

GOVERNANCE TOOLS FOR STAKEHOLDER INTERACTION IN THE INNOVATION ECONOMY

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Abstract

How to cite this paper: Ostapenko, V., Tyshchenko, V., & Naidenko, O. (2026). Governance tools for stakeholder interaction in the innovation economy. *Journal of Governance and Regulation*, 15(1), 30–40. <https://doi.org/10.22495/jgrv15i1art3>

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ISSN Print: 2220-9352

ISSN Online: 2306-6784

Received: 28.02.2025

Revised: 13.06.2025; 23.07.2025; 17.12.2025

Accepted: 31.12.2025

JEL Classification: C65, D80, O30

DOI: 10.22495/jgrv15i1art3

This paper explores governance tools designed to enhance stakeholder interaction within innovation policy frameworks, particularly in the context of Ukraine's dynamic and crisis-affected economy. The study addresses the lack of structured and adaptive information and analytical support (IAS) necessary for effective collaboration among education, science, and business actors. Using a process-spatial modeling approach based on the function modeling IDEFO methodology and ERwin Model Navigator, the research develops a comprehensive governance model that integrates institutional levels, resource flows, and temporal dynamics. The proposed IAS framework supports data-driven decision-making, transparency, and coordination across stakeholder groups, offering actionable mechanisms for shaping responsive and inclusive innovation policies. The model covers international, national, and regional levels and identifies key IAS resources (financial, intellectual, technological, etc.) and time intervals (pre-2019 sustainable development, COVID-19 crisis 2020–2021, and wartime economy from 2022). The analytical tools employed include strategic, operational, qualitative, and causal methods. The findings offer a systematized framework for improving collaboration among stakeholders and forming policy-relevant strategies in innovation ecosystems. The research builds on the conceptual foundations of Schumpeter (1911) and the stakeholder-focused innovation system approach of Lundvall (1992), contributing to ongoing efforts to strengthen Ukraine's integration into global innovation processes.

Keywords: Information and Analytical Support, Innovative Economy, Stakeholders, Education, Science, Business, Resources, Levels, Time Intervals, Structural and Functional Modeling, IDEFO

Authors' individual contribution: Conceptualization — V.O.; Methodology — V.O.; Investigation — V.T. and O.N.; Resources — V.T. and O.N.; Writing — Original Draft — V.O., V.T., and O.N.; Writing — Review & Editing — V.T.; Supervision — V.O. and V.T.; Funding Acquisition — V.O., V.T., and O.N.

Declaration of conflicting interests: The Authors declare that there is no conflict of interest.

1. INTRODUCTION

The current challenges of European integration of Ukraine's economy, its globalization in the context

of highly dynamic global technological progress, and Ukraine's significant lag in modernizing its own production and economic capacities are exacerbated by the financial, economic, and political crises and

the escalation of hostilities with Russia. All of this requires the formation of an effective system of economic management, especially in the innovation sector, as the basis for development. The ongoing European integration of Ukraine and the intensification of global technological transformations highlight critical gaps in the country's capacity to develop a resilient innovation economy. Ukraine continues to face significant challenges due to outdated industrial infrastructure, fragmented institutional frameworks, and the destructive consequences of geopolitical instability. These factors expose a literature gap related to the insufficient integration of information and analytical support (IAS) systems into models of stakeholder interaction in the innovation economy. While studies by Schumpeter (1911), Lundvall (1992), and Foray (2004) laid the conceptual foundation for innovation systems, there remains a need for applied models that reflect the specific context of countries in transition, such as Ukraine.

IAS is a type of scientific and information activity that, in the context of European integration and globalization of information and economic processes, should be clearly focused on Ukraine's innovative development, commercialization of ideas, research, and development results, etc. This study addresses the urgent necessity to develop a comprehensive and structured system of IAS that fosters effective interaction among key stakeholders in education, science, and business. The research aims to conceptualize and implement a process-spatial model that integrates strategic, operational, and contextual elements of IAS. The central research question is structuring of the IAS model enhances the coordination, performance, and strategic development of stakeholder interaction in Ukraine's innovation economy under varying socio-economic conditions.

Theoretical grounding is based on the systems approach and Triple Helix concept (Etzkowitz & Leydesdorff, 2000), complemented by the IDEF0 methodology for functional modeling. This combination allows for decomposing complex stakeholder relationships into analyzable components, using resources, levels of interaction, and time intervals as key structuring dimensions. Methodologically, the paper employs structural-functional modeling with ERwin model navigator IDEF0 to map out logical relationships between elements of the IAS system.

The relevance of this study lies in its ability to provide a flexible model for adapting innovation policy tools to crisis conditions, such as those posed by the COVID-19 pandemic or wartime disruptions, while also aligning Ukraine's innovation system with international benchmarks (Freeman, 1982; Foray, 2004; Shin et al., 2023). The findings offer both theoretical insights and practical recommendations for improving innovation governance and stakeholder collaboration mechanisms.

Significant changes necessitate consideration of the state and trends of interaction between education, science, and business stakeholders in problematic areas and will allow for determining the prospects for the development of Ukraine's innovative economy in the future. At the same time, maximizing the result directly depends on the IAS — the completeness, reliability, and relevance of the information received by its participants at each stage.

It is important to develop a transition from the processes of passive accumulation of information to its transformation into a holistic, clearly oriented strategy for potential users of a highly effective knowledge system. This reform requires, first of all, an in-depth study of the methodological and practical foundations of IAS for the innovation sector by European experience. IAS should perform the task of qualitative and substantive transformation of primary information, with functional overlap with scientific (production of new knowledge) and managerial (development of alternative solutions, scenarios) activities.

Therefore, it is necessary to further clarify and systematize the formation of IAS for the interaction of education, science and business in the innovation economy, which allows to determine the trends and effectiveness of interaction between stakeholders of education, science, and business in the innovation economy, on the basis of which it is advisable to make public administration decisions, on the one hand, and to carry out constant monitoring in order to adjust further strategies for innovative development. Theoretical and methodological aspects of IAS of the innovation sphere, taking into account the high level of dynamics and prospects for the development of the Ukrainian economy, require additional research.

The structure of this paper is as follows. Section 2 provides a literature review and highlights key theoretical contributions to the understanding of stakeholder interaction in the innovation economy. Section 3 outlines the methodological approach and modeling tools applied. Section 4 presents the results of the proposed IAS system, including its structural components and modeling diagrams. The final Section 5 concludes with key takeaways and potential applications of the proposed model in national and international contexts.

2. LITERATURE REVIEW

Authors from different countries offer different perspectives on the interaction between education, science, and business in the context of the innovation economy. Schumpeter (1911) on the innovation economy and the concept of creative destruction remains fundamental to understanding the interaction between innovation and economic development. Freeman's (1982) study is known for its research on the innovation economy and technological modes. His work can help in understanding the interaction between education, science, and business in the context of innovation development. Nelson (1993) has made a significant contribution to the theory of innovation economics on the role of institutions and public administration in the development of innovation. Lundvall (1992) is known for his approach to innovation economics, which emphasizes the importance of interaction between different stakeholders, including education and business, for the development of innovation. Foray (2004) has been working on the innovation economy and the role of education and science in this context. Author emphasizes the importance of knowledge as a key resource in the modern economy and views innovation as materialized scientific and technical ideas that have been recognized by

the consumer market. His work focuses on the interaction between different stakeholders in innovation systems, including education, science, and business. He supports the idea that innovation is not limited to the laboratories of universities and research centers, but is an organic part of economic processes.

Sotirofski (2024) conducts a literature review with the aim of summarising existing research on innovation ecosystems with a focus on open innovation and value creation. By analysing conceptual models, empirical studies, and practical conclusions, the author offers a comprehensive overview of the mechanisms, challenges, and opportunities that shape these ecosystems and emphasises the role of networks, regulatory frameworks, and organisational capabilities in stimulating innovative growth and sustainable development in dynamic and interconnected innovation ecosystems.

Linton (2024) identifies critical factors such as collaboration, commercialisation, innovation, and adaptation. This study provides new theoretical insights and practical conclusions on the use of hybrid organisations within the Triple Helix model, thereby providing valuable recommendations for policymakers, practitioners, and researchers involved in developing strategies to stimulate regional growth, innovation, and value creation in today's dynamic global environment.

Khan et al. (2022) and Desai et al. (2025) analyse the factors underlying the success and failure of collaboration between universities and industry in the field of digitalisation, focusing on cases from 2020 to 2024, and examine typical challenges that lead to failure, such as poor planning and lack of trust. By analysing both successful and unsuccessful collaborations, the study aims to provide a balanced and realistic view of the critical factors influencing these partnerships in order to identify best practices and avoid repeating mistakes in future collaborations.

Vola and Gransinigh (2025) contribute to the ongoing discourse on sustainable development reporting by examining the previously mentioned frameworks in detail. Its primary objective is to assess the extent to which the suggested regulations and practices align with the core principles and findings of stakeholder theory in the existing academic literature. Misra and Wilson (2023) investigated how stakeholders use digital tools, human resources, and combinations thereof to gather information and make decisions in innovation ecosystems. They found that stakeholders used digital tools to search for "high-level" information to support initial decision-making efforts, but ultimately relied on contextual information provided by human networks to make final decisions.

Shin et al. (2023) propose new measurement methods and social media data as a new empirical source of assessment. The authors focused on

a specific funding programme, Tandem Industry-Academia (TIA), launched by the Finnish Foundation for research impact in 2020, and found a growing trend towards diversification of public discourse and knowledge clusters. However, TIA did not improve interaction between clusters, which is a necessary condition for joint evolution. Akter et al. (2024) identify sources of data-driven innovations (DDI) opportunities for addressing various global challenges. The results show three main foundations of DDI opportunities: market orientation, infrastructure orientation, and talent orientation.

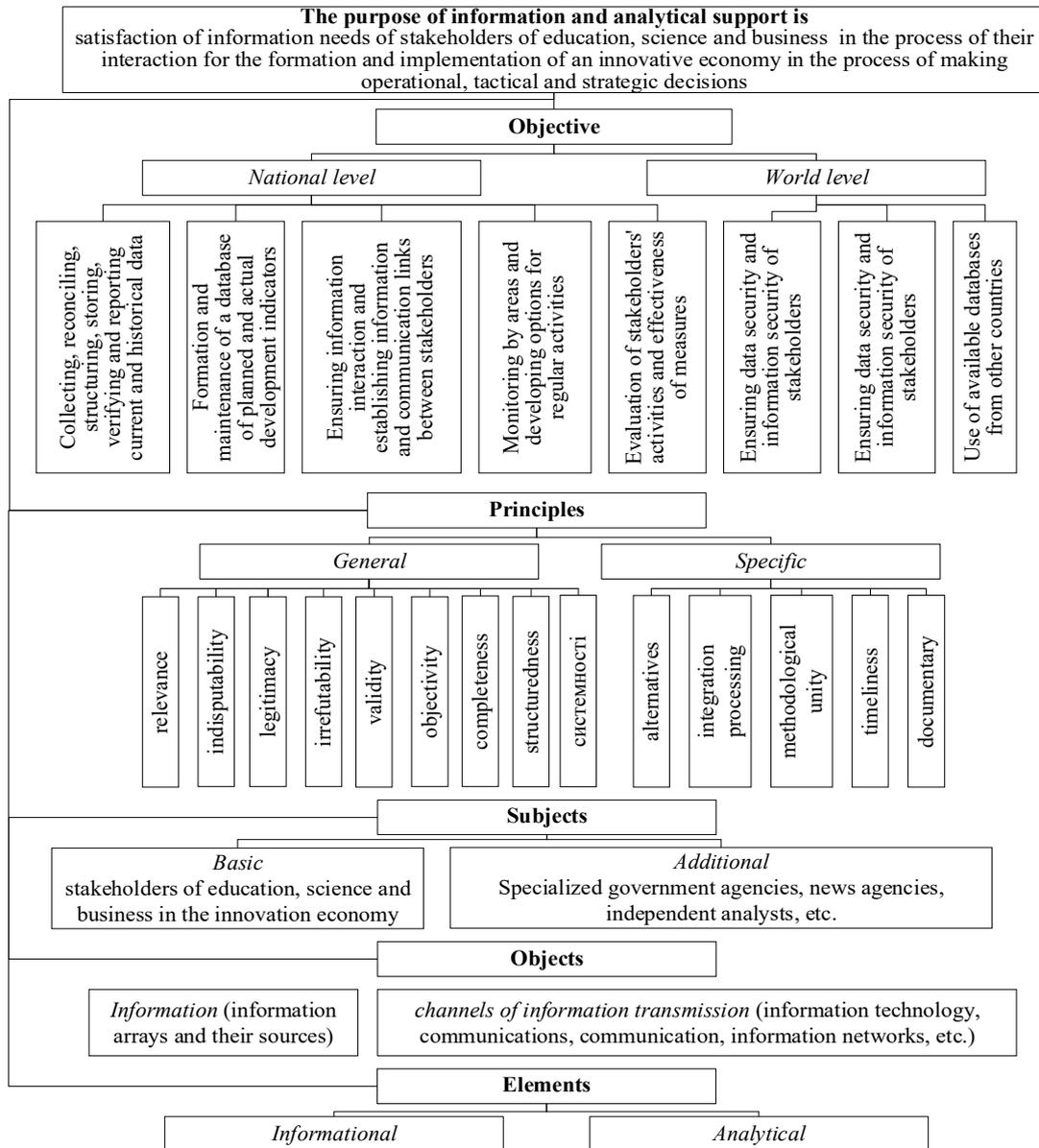
Process-spatial modelling means integrating process-based and spatial data approaches to understand, support, and optimise interactions between key stakeholders — education, science, and business — in the context of an innovation-based economy. This approach is increasingly recognised as necessary to promote effective collaboration, knowledge sharing, and sustainable economic development. In order to understand the process-spatial modeling and IAS, which are key to studying the interaction between education, science, and business in an innovative economy, Rostoka (2023) substantiates the expediency of clustering IAS, which allows for a deeper understanding of the results of scientific research and identifies the main areas of research. Varenko (2023) is devoted to the role of modeling in information processes, in particular, the disclosure of hidden information and its impact on effective decision-making in analytics.

2.1. System of IAS for interaction of stakeholders of education, science, and business in the innovation economy

Following the above-mentioned approaches to defining the essence of IAS, it is necessary to understand the organizational and methodological provisions of the formation of the information space, which includes process, activity, and methodological aspects of collecting, processing, analyzing, evaluating, and presenting information about social relations (social, political, economic, migration, international, legal and other) (as objects of managerial influence) and/or activities of public administration entities (both in terms of managing operational activities). The components of the IAS system are the goal, objectives, principles, objects, and subjects (see Figure 1).

The system of IAS for the stakeholders' interaction of education, science, and business in the innovation economy (see Figure 1) should take into account the priority areas of development of the innovation economy, the availability of resources, and the specifics of stakeholders of education, science, and business and should cover all levels of public administration in both the temporal (operational, tactical, strategic) and spatial aspects, in particular in the context of structural levels of the management system.

Figure 1. A system of IAS for the stakeholders' interaction of education, science, and business in the innovation economy



Source: Authors' elaboration.

2.2. Resource component of the information element of the IAS for the stakeholders' interaction of education, science, and business in the innovation economy

As part of the system of IAS for the stakeholders' interaction of education, science, and business in the innovation economy, it is necessary to take into account its elements related to the stages of information and analytical activities: direct information, which involves the search, collection (accumulation), storage of the resource component of information, as well as the transmission and dissemination of this information. The analytical element involves activities designed to evaluate information and prepare for managerial decision-making.

The resource component of the information element is the formation and use of various sources of information (see Table 1). Taking into account Table 1, it should be noted that the number of regulatory legal acts is to some extent sufficient, but their inconsistency, lack of provisions regulating organizational and technological processes in working with information, unification of the procedure for preparing and making management decisions, requirements for the use of electronic information resources and information security indicate the imperfection of the studied regulatory framework. One of the main problems with surveys in general is that there are usually only a few opportunities to link survey data to official statistics or other survey data. In this way, the survey can provide information on relevant control variables, such as the impact of different policy instruments.

Table 1. Resource component of the information element of the IAS for the stakeholders' interaction of education, science, and business

<i>Resource</i>	<i>Characteristics</i>	<i>Examples</i>
Legislative and regulatory acts	Legislative and regulatory acts governing the processes of obtaining, processing, using, and disseminating information.	Laws of Ukraine "On the National Informatization Program", "On the Concept of the National Informatization Program", "On Electronic Documents and Electronic Document Management", "On Information Protection in Information and Telecommunication Systems", "On the Basic Principles of Development of the Information Society in Ukraine for 2007-2015", CMU Decrees "On Approval of the Concept of Formation of the System of National Electronic Information Resources", "On Approval of Measures and Implementation of the Concept of Formation of the System of National Electronic Information Resources".
	Legislative acts that form the regulatory framework for the activities of stakeholders in education, science, and business, as well as the innovation economy.	The Strategy of Innovative Development of Ukraine for 2010-2020 in the Context of Globalization Challenges; the Strategy of Sustainable Development "Ukraine – 2020"; national and regional development programs; national and regional legislation.
Reports (international, industry, and market)	High-level reports that describe global market trends, such as market growth forecasts, key barriers and drivers of growth, and market size information.	Reporting and analytical materials of the State Statistics Service of Ukraine, data of the World Bank, data from the Eurostat statistical database, results of domestic and foreign scientific research, and analytical information from agencies.
Online databases/information services, data services, platforms	Digital resources that provide access to a large amount of structured information. They allow you to search, analyze, and visualize data to make decisions in the scientific, educational, and business fields.	ProZorro, Research4Life, etc., platforms, and the online resource Scopus. Citizens' appeals to state authorities to realize their legitimate interests and subjective rights (servicing and protection of citizens' rights and freedoms).

Source: Authors' elaboration.

2.3. Governance tools for implementing analytical support in education-science-business interaction within the innovation economy

The analytical element of interaction between stakeholders of education, science, and business is implemented based on certain types of analysis (see Table 2).

The first group of approaches allows assessing the internal and external landscape of the prospects for making a decision, but does not operate on parameters that are directly related to the characteristics of the invention and the stage of its possible transformation into an innovation. The second group of approaches allows for a more in-depth assessment of the risks on the way to innovation and determines what criteria

an invention must meet to become an innovation. However, this approach is subjective, as the analysis is conducted only by the inventor. The third group of approaches is the most appropriate for implementation in innovation transfer processes. These approaches can take into account two (Ansoff matrix), three (Abel matrix and four (Balanced scorecard measures) groups of factors, determine the interval value of a group of factors for expanding strategic positions (GE McKinsey matrix). At the same time, the proposed methods are characterized mainly by qualitative assessment indicators and consideration of expert opinions, which also adds elements of subjectivity to the results of the analysis. These methods also do not take into account the importance of factors in each group.

Table 2. Governance tools for implementing the analytical element of IAS for the stakeholders' interaction of education, science, and business

<i>Type of analysis</i>	<i>Characteristics</i>	<i>Governance tools</i>
Operational	Designed to analyze and optimize business processes in the short term.	Relevant and operational analysis, margin analysis, cost-volume-profit (CVP) analysis, and operational pricing.
Strategic	Help to obtain information about business processes in the long term. This information is necessary for making management decisions related to the goals.	Investment and strategic analysis, strategic pricing, life cycle analysis, value chain analysis, business process mapping, ABC, XYZ, strengths, weaknesses, opportunities, and threats (SWOT) analysis; functional and value analysis (FVA); Ansoff and Abel matrices; GE McKinsey matrix; strategic position and action evaluation (SPACE) matrix; balanced scorecard measures.
Qualitative	Allows for assessing the internal and external landscape of prospects/unpromising decision-making.	SWOT; local, national, global, political, economic, social, technological, legal, and environmental factors (LONGPESTEL); specific, measurable, achievable, relevant, and time-bound factors (SMART); political, economic, socio-cultural, and technological factors (PEST); political, economic, social, technological, legal, and environmental factors (PESTEL); political, economic, social, technological, environmental, legal, and industry factors (PESTELI); social, technological, economic, environmental (ecological), and political factors (STEEL).
Causal and quality control	Allows for a deeper assessment of risks and determining what criteria the target should meet. However, this approach is subjective, as the analysis is conducted by experts.	Ishikawa method, Deming-Schuchart cycle.

Source: Authors' elaboration.

In the process of implementing the analytical element (see Table 2), it is possible to use both a single type of analysis and a set of relevant techniques with a detailed description of certain aspects. Regarding the level of measurement of control variables for different types of analysis, it will always be the best solution to analyze interval data, since the number of missing values for these questions will be very large, and the results of the analysis are likely to be biased. Among a large number of approaches to analyzing internal and external factors influencing the decision-making process, it is advisable to select only certain governance tools for analysis. The main criterion for choosing among the list of tools is the ability to use them to achieve the goal and obtain the necessary information.

3. RESEARCH METHODOLOGY

For the development of applied foundations of IAS for the interaction of stakeholders in education, science and business, it is advisable to apply a systematic approach to meet the needs of the innovation economy, so it is proposed to apply the methodology of structural and functional modeling IDEF0 (originally, structured analysis and design technique — SADT) based on the ERwin Model Navigator IDEF0 software. Function modeling is a methodology of functional modeling and graphical description of processes designed to formalize and describe business processes. IDEF0 considers the logical relationships between activities, emphasizing the hierarchical representation of objects. The IDEF0 standard describes a set of methods, procedures, and rules designed to build a functional model of an object in any subject area. A functional model reflects the functional structure of an object, i.e., the actions it produces and the relationships between these actions. The IDEF0 model provides an overview of the entire system.

To develop the applied foundations of IAS for the interaction among stakeholders in education, science, and business, this study adopts a systematic and structured modeling approach. Specifically, the methodology of structural and functional modelling IDEF0, SADT, is applied using the ERwin model navigator IDEF0 software. This method enables a hierarchical graphical representation of system functions, relationships, and resources, providing clarity in the design of complex socio-economic processes. The IDEF0 methodology is particularly well-suited for modeling stakeholder interaction systems, as it allows for the decomposition of processes into manageable and logically connected components. The resulting process-spatial model includes diagrams, textual annotations, and glossaries that collectively describe the organization and flow of information and decision-making across different levels of stakeholder engagement. Each diagram is composed of functional blocks and links, where the position and type of link define the interface (input, control, output, or mechanism), thus reflecting the systemic interdependencies within the IAS. The implementation of the IDEF0 model in this study facilitates the visualization and analysis of the organizational, structural, and temporal dimensions of interaction between education, science, and business. It forms a robust basis for strategic development, allowing the identification of key decision points, bottlenecks, and opportunities for optimization.

While IDEF0 provides a strong foundation for functional modeling, several alternative or complementary methods could also be applied to deepen the analysis or expand the research. Business process model and notation (BPMN) offers a detailed and standardized way to describe business processes with specific event-driven actions and workflow logic. BPMN is particularly useful for software implementation or operational-level modeling. System dynamics modeling (SDM) is suitable for simulating the behavior of complex systems over time. It could help in understanding the long-term dynamics and feedback loops in stakeholder interactions. Agent-based modeling (ABM) allows for the simulation of autonomous actors (stakeholders) and their interactions within an innovation ecosystem. ABM is effective for exploring emergent phenomena and behavioral patterns. Data flow diagrams (DFD) focus on how information moves through a system, which could complement IDEF0 by detailing data sources, sinks, and transformation processes. Network analysis and mapping can be used to visualize and analyze the relationships between different stakeholders in terms of communication, influence, or collaboration intensity. Scenario planning and the Delphi method are useful for strategic foresight and expert-based validation of stakeholder roles and processes under uncertain future conditions. Each of these methods provides a different analytical lens and could be integrated into further research phases to validate and refine the IAS model or to adapt it for specific sectoral or regional contexts.

The result of the application of this standard is a process-spatial model of IAS for the interaction of education, science, and business stakeholders in the innovation economy, which will consist of diagrams, text fragments, and glossaries that have links to each other. This software will allow us to better model all organizational, structural, and temporal processes of interaction between education, science, and business stakeholders in the innovation economy.

Diagrams are the main components of the process-spatial model. All functions and interfaces in the diagrams are represented as blocks and links. The place where a link is connected to a block determines the type of interface. A specific role is demonstrated by the links that underlie the rectangle representing the system, in our case, the basis for developing a strategy for the development of interaction between education, science, and business stakeholders in the innovation economy.

4. RESULTS

4.1. Structuring of the IAS for the interaction of education, science, and business stakeholders

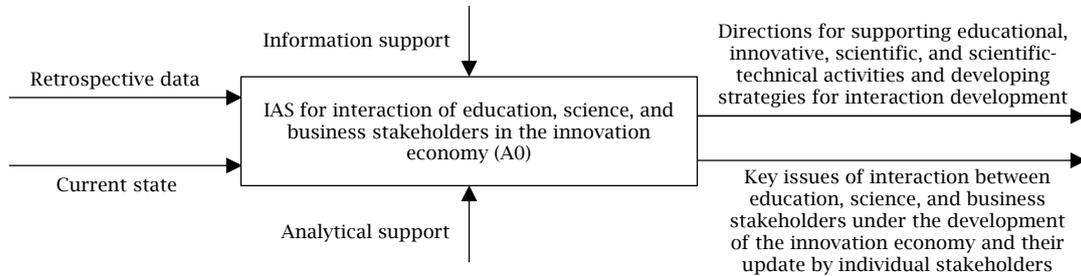
Figure 2 shows a prototype of an interactive dashboard that allows visualizing the generally accepted methods used to analyze the interaction of education, science, and business stakeholders.

The result of the implementation of the process-spatial model of IAS (see Figure 2), i.e., the initial data, is to identify the main problems of interaction between stakeholders of education, science, and business in the context of the development of the innovation economy and their actualization by individual stakeholders, to separate the areas of support for educational, innovation, scientific and scientific and technical activities and to develop a strategy for

the development of their interaction. To achieve this result, retrospective data and the current state of interaction between education, science, and business stakeholders in the innovation economy should be used as the basic (initial) data. An important feature of the IDEF0 methodology is the gradual

introduction of all levels of detail of the IAS after refining/specifying the diagrams that reflect the model. That is, each stage of the IAS is subject to decomposition, and the rectangular blocks denoting the stage and the constituent elements of the system are detailed or clarified/specified.

Figure 2. A prototype of an interactive dashboard that allows visualizing the formation of IAS for the interaction of education, science, and business stakeholders

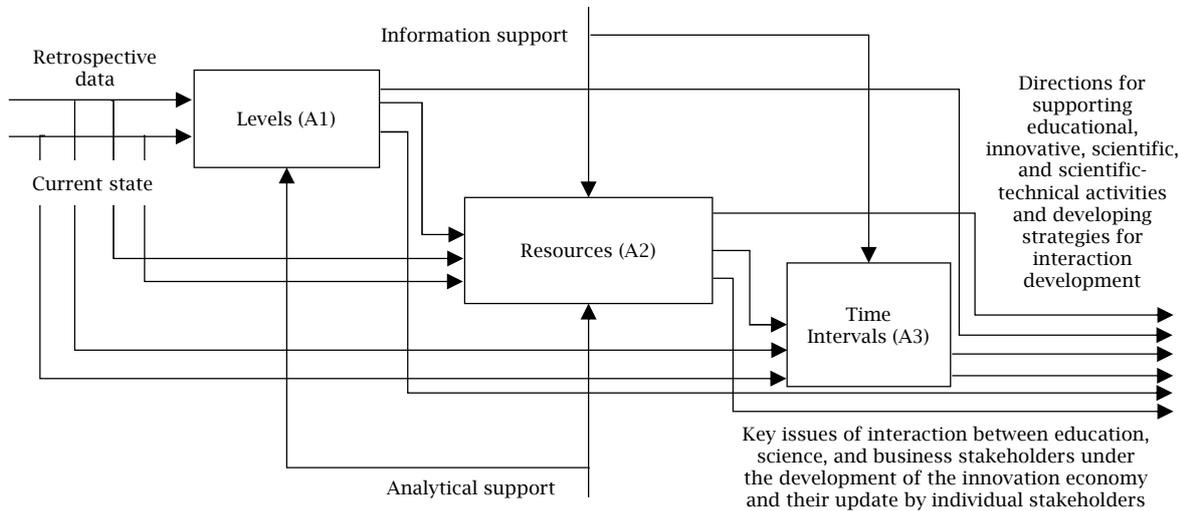


Source: Authors' elaboration.

The three stages obtained as a result of detailing the IAS for the interaction of education, science, and business stakeholders in the innovation economy (see Figure 3) are connected by arrow links that demonstrate the sequence of implementation of these stages to achieve the result. The proposed three stages of implementation of IAS for the stakeholders' interaction of education, science, and business provide for their further specification (see Figures 4-6). This specification of the IAS model reveals the key aspects of the process and possible elements. Each of the decomposition diagrams (A1, A2, A3) demonstrates the internal structure of

IAS on the basis decomposition of the functional diagram model A0 (Figure 2). All managerial influences, relationships, and resources of the contextual diagram A0 (Figure 2) are described in the form of links. Within the framework of this model, this means that these links are connected to all sub-stages and may not necessarily be shown in the decomposition diagram A0 (Figure 2). If necessary, some links may be specified in subsequent stages of the decomposition. Figure 2 demonstrates the system as a whole and can be further detailed in the diagram shown in Figure 3.

Figure 3. Decomposition of the functional diagrammatic model "IAS for the stakeholders' interaction of education, science, and business", A0



Source: Authors' elaboration.

The model in Figure 3 consists of three stages, namely levels (A1), resources (A2), and time intervals (A3). Clear spatial, resource, and time structuring of IAS increases the likelihood of achieving a positive result, but it will still be iterative, as it is characterized by significant uncertainty — both in terms of results and the perception of their value by stakeholders. Each of these sub-functions is demonstrated in the context diagram (tunnel connections). An auxiliary management link for all

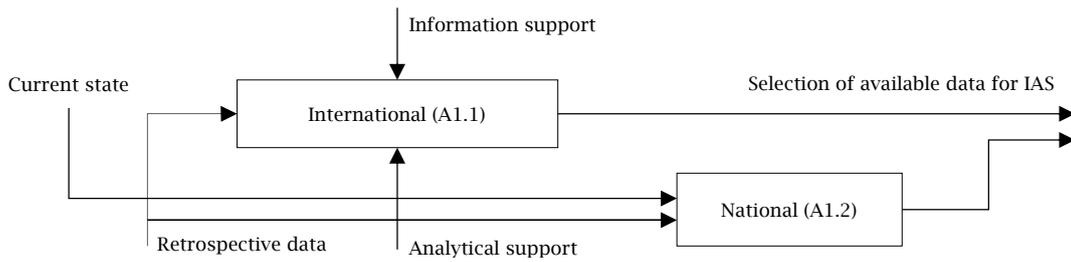
stages and elements is feedback in the form of corrective actions. It is they that make it possible to manage the formation and development of stakeholder interaction and guarantee the successful performance of the process-spatial model. This sequence allows us to detail the criteria for searching and identifying possible sources for IAS, analyze them, and draw the necessary conclusions in order to improve the interaction of stakeholders in education, science, and business in the innovation economy.

4.2. Levels of interaction between education, science, and business stakeholders in the innovation economy

For stage A1 “Levels” (Figure 4), it is important to differentiate IAS according to the level of interaction into international and national levels. In turn, the national level can be disaggregated by regional and organization or stakeholder levels, while the international level can be studied, on the one hand, as Ukraine’s positioning among other countries.

The directions of analysis presented in Figure 4 areas of analysis provide an opportunity to gain a deeper understanding of how the country interacts with other actors at the national and international levels, as well as to identify the strengths and weaknesses of its development, positioning of the country among other countries of the world, compare the elements of analysis presented in international and national sources of information and identify priority areas for development in accordance with various strategic goals.

Figure 4. Decomposition of the diagram “Levels” within the context model “IAS for the stakeholders’ interaction of education, science, and business”, A1



Source: Authors’ elaboration.

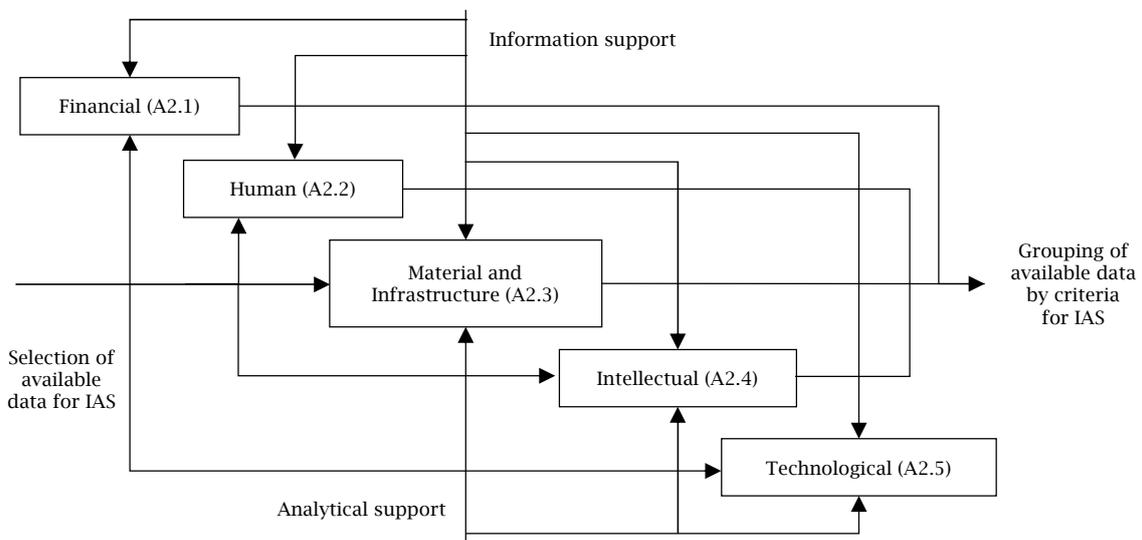
At this stage, it is advisable to select and analyze the structural components of various sources of information, which may include an analysis of the interaction of stakeholders in education, science, and business in the innovation economy. As for the international level, it is advisable to identify those sources in which Ukraine is represented. The world is developing rapidly, and this is happening in various ways. Nowadays, the speed of change is extremely high, which puts different demands on society to adapt and respond. This can mean more opportunities for development, but it can also bring challenges in managing change and ensuring stability. Technological advances, economic changes, socio-cultural trends, and other factors contribute to constant change. This can be

both a positive and a negative aspect, depending on the specific circumstances. In researching and analyzing these dynamics, it is important to consider and compare a wide range of factors and indicators to get a fully objective picture of the situation and understand what factors are driving change and how they may affect the future.

4.3. Resources for interaction between education, science, and business stakeholders in the innovation economy

Using the selected components, it is advisable to distribute them according to the proposed resources (see Figure 5).

Figure 5. Decomposition of the diagram “Resources” within the context model “IAS for the interaction of stakeholders in education, science, and business in the innovation economy”, A2



Source: Authors’ elaboration.

Decomposing these resources will help us better understand what elements are needed for successful stakeholders' interactions of education, science, and business in the innovation economy and how to manage them to achieve common goals.

4.4. Time intervals of interaction between education, science, and business stakeholders in the innovation economy

Schwab et al. (2020) offer a detailed description of the priorities for restoring and reviving competitiveness, as well as consideration of the transition to new economic systems that combine "productivity", "personality", and "planet" goals.

In 2021, the World Economic Forum (WEF) returned to the comparative analysis of the global competitiveness of countries. The special issue analyzes historical trends in competitiveness factors, as well as the latest reflections of WEF experts on the future priorities of the global economy. Thus, the recommendations are presented in three time frames:

- priorities arising from historical analysis before the financial crisis;
- priorities that are needed to restart the economy, beyond the immediate response to

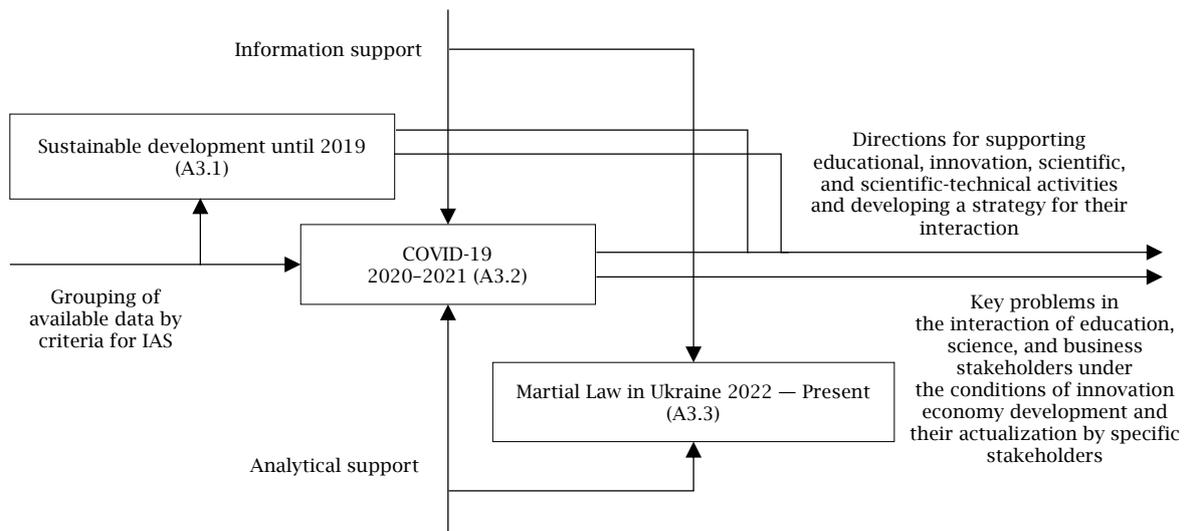
the COVID-19 crisis, while simultaneously including the population of the entire planet in economic policy (revival over the next 1–2 years);

- priorities and policies needed to reboot economic systems in the long term to achieve sustainable and inclusive prosperity in the future (transformation over the next 3–5 years).

Therefore, it is proposed to analyze the following time periods: sustainable development (until 2019), COVID-19 (2020–2021), and martial law in Ukraine (from 2022 to the present), which involve global changes in the world (Figure 6). These time periods differ significantly in the interaction of stakeholders, education, science, and business in the innovation economy and, accordingly, create new directions for strategic goals.

The decomposition of the diagram "Time intervals" for the context model "IAS of stakeholders interaction of education, science, and business in the innovation economy" (Figure 6) can be detailed, taking into account the following time intervals. Sustainable development (until 2019) involves the development and implementation of strategies based on the principles of sustainable development. Implementation of projects and programs to support sustainable development in these sectors.

Figure 6. Decomposition of the diagram "Time intervals" within the context model "IAS for the interaction of stakeholders of education, science, and business in the innovation economy", A3



Source: Authors' elaboration.

The global pandemic has had a profound impact on economic activity. However, in many ways, this crisis differs from previous macroeconomic crises. In this context, it is advisable to monitor the impact of the COVID-19 pandemic on educational, scientific, and business processes, develop and implement measures to adapt to new conditions, including distance learning, research, and development of strategies to overcome the negative consequences.

In a war economy, an innovative renewal of all social and economic relations is necessary to ensure Ukraine's postwar economic development. This is a period of significant transformation and restructuring of many sectors of the economy and society as a whole: increasing the degree of openness of the national economy to European

integration processes, on the one hand, and its vulnerability to destructive, even devastating military operations in the eastern regions and in the south of Ukraine, on the other, necessitates the search for effective ways to reform and restructure the system of innovation development at the regional and national levels, accelerate the processes of restoring not only knowledge-intensive production and All of this requires monitoring the situation on the military front and studying its impact on educational, scientific and business processes, developing and implementing measures to maintain stability and support the development of industries in wartime, managing risks and seeking opportunities for cooperation and innovation in times of crisis. These time periods

reflect global changes and challenges that affect the interaction between stakeholders in education, science, and business in the innovation economy. Responding to such changes requires analysis, strategic planning, and effective coordination between different stakeholders.

5. CONCLUSION

This research presents a structured approach to modeling IAS for the interaction of stakeholders in education, science, and business within the innovation economy. By applying process-spatial and structural-functional modeling (particularly the IDEF0 methodology), the paper proposes a three-level model that considers institutional levels, resource elements, and time intervals. These analytical frameworks help visualize and enhance stakeholder interaction across operational, tactical, and strategic layers.

As a result of the implementation of the IAS, the interaction of education, science, and business stakeholders within the national economy, or in comparison with other countries of the world (based on the definition), in general and by component composition is carried out, identifying strengths and weaknesses, advantages and disadvantages, problems and prospects for the development of their interaction.

This system will contribute to the formation of an effective system of management of information resources in the innovation sphere: solving problems related to the need to improve the domestic legislative, regulatory, and legal framework for scientific, technical, and innovation activities; development of state standards in the innovation sphere, harmonization with International Organization for Standardization (ISO) standards to ensure their compatibility and integration; introduction of monitoring of information resources (to establish effective information exchange, avoid duplication in the formation of information resources).

Thus, according to the study's results, the essence and structure of IAS for the interaction of stakeholders in education, science, and business in the innovation economy are investigated, and a system is formed, including the purpose, objectives, principles, objects, subjects, and elements. Modeling of IAS for the interaction of stakeholders in education, science, and business in the innovation economy is carried out.

Stakeholder-based modeling, including system dynamics and geospatial stakeholder-based modeling, brings together stakeholders from different fields (science, industry, government) to jointly identify problems, develop models, and simulate the impact of various measures. This process promotes mutual

understanding, personalizes connections with common challenges, and builds consensus on practical solutions. The inclusion of geospatial data and modeling allows stakeholders to visualize the spatial distribution of resources, knowledge flows, and innovation hubs, clarifying the scope of influence and decision-making authority. Spatial modeling helps identify where intervention is most needed and where joint efforts can have the greatest impact. Process modeling reflects workflows, interactions, and knowledge sharing among stakeholders, highlighting bottlenecks and opportunities for improvement.

The findings of this study have several practical implications. First, the developed IAS model can serve as a foundation for policymakers aiming to strengthen coordination among educational institutions, research centers, and business entities. Second, it supports the formulation of evidence-based decisions by emphasizing the role of data structuring and analytical tools in monitoring innovation ecosystems. Third, the model can be adapted for international benchmarking and for evaluating Ukraine's positioning in the global innovation space.

Despite the comprehensiveness of the proposed model and its applicability to Ukraine's innovation ecosystem, this study has several limitations. The reliance on the IDEF0 methodology and ERwin Model Navigator, while effective for structural-functional modeling, may not capture the full dynamism or feedback mechanisms present in real-time stakeholder interactions. The research draws heavily on secondary data sources and expert-based analytical methods, which can introduce subjectivity and limit replicability. While the model accounts for national and international contexts, it may require adaptation for sector-specific applications or for innovation systems in different geopolitical or economic environments.

From the perspective of future research, this study opens several promising directions. The proposed methodological framework can be further developed through the application of dynamic simulation models or ABM, which would allow for the analysis of evolving stakeholder interactions over time under varying scenarios. Applying the model in a cross-country context would enable comparative assessments and the identification of best practices in managing IAS within different innovation ecosystems. Future investigations could incorporate participatory and stakeholder engagement methods to empirically validate, test, and enhance the proposed IAS structure, ensuring its practical applicability and responsiveness to real-world conditions.

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