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MODELLING THE DYNAMICS OF SUSTAINABLE DEVELOPMENT AND DIGITAL TRANSFORMATION OF ORGANIZATIONS

МОДЕЛЮВАННЯ ДИНАМІКИ РІВНЯ ГАРМОНІЙНОГО РОЗВИТКУ ТА ЦИФРОВОЇ ТРАНСФОРМАЦІЇ ОРГАНІЗАЦІЙ

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Харчук В.Ю., Павлюх І.П., Харчук В.Ю. Моделювання динаміки рівня гармонійного розвитку та цифрової трансформації організацій. Науково-методична стаття.

На сьогодні проблематика кількісного оцінювання та відслідковування динаміки рівня гармонійного розвитку та цифрової трансформації організацій є малодослідженою, особливо з точки зору використання кількісних та якісних показників та врахування очікувань зацікавлених сторін, стосовно такого розвитку. Автори розвинули методологію, яка поєднує врахування зазначених аспектів, використовуючи набір показників, запропонований міжнародними стандартами GRI та підходу MIND, які розроблені для оцінювання зазначених аспектів. У статті пропонується використовувати інструментарій багатомірного шкалювання для одночасного ідентифікування рівня гармонійного розвитку та цифрової трансформації та отримати узагальнене уявлення про наближення чи віддалення такого розвитку стосовно очікувань стейкхолдерів. На додачу у статті представлено застосування розвинутої методології на прикладі Корпорації «Енергоресурс-інвест».

Ключові слова: гармонійний розвиток, цифрова трансформація, багатомірне шкалювання

Kharchuk V.Yu., Pavliukh I.P., Kharchuk V.Yu. Modelling the Dynamics of Sustainable Development and Digital Transformation of Organizations. Scientific and methodical article.

Today, the issue of quantitatively assessing and tracking the dynamics of sustainable development and digital transformation in organizations is underexplored, particularly regarding the use of both quantitative and qualitative indicators and the expectations of stakeholders for such development. The authors have developed a methodology that considers these aspects by utilizing a set of indicators proposed by the international GRI standards and the MIND framework, which are intended to evaluate these dimensions. The article advocates for employing a multidimensional scaling toolkit to simultaneously gauge the levels of sustainable development and digital transformation, while providing a comprehensive understanding of the alignment or deviation of such development concerning stakeholder expectations. Furthermore, the article illustrates the application of the developed methodology through the example of Energoresurs-Invest Corporation.

Keywords: sustainable development, digital transformation, multidimensional scaling

In recent years, sustainable development and digital transformation topic become an object of interest and a question of heated debate among various actors. Specifically, policymakers, state and local government representatives, business organizations, researchers and civil society organizations made significant contributions toward discussing its strategic and sustainable vision, key goals and challenges, areas of action and possible ways of cooperation. The challenges outlined above are particularly significant for organizations aiming to integrate sustainable development and digital transformation into their business processes. This necessity arises not only from current business practices in the Eurozone but also from the need to achieve a long-term, resilient competitive advantage in the market. One of the key challenges facing Ukrainian organizations is the requirement to simultaneously evaluate the current level of their initiatives for sustainable development and digital transformation while also tracing the progression of these initiatives in accordance with stakeholder expectations. This approach enables the simultaneous identification of the most effective initiatives for sustainable development and digital transformation, providing a comprehensive overview of the organization's overall progress in these areas. Therefore, developing a tool to assess the level of sustainable development and digital transformation is both relevant and timely. This tool will facilitate tracking their progress while considering stakeholder requests.

Analysis of recent researches and publications

To the best of our knowledge, numerous publications directly or partially contributed to shedding light upon sustainable development and digital transformation of organizations. In the scientific literature from both Ukrainian and international scholars [1-12], there is currently no unified framework for assessing the state or level of sustainable development in organizations. Researchers predominantly focus on developing assessment procedures tailored to individual enterprises [1, 5, 7, 11], specific economic sectors [3, 4, 6], or regions [9, 10, 12]. A common element within this set of studies is the clear delineation of sustainable development areas (spheres), which is subsequently followed by the identification of relevant indicators and the utilisation of appropriate mathematical tools aligned with the objectives of the analysis. In addition, several authors [2, 13, 14] present methodologies that encompass the creation of a composite indicator, the establishment of an assessment scale, or the formation of clusters of organizations regarding companies' sustainability or digital transition. It is worth mentioning that analysing the level of companies' digital transition has become an area of particular interest for scholars over the last decade. Specifically, the authors [15] pay attention to developing a comprehensive model, which includes such aspects as strategy and governance, to navigate their digital transition. In contrast, Cosa, M. and Torelli, R. [16] made an extensive literature analysis on the evolution of performance measurement systems related to the digital transition of organisations. Interestingly, Verhoef et al. [17] present a multi-layered framework that investigates digital transformation within the organization by examining its core and peripheral activities along with its external environment. The given framework highlights the intricate interconnectedness of various organizational elements involved in the digital transformation process. Other insightful approaches towards determining the level of sustainable development and digital transformation are the methodologies developed by international rating organizations, such as B Corporation, the Dow Jones Sustainability Index, S&P Global Ratings, and MSCI ESG Ratings [18-21]. These approaches commonly involve conducting external expert assessments of organizations, which lead to the creation of a composite indicator for measuring their progress in sustainability and digital journey. In addition, companies are assigned a certain rank in the general rating of organizations, in terms of the level of their sustainable development or digital transformation, respectively. Although significant progress has been made in understanding and assessing the sustainable development and digital transition phenomenon, further research is needed to develop comprehensive and adaptable frameworks that can effectively address the multifaceted nature of these processes and be easily implemented by Ukrainian companies under current circumstances.

Unsolved aspects of the problem

Based on the analysis of the research and practical developments mentioned above, it becomes possible to outline the key features of assessing an organization's level of sustainable development and digital transformation, and outline the aspects that need to be addressed:

1) sustainable development and digital transformation within each organization will be characterized by distinctive features determined by the specifics of the industry, market, size of the organization, its production process, philosophy, vision, and development goals etc. The vast majority of scientific research and successful business practices emphasize the importance of engaging with stakeholders. This cooperation involves conducting a two-way dialogue, based on their requests and demonstrating the implemented changes that correlate with the most relevant aspects of the organization's activities. Therefore, addressing stakeholders' expectations, which often vary, is a crucial requirement when developing a methodology and choosing mathematical tools needed to model the level of sustainable development and digital transformation;

2) sustainable development and digital transformation within an organization possess inherently open and adaptive characteristics. These characteristics emerge as a result of a multitude of unpredictable factors, trends, and changes that can occur in both external and internal environments. Therefore, it is crucial to consider the multifaceted and dynamic nature of these processes.

Despite the availability of numerous assessment models and frameworks, assessing challenges continue to arise due to the evolving and complex nature of sustainable development and digital transition, along with the diverse challenges that Ukrainian companies are dealing with.

The aim of the article is to develop the methodology for modelling the dynamics of an organization's sustainable development and digital transformation from the perspective of key stakeholders' expectations. In addition, the article demonstrates the application of the developed methodology using a case study of a Ukrainian company.

The main part

The outlined task and the above-mentioned features of analysing sustainable development and digital transformation can be effectively addressed by using the multidimensional scaling (MDS) toolkit [22-26]. In the context of the current study, the essence of MDS is to simultaneously present the levels of sustainable development and digital transformation within the organization alongside the ideal vision of such development defined by stakeholders within a specific theoretical framework. It is important to emphasise that MDS also enables the identification of latent factors that may influence the organization's ability to achieve a certain level of sustainable development and digital transition. As a result, these identified factors can be subject to theoretical interpretation that enables an understanding of the interactions among the characteristics of the subject being studied.

It is important to stress that MDS is widely utilized in research to analyse sustainable development. Specifically, in the study by Yudhari et al. [24], researchers assessed the sustainable development of coffee tourism in Bali based on four sustainability dimensions: economic, environmental, socio-cultural, and institutional. At the business entity level, Mecaj and Bravo [27] employed MDS to evaluate the impact of financial crises on policy changes and the implementation of corporate social responsibility measures, specifically focusing on American companies classified as either "healthy" or "problematic". Additionally, the application of MDS in the research conducted by Deutsch and Berényi [28] is particularly noteworthy. The study analyses the way students from three Hungarian universities perceive sustainable development and corporate social responsibility. This research provides valuable insights into students' awareness of these concepts and highlights key aspects based on their aggregated responses regarding the perception of global issues within the EU and the environmental impact of various industries.

To sum up, the MDS toolkit has been utilized in research primarily to analyze sustainable development implications. However, its application in examining sustainable development at the level of business entities, specifically in modelling such progress concerning the primary needs of stakeholders, has been less common. Therefore, there is an increasing need to enhance the process of modelling sustainable development and digital transition through the application of multidimensional scaling tools at the company level.

In light of this study, it is suggested to employ MDS to model the dynamics of sustainable development and digital transition for the Ukrainian business case. This approach will also enable the comparison of the company's sustainability and digital transition levels with the key stakeholders' expectations. The implementation of this procedure will involve a specific sequence of steps, as outlined in Figure 1.

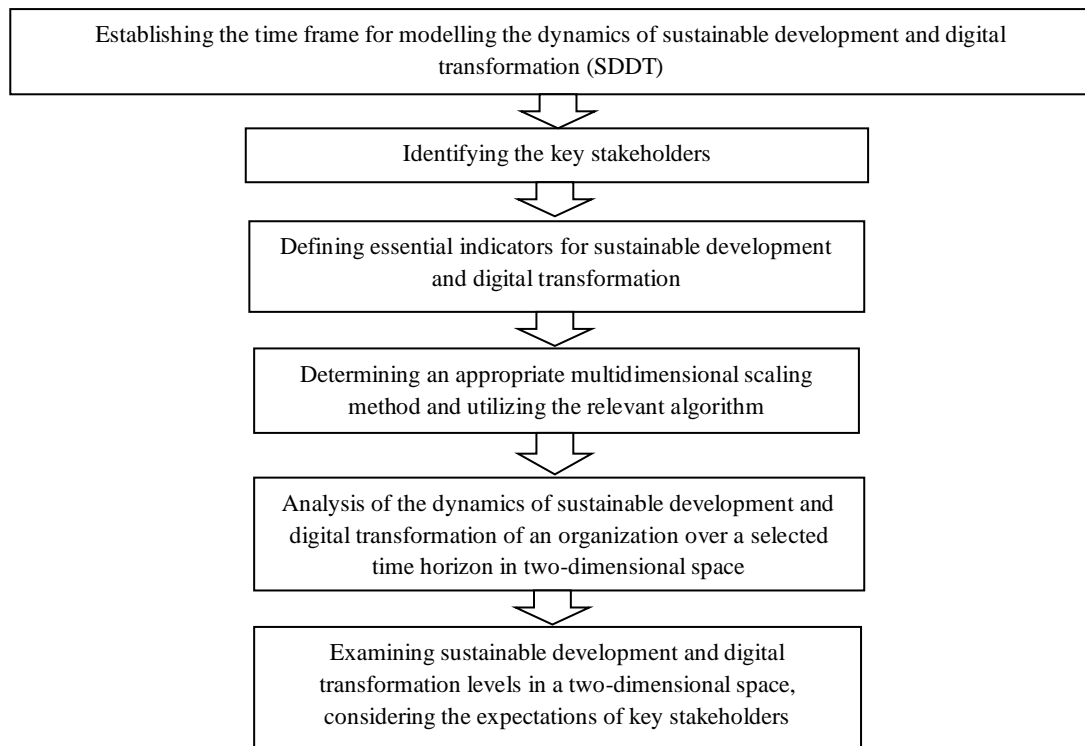


Figure 1. Methodology for modelling the dynamics of an organization's sustainable development and digital transformation from the perspective of key stakeholders' expectations

Source: compiled by authors on materials [4, 15, 23, 29]

The first stage of the proposed methodology involves determining the goals and timeframe of the modeling process. It is a well-known fact that the determination of goals and time horizons is the prerogative of each organization. The latest is influenced by various factors, including company needs, the presence or absence of sustainability and digital transition indicators (that reflect implemented initiatives to initiate and maintain these developments), the management's strategic vision for the company's future, its life cycle, the peculiarity of the value chain, communication with stakeholders, etc. For the analysis, we have selected the Energoresurs-Invest Corporation, due to its comprehensive data set on business sustainability and digital transition efforts. The designated timeframe encompasses the last three calendar years: 2022, 2023, and 2024. The second stage of modeling envisages the identification of key stakeholders. Owners, managers, and consumers have been selected as the key stakeholders. The third stage of the developed methodology entails the input of actual values for key indicators pertaining to sustainable development and digital transformation within the organization over the last three years. Furthermore, it incorporates the input of expected values of these indicators from the perspective of the key stakeholders that were selected in the previous stage. For this purpose, indicators based on the well-known

Global Reporting Initiative (GRI) methodology were utilized to assess the sustainable development of Energoresurs-Invest [30]. Additionally, the MIND framework was applied to evaluate the current state of the organization's digital transformation [31]. Since some values of the indicators are represented as qualitative statements, specifically "yes" or "no", we represent them as Boolean variables [32]. Specifically, for indicators that have a "yes" value in the original sample, we assigned a value of "1". Conversely, for indicators with a "no" value, we represented them as "0". To ensure that the data is comparable and yields relevant results, we utilized a standardization procedure. It is worth noting that this study utilizes the non-metric multidimensional scaling method (NonMetricMDS) [22] due to the simultaneous existence of both quantitative values of characteristics (key indicators of sustainable development and digital transformation) and qualitative variables.

According to the MDS algorithm, the next step is to create a matrix of differences or similarities. This matrix is generated by calculating the Euclidean distances between points (Formula 1), which is possible due to the lack of correlation between the independent variables [25, 26]:

$$\delta_{rs} = \sqrt{(x_r - x_s)'(x_r - x_s)} = \left(\sum_{i=1}^p (x_{ri} - x_{si})^2 \right)^{1/2}, \quad (1)$$

were δ_{rs} – the distance between the points,

x_{ri}, x_{si} – coordinate values of characteristics in space.

The SPSS software package is used to calculate Euclidean distances.

The next stage of the NonMetricMDS procedure is the metric stage, which consists of refining the coordinate estimates based on the initial data on the distances between stimuli in the theoretical space. This procedure is carried out according to the Lingoes-Roskam formula [33]:

$$x_{ik}^{c+1} = x_{ik}^c - \frac{1}{j} \sum_j \left(1 - \frac{d_{ij}^{c+1}}{d_{ij}^c} \right) (x_{ik}^c - x_{jk}^c), \quad (2)$$

were x_{ik}^{c+1} – new estimates of coordinates,

d_{ij}^c та d_{ij}^{c+1} – original and refined distances between the characteristics of the sustainable development and digital transition (stimuli) in the theoretical space.

This procedure is executed automatically using the STATISTICA software package. A critical aspect of utilizing the MDS toolkit involves the determination of eigenvalues and the construction of the point matrix representing the newly derived two-dimensional theoretical space. In order to determine the optimal number of dimensions using the elbow criterion [26]. This method involves plotting the relationship between stress values (the eigenvalues of the matrix) and the dimensionality of the newly constructed space. The point at which we observe a noticeable inflexion or a sharp decline indicates the appropriate number of dimensions (see Figure 2).

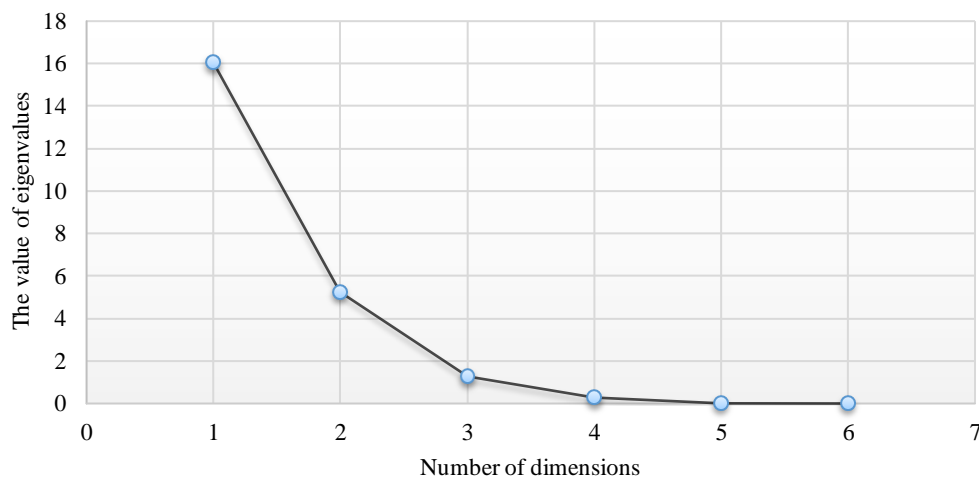


Figure 2. Graph of stress versus dimension of new space
Source: authors' own elaboration

Hence, the presented graph suggests the presence of a two-dimensional space suitable for analyzing the sustainable development and digital transformation of the Energoresurs-Invest Corporation. The application of NonMetricMDS to model the dynamics of sustainable development and digital transformation of the Energoresurs-Invest Corporation, using the STATISTICA software package, yielded the following results, which are presented graphically in Figure 3.

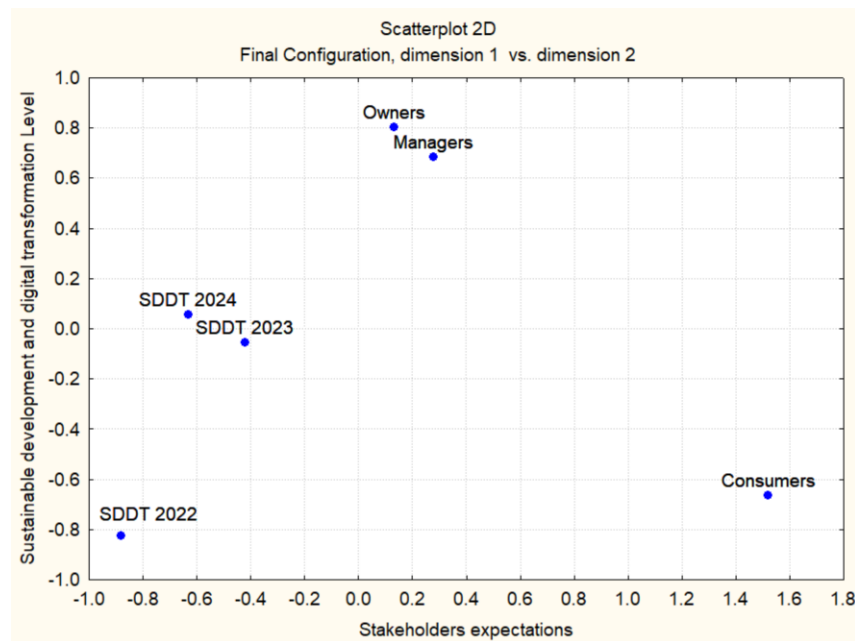


Figure 3. Graphical interpretation of the results of modelling the dynamics of the sustainable development and digital transformation levels of the Energoresurs-Invest Corporation and its expected levels from the point of view of key stakeholders. Notes: 1) SDDT – sustainable development and digital transformation level of the corresponding year (2022-2024)

Source: authors' own elaboration

Notably, the points SDDT2022, SDDT2023, and SDDT2024 (Figure 3) represent the levels of sustainable development and digital transformation of the corporation based on the assessment for the corresponding years. Each point serves as a composite indicator, derived from key metrics assessing the sustainable development and digital transformation of the Energoresurs-Invest Corporation. Analyzing changes in this composite indicator enables us to identify the trajectory of sustainable development and digital transformation levels within the theoretical space, particularly in relation to key stakeholders' expectations.

The verification of the obtained results is conducted by calculating J. Kruskal's stress formulas (3–5) and comparing them with the recommended threshold values [26]:

$$S_1 = \left[\frac{\sum_{ij} (d_{ij} - \hat{d}_{ij})^2}{\sum_{ij} \hat{d}_{ij}^2} \right]^{\frac{1}{2}}, \quad (3)$$

$$S_1 = \left[\frac{\sum_{ij} (d_{ij} - \hat{d}_{ij})^2}{\sum_{ij} (d_{ij} - \hat{d}_{ij})^2} \right]^{\frac{1}{2}}, \quad (4)$$

де d_{ij} – standardized distances,

$\hat{d}_{..}$ – the arithmetic mean of all estimated distances, which is calculated by the formula [26]:

$$\hat{d}_{..} = \frac{1}{ij} \sum_{ij} d_{ij}. \quad (5)$$

The stress test calculations were performed using the STATISTICA software package, yielding a result of $S_{1,2}=0.000$. According to the corresponding tabular value, the obtained result indicates a high level of reliability for the present study [26].

The next stage of the proposed methodology (Figure 1) involves analyzing the dynamics of changes in sustainable development and digital transition levels. In particular, over the analyzed period, the sustainable development and digital transition level of Energoresurs-Invest has shown significant improvement (Figure 3). This is evidenced not only by the positioning of the corresponding points in the newly constructed space but also by the analysis of the initial data for the specified time frame. Over the past two years, the company has successfully implemented various measures to advance its sustainable development and digital transformation across economic, environmental, and social spheres. Since its establishment, the Energoresurs-Invest Corporation has operated profitably while putting significant attention on environmental protection. The initial focus on certain aspects of the social dimension, such as corporate governance and organizational culture, received limited improvements and was not effectively communicated to key stakeholders, despite some positive developments. In

contrast, the last two analyzed periods have shown significant advancements in stakeholder engagement and enhanced business transparency. Specifically, we found evidence of this through increased communication via the company's official website, the establishment of new partnerships, and the expansion of publicly available official documents. Additionally, the application of multidimensional scaling provides a structured approach to outlining and tracking the trajectory of changes in the organization's sustainable development and digital transformation. This methodology enables an assessment of whether such development remains static or dynamic and ultimately facilitates an evaluation of its overall improvement or decline.

The final stage of the proposed modelling methodology (figure 1) involves analyzing the dynamics of changes in the organization's sustainable development and digital transformation levels from the perspective of key stakeholders. The positioning of points in Figure 3, representing these levels, provides insight into the extent to which both the current state of development and its trajectory over the analyzed period have converged with or diverged from specific stakeholder groups' expectations. This analysis facilitates evidence-based adjustments to strategic and tactical planning, enabling a reassessment of stakeholder engagement methods, communication channels, and overall interaction strategies. The obtained modelling results (presented in Figure 3) indicate that the sustainable development and digital transformation of the Energoresurs-Invest Corporation align more closely with the vision of its owners and managers while, to a lesser extent, reflecting the perception (expectations) of its consumers. Specifically, 2023 stands out as a pivotal year, during which a significant shift in the organization's sustainable development and digital transformation levels has occurred. This period marks a clear convergence with the managerial vision on these developments, while simultaneously representing the closest alignment with consumer perceptions of sustainability and digitalisation. In contrast, the subsequent period (2024) is characterized by a slight shift in the trajectory of sustainable development and digital transformation toward the expectations of the company's owners. This change may be attributed to the broader impact of the full-scale invasion of Ukraine, which likely influenced the company's strategic priorities. In response, the organization appears to have focused primarily on preserving employee well-being, safeguarding material assets, cybersecurity, data protection, and maintaining financial stability. The findings of this study are particularly valuable for the company's leadership, as they provide an opportunity to reassess the overall development strategy and potentially place greater emphasis on addressing consumer needs and expectations concerning the company's sustainable development and its digital transformation.

Conclusions

The results obtained through the utilization of the developed methodology for modelling the dynamics of an organization's sustainable development and digital transformation from the perspective of key stakeholders' expectations provide valuable insights for both reconsidering the organization's corporate strategy, maintaining its sustainable development, and supporting digital transformation. Specifically, it contributes to the following:

- 1) monitoring organizations' sustainable development and digital transformation as a set of initiatives and measures implemented throughout the analyzed period;
- 2) identifying the direction of the organization's sustainable development and digital transformation. Specifically, to trace the trajectory of the organization's sustainable development and digital transformation during the analyzed time frame and identify the presence of multi-vector nature of such development in relation to key stakeholder's expectations;
- 3) determining periods in which the organization's sustainable development and digital transformation significantly converged with or diverged from specific stakeholder groups' expectations;
- 4) outline stakeholder groups for whom the current level of sustainable development and digital transformation remains most distant, indicating a misalignment with their expectations.

Future research will be focused on developing a comprehensive business model for the effective integration of sustainable development principles and digital transformation initiatives into business processes.

Abstract

Introduction. In recent decades, the subjects of sustainable development and digital transformation have received considerable attention and have ignited vigorous discussions among a wide array of stakeholders. Policymakers, representatives from state and local governments, business organizations, researchers, and civil society groups have all played vital roles in advancing discussions surrounding the strategic vision, key objectives, challenges, areas for action, and potential avenues for collaboration. The challenges identified are particularly important for organizations seeking to incorporate sustainable development practices and digital transformation principles into companies' business models. The given approach emerges not only from contemporary business practices observed within the Eurozone but also from the necessity of attaining a long-term, resilient competitive advantage in the marketplace.

The purpose of the study is to develop the methodology for modelling the dynamics of an organization's sustainable development and digital transformation from the perspective of key stakeholders' expectations. Research methods. This article utilizes a multidimensional scaling (MDS) toolkit, in particular NonMetricMDS to model the dynamics of sustainable development and digital transformation levels of the Energoresurs-Invest

Corporation from the perspective of the key stakeholders' expectations. The STATISTICA software package is being used for all calculations.

Results of the study. The authors have developed a methodology aimed at assessing the level of organisations' sustainable development and digital transformation simultaneously enabling tracing their trajectory concerning key stakeholders' expectations. As a base for assessment, the authors have used a set of indicators derived from the international GRI standards and the MIND framework, which are designed to evaluate the level of sustainable development and digital transformation of the company. The article advocates for employing a multidimensional scaling toolkit to simultaneously gauge the levels of sustainable development and digital transformation while providing a comprehensive understanding of the alignment or deviation of such development concerning stakeholder expectations. In addition, the article demonstrates the application of the developed methodology using the case of Energoresurs-Invest Corporation.

Conclusions. The results obtained through the utilization of the developed methodology for modelling the dynamics of an organization's sustainable development and digital transformation from the perspective of key stakeholders' expectations provide valuable insights for reconsidering the organization's corporate strategy, maintaining its sustainable development practices, and supporting digital transformation with the collaboration of companies stakeholders.

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