The regression component indicates that liquidity-driven determinants–particularly the share of highly liquid assets in working assets–represent the strongest internal driver of the Economic Development Index. This finding supports the managerial interpretation that crisis resilience and development capacity depend critically on the internal liquidity architecture and the structure of working assets. In this respect, the study complements research demonstrating that constrained development outcomes depend on the efficiency of resource allocation; however, it shifts attention from macro- and project-level allocation to enterprise-level internal resource structure under crisis conditions (Bu et al., 2021).

In forecasting terms, the results contribute to ongoing debates between econometric and machine-learning approaches. While deep learning and neural network models have demonstrated strong predictive performance in certain contexts, interpretability and robustness under structural breaks remain key challenges for crisis forecasting (Berger, 2026; Hill et al., 1994; Zhang et al., 1998). Recent econometric forecasting research similarly stresses the importance of modelling strategies that remain reliable after large forecast errors and regime shifts. (Castle et al., 2025). The proposed approach prioritises interpretability and actionability, which is crucial when modelling outcomes should directly inform anti-crisis resource allocation decisions rather than purely maximise forecast accuracy.

At the same time, the findings should be interpreted with due consideration of the study's limitations. First, empirical validation relies on a single enterprise case, which restricts external generalisation of the quantitative results and factor dominance. Second, the heuristic construction of the indicator system is inherently dependent on expert judgement, which may introduce subjectivity and potential bias in indicator selection, weighting logic, and interpretation. Third, the taxonomic benchmark structure can be sensitive to extreme values and outliers, especially in wartime periods characterised by discontinuities. Fourth, the econometric model captures only a limited set of endogenous factors and does not explicitly incorporate exogenous shocks (e.g., regulatory interventions, supply chain disruptions, inflationary pressure), which may partly explain residual variation in the index trajectory. Finally, the framework is primarily deterministic and does not directly model probabilistic uncertainty or regime-switching behaviour, which may affect forecasting stability under abrupt structural changes. (Castle et al., 2025; Jia et al., 2020).

Overall, the study provides a coherent and practically oriented methodological toolkit that integrates heuristic systemic reasoning with taxonomic synthesis and econometric forecasting. Its primary contribution lies in enabling the identification of an enterprise development vector and the dominant internal determinants shaping crisis-development cyclicality, thereby strengthening the analytical basis for anti-crisis resource distribution and managerial decision-making.

Conclusions

The growing intensity of war-related shocks, together with pervasive globalisation and rapid digitalisation processes, has substantially transformed conventional approaches to forecasting and analysing the development of economic objects. The review of relevant information sources and methodological approaches to forecasting and dynamic analysis in the context of resource allocation and anti-crisis management confirms the multi-dimensional and multi-vector nature of the posed tasks. This complexity justifies the relevance of heuristic reasoning and systemic analysis as an appropriate methodological basis for the analytical substantiation of managerial decisions under uncertainty.

In this study, economic entities are conceptualised as dynamic economic systems, which determines the specificity of solving forecasting and analytical tasks related to economic development dynamics. On this basis, an integrated methodological approach is proposed, combining heuristic tools and systemic logic with formal quantitative procedures. The developed framework synthesises expert judgement in the formation of development parameters, taxonomic methods to construct an integrated Economic Development Index, and an economic-mathematical model based on correlation–regression analysis to quantify factor impacts on the index.

The empirical results demonstrate that the strongest interdependence in the financial and economic development of the analysed object is observed between financial independence and solvency indicators. This relationship is shaped primarily by the liquidity and payment capacity of the enterprise, which provides a justified foundation for determining the acceptable magnitude of obligations and for ranking the importance of determinants reflected through pairwise correlation coefficients with the Economic Development Index (Y). The analysis of the correlation–regression model parameters made it possible to identify the degree of influence exerted by the selected factors on the economic development index through the asset structure of the economic object under study.

Furthermore, the statistical evaluation of the model confirms its methodological applicability for forecasting the dynamics of the integrated economic development index. This substantiates the practical potential of the proposed framework as a decision-support tool for anti-crisis resource allocation, enabling more objective analytical justification of managerial interventions depending on the stage of the system's development trajectory and the internal configuration of liquidity, solvency, profitability, and financial stability.

Future research should focus on advancing the proposed methodological toolkit for forecasting and modelling economic development dynamics by explicitly addressing the challenges of analysis and synthesis under uncertainty of initial environmental conditions. In particular, improving forecast precision and decision robustness requires the integration of stochastic elements, stress-testing, and scenario-based analysis into the modelling architecture. Overall, existing evidence suggests that effective forecasting and analysis of economic development dynamics in the management of economic systems depends on a deeper understanding and incorporation of heuristic approaches in responding to emerging challenges, in substantiating resource allocation decisions, and in reorienting modelling methodology from stabilisation-centred frameworks toward approaches capturing self-organisation mechanisms in complex socio-economic systems.

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