Modern Conditions of Development of Science, Education and Production in the World – 2026

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CHAPTER 1. MODERN BASICS OF ECONOMICS, MANAGEMENT AND TOURISM

1.1. Improvement of Tactical Planning of Foreign Economic Activity Based on an Algorithm for Evaluation and Selection of Priority Foreign Sales Markets

Under conditions of intensifying globalization processes and increasing competition in international markets, effective tactical planning of enterprises' foreign economic activity becomes crucial for ensuring sustainable development and enhancing competitiveness. Particular importance is attached to the ability of enterprises to rapidly adapt to changes in the external environment through the well-founded selection of priority sales markets, which directly affects the effectiveness of export activities.

Tactical planning of foreign economic activity serves as a tool for detailing the strategic goals of an enterprise in the short- and medium-term perspective, ensuring alignment between resource capabilities and market conditions. At the same time, traditional approaches to selecting foreign markets often fail to consider the complexity of influencing factors, which leads to insufficiently justified resource allocation and the loss of potential development opportunities.

In this context, the development of an algorithmic approach to the evaluation, selection, and prioritization of foreign sales markets becomes particularly relevant, as it allows systematizing the decision-making process and increasing its validity. The use of such an algorithm contributes to reducing uncertainty, optimizing managerial decisions, and improving the effectiveness of tactical planning of foreign economic activity of the enterprise.

The relevance of the research is driven by the need to improve the effectiveness of managerial decision-making in the field of enterprises' foreign economic activity under conditions of a dynamic and unstable international environment. Modern markets are characterized by high volatility, intensified competition, changes in regulatory requirements, and the growing influence of geopolitical risks, all of which complicate the process of selecting priority export directions.

Most enterprises face the problem of fragmented approaches to foreign market assessment, where decisions are made based on isolated indicators or expert judgments without the use of a systematic toolkit. This reduces the quality of tactical planning of foreign economic activity and limits the possibilities for effective utilization of the enterprise's resource potential.

In this context, there is a need to develop a consistent, multicriteria algorithm for the evaluation and selection of foreign sales markets that would ensure objectivity, transparency, and reproducibility of managerial decisions. Such an approach allows for the integration of economic, logistical, competitive, and risk-related parameters into a unified evaluation system, which is an important tool for improving the tactical planning of an enterprise's foreign economic activity.

The planning hierarchy within an enterprise can be represented as a system of nested and interrelated cycles, where each lower level specifies and concretizes the directives of a higher level. Tactical planning serves as an instrument for strategy

implementation, ensuring the linkage between global objectives and the actual capabilities of the organization. It enables a clear allocation of tasks among functional and line departments, taking into account available resources and time constraints (Table 1) [1].

Tactical planning is characterized by a lower level of subjectivity compared to strategic planning, as managers at this level operate with more detailed and specific information. The implementation of tactical decisions is associated with lower risk, since they mainly address internal organizational issues and resource provision, which is easier to forecast. Moreover, tactical results are easier to evaluate because they are expressed in specific quantitative indicators.

Table 1. Comparative analysis of planning types within an enterprise

Planning level	Nature of decisions and time horizon	Main objects and tasks
Strategic	Long-term (3–5+ years), conceptual, high level of risk	Mission, market selection, general development direction
Tactical	Medium-term (1–3 years), specific, based on quantitative methods	Resource allocation, interdepartmental coordination, operational conditions
Operational	Short-term (up to 1 year: quarter, month), highly detailed	Specific actions, schedules, performance standards

It should be noted that tactical planning tends to be associated with middle and lower levels of management, covering individual regional or functional units. It ensures the integration of efforts across different departments: for example, based on a sales plan developed by the marketing department, production planning, material and technical supply planning, and financial planning are carried out. Thus, the tactical level serves as a "coordination hub," where abstract strategic ideas are transformed into a coordinated set of actions for each workshop or department.

The importance of tactical planning also lies in its role as a realism filter. Strategic plans may be ambitious, but it is the tactical analysis of capabilities and resources that determines whether an organization can implement these plans within the specified time frame. The detailing of tactical plans in time and space, as well as the establishment of intermediate goals and tasks, continues within the operational planning process, thereby completing the integrated planning cycle of the enterprise.

The functions of tactical planning are specific types of work, procedures, and actions carried out during the planning process and aimed at changing the state of the enterprise in the desired direction [2]. The successful achievement of organizational goals largely depends on how fully and effectively these functions are performed, in particular:

1. Goal-setting and decomposition function – involves transforming strategic objectives into a system of specific, measurable indicators for each department;
2. Resource function – focuses on determining the exact need for financial, material, and human resources required to implement planned production and sales volumes;

3. Coordination function – ensures interconnection between different functional areas (marketing, production, logistics, finance), helping to avoid resource conflicts;
4. Optimization function – involves selecting the most efficient ways of utilizing capacities and capital to maximize results while minimizing costs;
5. Control and incentive function – relates to establishing a basis for performance monitoring and developing personnel motivation systems based on the achievement of planned targets.

The classification of tactical planning makes it possible to structure this complex process according to various criteria (Table 2). Understanding the types of planning helps to select the most appropriate management model for specific operating conditions. The diversity of tactical plans requires their continuous coordination. The planning process typically begins with determining sales volumes (a marketing function), followed by the formation of a production program, a material and technical supply plan, a personnel plan, and finally a financial plan. Such a logical sequence ensures the integrity of the planning system and its alignment with real market conditions.

Table 2. Classification of tactical management types within an enterprise [3,4]

Classification criterion	Types of tactical planning (plans)
By planning object	Sales planning, production, personnel, costs, finance, infrastructure, investment
By time horizon	Medium-term (1–3 years) and short-term (up to 1 year: quarter, month)
By degree of obligation	Directive (mandatory tasks) and indicative (recommendatory guidelines)
By form of presentation	Programs (plan-progrcams), business plans, budgets
By development stage	Preliminary (forecast), intermediate (coordination), and final (approved)

Foreign economic activity (FEA) is one of the most complex and high-risk areas of enterprise operation, requiring special approaches to planning. Tactical planning of FEA is the process of detailing the strategy for entering and operating in foreign markets over a period of one to two years. It involves defining specific ways of using resources to achieve long-term goals of international expansion, taking into account the specifics of international marketing, logistics, and finance.

The importance of tactical planning of FEA is driven by the need to synchronize the internal capabilities of an enterprise with the requirements and constraints of global markets. This process makes it possible to transform a strategic vision ("becoming a global player") into a concrete program of export-import operations, currency transactions, and logistics schemes.

Key aspects of the essence of tactical planning of foreign economic activity (FEA):

planning of export-import operations – based on determining shipment volumes, selecting foreign partners, and justifying the product assortment that meets international quality standards;

currency planning – forecasting foreign currency inflows and outflows, planning conversion operations, and hedging against adverse exchange rate fluctuations;

international logistics – planning complex cross-border supply chains, selecting optimal transport modes and routes, and arranging customs clearance;

international risk management – taking into account not only commercial but also political and legal risks in planning calculations [5].

Tactical planning of FEA begins with marketing research, where the marketing department forecasts sales volumes in foreign markets, prices, and potential profitability. Based on these forecasts, a production program is developed, which must take into account specific product requirements in different countries (certification, packaging, language specifications).

An important instrument here is logistics planning. At the tactical level, the logistics team develops an "assumptions table" — a list of expected conditions (freight costs, border crossing times, customs duties), which serve as a basis for calculating costs and delivery timeframes. The consistency of these assumptions among all participants in the planning process ensures the integrity of the FEA plan [6-8].

Tactical planning of foreign economic activity enables an enterprise to remain flexible. The use of a scenario-based approach makes it possible to develop action plans in case of changes in customs regulations, the introduction of sanctions, or sharp fluctuations in exchange rates. This ensures the resilience of the enterprise in an unstable global environment and helps to avoid significant financial losses.

Thus, it can be concluded that tactical planning at the enterprise is a complex, multifaceted management function that ensures the viability of the organization under market conditions. It occupies a unique niche in the planning hierarchy, combining strategic ideals with operational reality. The use of a wide range of methods from balance methods to economic-mathematical approaches allows for the development of well-founded and coherent development plans. In the context of foreign economic activity, tactical planning becomes particularly important, serving as an instrument of adaptation to global challenges and a mechanism for minimizing international risks. An effective system of tactical FEA planning enables an enterprise not only to survive but also to develop dynamically, exploring new horizons of the global economy.

In the current conditions of instability in international agricultural markets, diversification is one of the key instruments for reducing dependence on individual countries or trade directions. However, in business practice, the process of selecting and developing foreign markets may be carried out without a unified, coherent system of criteria and long-term logic.

This is manifested in the fact that decisions regarding entry into new markets or expansion in existing ones may be made on an ad hoc basis, without a comprehensive comparison of alternative directions. The absence of a clear methodology for assessing market attractiveness leads to the fact that different opportunities are considered in isolation, without taking into account their mutual influence on the overall structure of exports.

As a result, a certain imbalance in the geography of sales is formed, when the enterprise may become excessively oriented toward a limited number of foreign markets.

The fragmentation of approaches also complicates long-term planning. In the absence of a coherent diversification algorithm, it is difficult to determine market

priorities, assess the potential risks of entering new territories, and ensure a gradual expansion of export activities. This reduces the effectiveness of tactical planning, as it is not based on a holistic vision of foreign market development but is instead formed as a set of separate decisions.

The solution to the problem of fragmented approaches to the diversification of foreign sales markets at the enterprise level should be implemented through the development and introduction of a comprehensive algorithm for the evaluation, selection, and prioritization of foreign markets. Such an approach makes it possible to shift from situational decision-making regarding entry into new markets to a systematic, logically consistent process based on unified criteria and a transparent methodology for comparing alternatives. The proposed algorithm for the evaluation, selection, and prioritization of foreign sales markets of enterprises is presented in Figure 1.

The first stage of the algorithm is the preliminary screening of potential foreign markets. At this stage, a broad list of countries or regions that may potentially be interested in the enterprise's products is formed. The selection is based on basic criteria such as demand for agricultural products, the overall economic stability of the country, market openness to imports, and the absence of critical trade restrictions. The purpose of this stage is to create an initial "pool" of markets for further in-depth analysis.

The second stage is the basic analytical assessment of the selected markets. At this level, unified evaluation criteria are applied, allowing markets to be compared with one another. Such criteria may include the volume of potential demand for the products of the company the level of price attractiveness, the degree of competition, the stability of the economic environment, and logistical accessibility. To ensure objectivity of the assessment, each criterion may be assigned a weighting coefficient reflecting its significance for the enterprise.

The third stage involves a more in-depth comparative assessment of markets using a matrix approach. At this stage, markets are systematized in the form of a matrix that combines key attractiveness indicators with the level of potential risks. This enables both a visual and analytical identification of the most promising directions for export development. In particular, markets with high demand and a low level of risk receive the highest priority, whereas markets with high competition or logistical barriers may be classified as secondary.

The fourth stage is the prioritization of foreign markets and the formation of a ranking of their attractiveness. Based on the results of the matrix analysis, markets are ranked according to an integrated indicator. This allows the enterprise to determine the sequence of entering new markets or expanding its presence in already developed ones. Prioritization ensures consistency of managerial decisions and prevents the dispersion of resources across too many directions simultaneously.

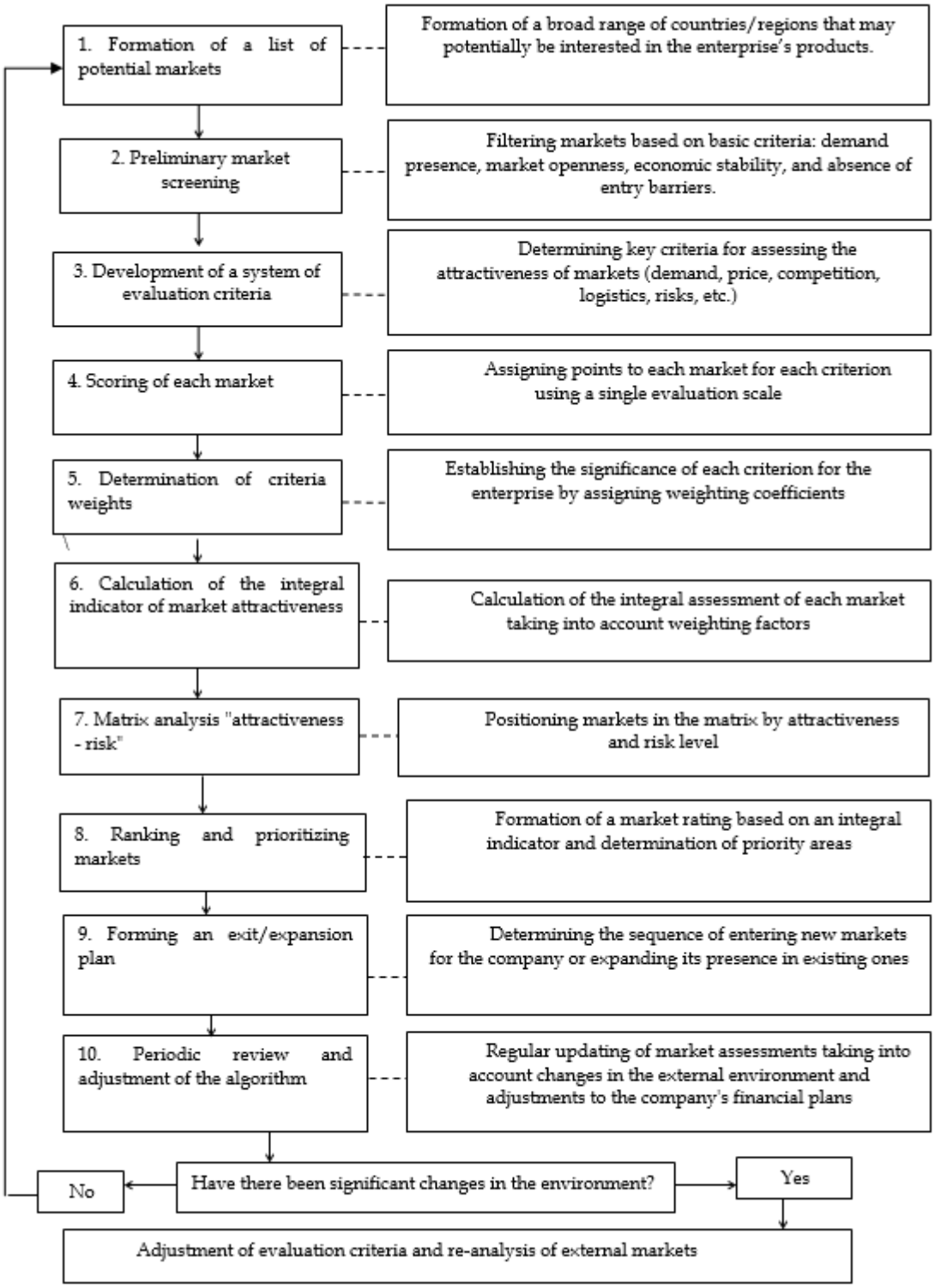

Fig. 1. Recommended algorithm for assessing, selecting and prioritizing external markets for enterprise products in order to improve tactical planning of foreign economic activity

The fifth stage is the integration of the algorithm's results into the tactical planning system of foreign economic activity. This involves regular updating of market assessments in response to changes in the external environment, as well as aligning export plans with the identified priorities. Thus, the dynamic nature of the algorithm and its adaptability to fluctuations in international market conditions are ensured.

As a result of the implementation of a comprehensive algorithm, the DEMKIV Financial Group will receive a structured decision-making mechanism for diversifying sales markets, which will reduce the fragmentation of approaches, increase the validity of management decisions, and ensure a more stable and balanced development of foreign economic activity.

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1.2. Development of the Toolkit for Tactical Management of Enterprise Foreign Economic Activity Based on the Systematization of Analytical Support

In the context of dynamic transformations of the global economy, increasing global competition, instability of international markets, and a high level of uncertainty in the external environment, the importance of effective management of enterprises' foreign economic activity is growing. The competitiveness of business entities, their

ability to adapt to changes in market conditions, ensure the stability of foreign economic relations, and achieve planned economic results largely depend on the effectiveness of managerial decision-making at the tactical level.

Modern conditions of enterprise functioning are characterized by a significant influence of geopolitical, economic, technological, and logistical factors, which complicates the process of forecasting the development of foreign economic activity and requires the improvement of approaches to its tactical management. In this regard, the development of tactical management tools becomes particularly important, and these tools should be based on comprehensive analytical support capable of forming an informational basis for timely identification of trends, risk assessment, modeling of alternative scenarios, and substantiation of managerial decisions.

The effectiveness of the tactical management system of foreign economic activity is largely determined by the quality of analytical support for forecasting. However, in the practice of many enterprises, information and analytical processes are characterized by fragmentation, insufficient systematization, and limited possibilities for integrating heterogeneous data, which complicates the formation of reliable forecasts and timely response to changes in the external environment. Under such conditions, the need to develop and implement a technology for systematizing analytical support for forecasting becomes increasingly relevant, aimed at improving the quality of information support for tactical management processes in foreign economic activity.

Scientific and applied aspects of managing foreign economic activity, forecasting economic processes, and developing information and analytical support have been addressed in the works of domestic and foreign scholars. At the same time, modern challenges associated with increasing turbulence in the international environment, digitalization of business processes, and the need to enhance enterprise adaptability create the necessity for further improvement of tactical management tools for foreign economic activity based on the systematization of analytical support for forecasting.

In this regard, research aimed at forming modern approaches to the development of tools for tactical management of an enterprise's foreign economic activity, improving analytical support for forecasting, and enhancing the substantiation of managerial decisions under conditions of a changing international economic environment becomes particularly relevant.

Planning is a necessary prerequisite for ensuring the stable development of an enterprise, as it makes it possible to anticipate potential changes in both the internal and external environment, respond to risks in a timely manner, and use available resources efficiently. In the scientific literature, planning is considered as a process of defining an enterprise's objectives and developing a system of measures to achieve them. According to Ukrainian scholars, planning ensures the coordination of activities of all structural units of an enterprise, contributes to improving management efficiency, and creates a basis for making well-grounded managerial decisions [1].

In economic science, planning is traditionally defined as a management function that involves setting an enterprise's development goals, determining the necessary resources, and selecting optimal ways to achieve the defined objectives. The planning

process includes the analysis of the current state of the enterprise, assessment of the impact of external environmental factors, forecasting future performance results, and the development of appropriate planning indicators.

The importance of planning lies in the fact that it enables an enterprise to:

- ensure purposeful activity;
- increase the efficiency of the use of material, financial, and labor resources;
- reduce the level of uncertainty and risks;
- ensure coordination among structural units;
- enhance the enterprise's competitiveness;
- and adapt its activities to changes in the external environment.

The planning process is one of the key instruments for ensuring the economic stability of an enterprise. The absence of an effective planning system may lead to inefficient use of resources, loss of competitive positions, and a decline in the overall performance of the enterprise.

Scholars emphasize that the planning system should be comprehensive and cover all areas of an enterprise's activity. In particular, D. V. Kulish notes that enterprise planning should take into account not only internal capabilities but also the specifics of the external economic environment, international competition, and changes in market conditions [2]. The importance of the planning process for an enterprise can hardly be overestimated, as it allows addressing critical issues of self-identification and development. In particular, during the planning process, a firm must clearly define what it aims to become in the future, assess its current state, resources, and operating conditions, and choose a specific trajectory of development. Without a clearly formulated plan, any organization risks becoming a victim of chaotic changes in the external environment, losing its ability to act in a coordinated manner [3]. The parameters of the significance of planning and the characteristics of its impact on the enterprise are presented in Table 1.

Table 1.

Impact of Planning Parameters on an Enterprise

Planning parameter significance	Characteristics of its impact on the enterprise
Risk minimization	Allows for anticipating negative scenarios and preparing measures for their mitigation in advance.
Coordination of efforts	Ensures a unified direction of work of all structural units to achieve common goals.
Resource optimization	Promotes the rational allocation of material, financial, and labor resources.
Control function	Creates a basis (planned indicators) for comparison with actual results.
Motivational aspect	Clearly defines duties and responsibilities, thereby increasing discipline.

Planning as a type of managerial activity directly affects the efficiency of the use of production capacities and capital. It enables the modeling of the future state of an enterprise, which is the ultimate goal of any planning process. In the context of globalization and increasing competition, planning covers all enterprise operations – technical, financial, and commercial – taking into account time periods, sources, and

costs. Such a comprehensive approach ensures long-term effectiveness and the development of new market opportunities [4].

An important element of planning is its principles, which define the general requirements for the formation of enterprise plans. The main principles of planning include:

- the principle of systematicity;
- the principle of continuity;
- the principle of scientific validity;
- the principle of flexibility;
- the principle of balance;
- the principle of efficiency;
- the principle of comprehensiveness.

The principle of systematicity implies the interconnection of all planning elements and the coordination of plans among different structural units of the enterprise. The principle of continuity means the constant updating of plans in accordance with changes in both the external and internal environment. The principle of scientific validity involves the use of modern methods of analysis, forecasting, and economic justification of planning decisions.

Depending on the time horizons, objectives, and level of detail of managerial decisions, enterprise management distinguishes between strategic, tactical, and operational planning. Each of these types of planning performs a specific function within the enterprise management system.

Strategic planning is aimed at defining the long-term development goals of an enterprise and forming its overall strategy. It is focused on the prospective development of the enterprise and takes into account the influence of the external environment, competitive dynamics, and global economic trends.

Tactical planning occupies an intermediate position between strategic and operational planning. Its main purpose is to specify the strategic objectives of an enterprise and define mechanisms for their implementation in the medium-term perspective. Tactical planning ensures the transition from strategic decisions to the practical implementation of specific measures and programs of enterprise activity.

Operational planning, in turn, ensures the organization of the enterprise's day-to-day activities and is aimed at solving short-term tasks. It is characterized by a high level of detail in planning indicators and is directly related to the current management of production, financial, and organizational processes.

The effectiveness of tactical planning of an enterprise's foreign economic activity is significantly complicated by a number of internal organizational and analytical problems, among which the insufficient systematization of analytical support for forecasting export indicators and the fragmented approaches to the diversification of foreign sales markets are particularly prominent.

One of the problems of tactical planning faced by enterprises in the process of conducting foreign economic activity is the insufficient level of systematization of analytical support for forecasting export volumes and external demand for products. In

practice, the information used for the formation of tactical plans is often fragmented and generated without a unified approach to its collection, structuring, and interpretation. Data on product demand, seasonal fluctuations, changes in prices on foreign markets, and actual export volumes may be accumulated in different formats, which complicates their further aggregation and use for forecasting.

As a result of the lack of a clearly unified analytical base, difficulties arise in forming a comprehensive understanding of the market situation. Forecast indicators are often based on partial or non-systematic observations, which reduces their accuracy. This is especially critical for enterprises in the agricultural sector, where external demand is characterized by high seasonality, dependence on climatic conditions, and fluctuations in world prices. Under such conditions, insufficient structuring of analytical information leads to the risk of making managerial decisions based on incomplete or outdated data.

In addition, the absence of a unified approach to analysis complicates the comparison of planned and actual indicators, which reduces the effectiveness of controlling the implementation of tactical plans. It is difficult for an enterprise to timely identify deviations from the planned export volumes and to promptly adjust its foreign economic strategy. Thus, this problem is systemic in nature and directly affects the quality of managerial decisions made by enterprises in the process of conducting foreign economic activity.

The solution to the problem of insufficient systematization of analytical support for forecasting exports and external demand at the enterprise should be implemented through the development and implementation of a technology for systematizing analytical support for forecasting foreign economic activity. Such a technology should ensure the transition from fragmented, unsystematic information collection to an organized, regular, and logically structured process of forming an analytical base for managerial decision-making in the field of foreign economic activity. The recommended technology for systematizing analytical support for forecasting foreign economic activity of the enterprise involves the sequential implementation of five stages and is presented in Figure 1.

At the first stage of the proposed technology, the data collection process regarding external demand and product exports is unified. For this purpose, it is necessary to define a clear list of indicators subject to regular collection. These should include export volumes by country or counterparties, seasonal demand fluctuations, price levels for products on foreign markets, actual and forecast sales volumes, as well as deviations between planned and actual indicators. An important element is the establishment of a unified frequency for data collection (monthly or quarterly), which will ensure comparability of data over time.

The second stage of the proposed technology is the standardization of the format for presenting analytical information. This involves the development of standardized internal analytical forms (tables or reports) in which all structural units of the enterprise will record data in a unified format. Such an approach helps avoid situations where

information is presented in an arbitrary form and requires additional processing time. Standardization will contribute to faster aggregation of data and improve its reliability.

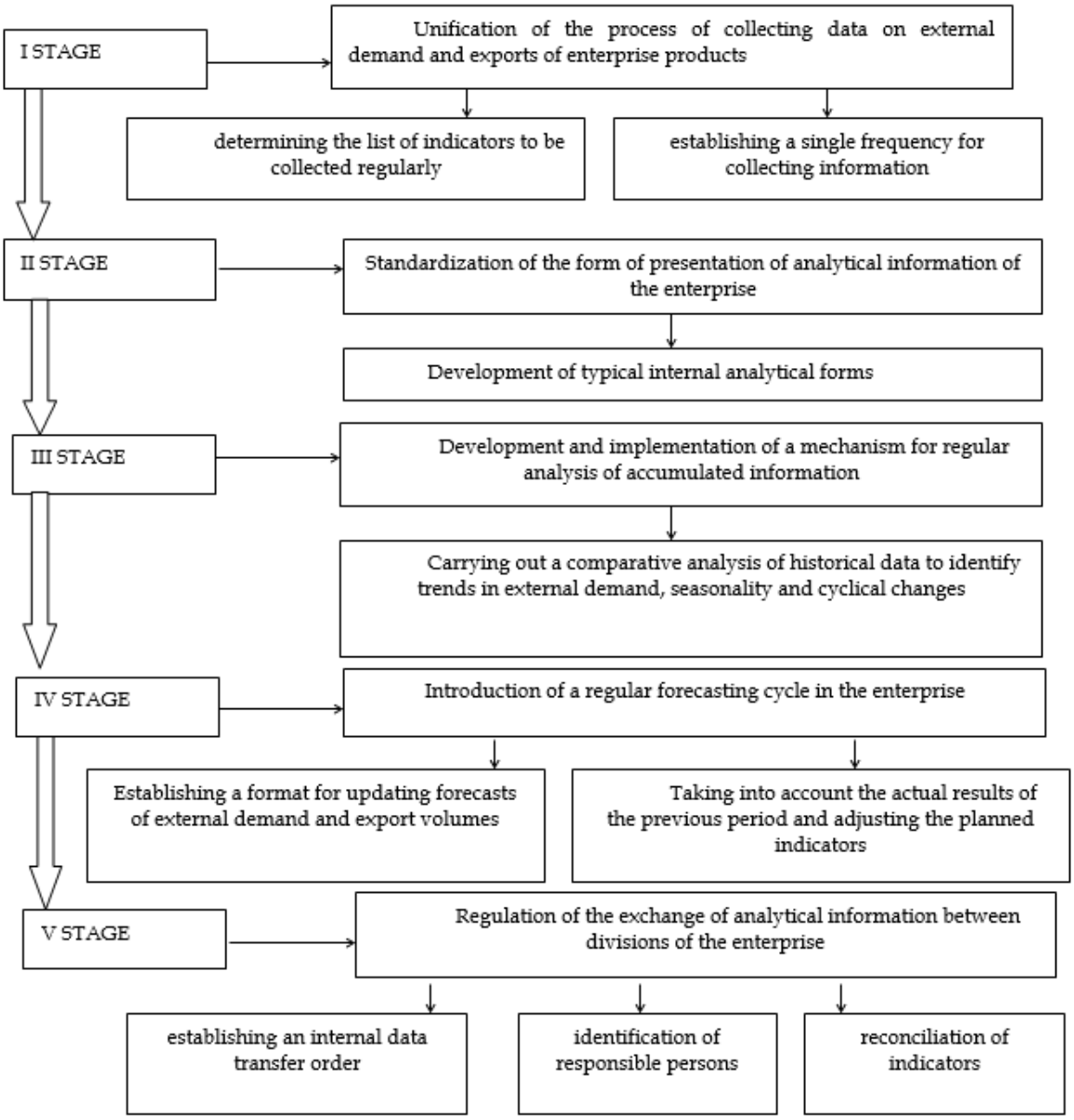

Fig. 1. Recommended technology for systematizing analytical support for forecasting the foreign economic activity of an enterprise

The third stage involves the development and implementation of a mechanism for the regular analysis of accumulated information, which implies the use of comparative analysis of historical data to identify trends in external demand, seasonality, and cyclical changes. Such analysis enables the enterprise not only to record the actual state of exports but also to form well-grounded short-term forecasts. It is important that the

results of the analysis are systematically used in the formation of tactical foreign economic activity plans.

The fourth stage of the technology is the introduction of a regular forecasting cycle. It is advisable to establish a monthly or quarterly format for updating forecasts of external demand and export volumes. At the same time, each new forecast should take into account the actual results of the previous period and adjust planned indicators accordingly. This approach ensures the adaptability of planning and increases its accuracy under changing conditions of international market conjuncture.

The fifth stage involves regulating the exchange of analytical information between the enterprise's structural units. It is necessary to establish an internal procedure for data transfer, define responsible persons for generating and updating information, and ensure a unified logic for aligning indicators. This will eliminate data duplication and reduce the risk of inconsistencies between different departments.

As a result of implementing the proposed technology, the enterprise will obtain an integrated system of analytical support for forecasting foreign economic activity, which will ensure improved forecast accuracy, reduced uncertainty in managerial decision-making, and increased efficiency of tactical planning of foreign economic activity.

Thus, the developed technology for systematizing analytical support for forecasting foreign economic activity is aimed at eliminating the fragmentation of information flows and forming a coherent information and analytical base for tactical managerial decision-making. Its implementation ensures the unification of data collection and processing processes, improves the quality of export forecasting, and contributes to the timely identification of changes in external market conditions.

The practical implementation of the proposed technology will enhance the enterprise's adaptability to external environmental influences, reduce the level of uncertainty and risks in planning, and improve the substantiation of tactical managerial decisions in the field of foreign economic activity. As a result, this will contribute to strengthening the enterprise's competitive position and improving the efficiency of its performance in international markets.

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1.3. Recommendations for Improving the Strategic Activities of Enterprises in Foreign Markets

The fundamental prerequisite for improving the quality of strategic planning is the use of effective methodological tools. A modern business strategy should be based on a multifactor analysis that assesses the financial condition, global market dynamics, regulatory risks, and the limitations of internal resources. Such an approach enables companies to act proactively and flexibly choose business scaling models in foreign markets, taking into account the institutional characteristics of a particular country. The primary direction for improving the activities of Ukrainian enterprises is the revision of the fundamental management philosophy. The implementation of a strategy for entering European markets requires replacing declarative intentions with the actual implementation of existing quality standards. At the same time, the modernization of a business strategy is impossible without a well-established mechanism for managing organizational change within the enterprise.

Scientific research and business practice demonstrate that the existence of a well-founded strategy is a fundamental prerequisite for a company's success. Such a plan should define priorities for strengthening competitive positions while ensuring stable income and profitability in the future. When it comes to entering foreign markets, strategy development focuses on comparing internal business processes and identifying the main growth points [1–3].

The problem of selecting a market entry strategy under conditions of high uncertainty is closely associated with the factor of geopolitical tension, which has become a key consideration for Ukrainian businesses. Therefore, the strategy cannot remain unchanged. It should be based on the diversification of target markets and the identification of niche opportunities in geographically distant but politically stable regions. The key conclusion is that successful expansion requires not only economic calculations but also a thorough analysis of political risks and the development of mechanisms for the rapid relocation of trade and production resources [4].

The improvement of the strategy begins with the appropriate selection of the market entry mode, ranging from indirect exporting to the establishment of joint ventures. The choice of a foreign market entry strategy should be flexible and based on a detailed analysis of entry barriers and the competitive advantages of the product. The integration of marketing and sales strategies is essential, enabling an enterprise not only to enter a market but also to establish a sustainable long-term presence within it [5].

Effective strategy improvement is impossible without a thorough analysis of the current state of foreign economic activity. O. Podra and N. Petryshyn provide the theoretical and methodological foundation for such an analysis, emphasizing that the assessment of foreign economic activity should be comprehensive and encompass not only performance indicators (export revenue, market share) but also resource-related and organizational aspects. The authors underline that strategic improvement begins with the identification of the enterprise's hidden reserves, which can be utilized to mitigate external threats. Their methodological recommendations enable businesses to develop an objective basis for decision-making regarding the expansion of their presence in international markets [1].

Some authors argue that the process of selecting a strategy for entering international markets can no longer be considered linear. Improving this process requires taking into account both internal factors (resource potential and management experience) and external macroeconomic determinants. Of particular value is the algorithm proposed by the authors for evaluating alternative expansion strategies, which makes it possible to minimize risks at the market entry stage and optimize resource allocation [6].

The strategy for promoting products in foreign markets is increasingly shifting toward enhancing the customer experience. Omnichannel sales strategies have become a decisive factor for success. In the context of global digitalization, international customers expect seamless transitions between online platforms, social media, and physical points of presence. The implementation of omnichannel strategies enables enterprises to collect deeper insights into consumer behavior across different countries, tailor marketing communications, and ensure a high level of customer loyalty, which is critically important when entering highly competitive foreign markets [7].

The quality of methodological tools is of fundamental importance for improving the strategic process. A modern strategy should be based on a multicriteria analysis that considers not only financial indicators but also the dynamics of international markets, regulatory changes, and internal resource constraints. Such a model enables enterprises to shift from reactive to proactive management, ensuring flexibility in selecting foreign market entry modes according to the institutional environment of the host country [8].

A key direction for improving the strategy of Ukrainian enterprises on the path toward European integration is a transformation in the very philosophy of management. A strategy for entering EU markets requires not merely declarative intentions but the implementation of European quality standards. Strategy improvement is inseparably linked to effective change management. This involves a transition to flexible Agile structures capable of integrating international ISO standards and Total Quality Management (TQM) principles into the company's day-to-day operations. Such an approach enhances the competitiveness of the strategy through high product quality and transparent business processes [9].

The final component of a modern strategy for foreign markets is compliance with global standards of ethics and transparency. Today, the improvement of strategic positioning is directly associated with environmental, social, and governance (ESG)

performance. For foreign investors and business partners, the availability of transparent non-financial reporting serves as evidence of low risk and a high standard of corporate governance. Thus, corporate social responsibility is viewed not as an additional cost but as a strategic instrument for gaining access to international capital and premium market segments [10].

To ensure that a strategy is viable, it is essential to have tools for the objective assessment of an enterprise's capabilities. Therefore, researchers propose an innovative approach to this issue through the development of a grid-based model for evaluating strategic potential. They argue that forecasting success in foreign markets is impossible without taking random factors into account. The application of mathematical modeling enables management to quantitatively assess a company's readiness for expansion and identify bottlenecks in resource availability before entering a foreign market. This transforms strategic planning from an intuitive process into a scientifically grounded decision-support system [11].

Strategic management of foreign economic activity is acquiring new characteristics under the influence of digitalization and geopolitical shifts. Today, improving a strategy in foreign markets is impossible without an innovation-driven approach and the digitalization of export operations. The key priority is no longer merely increasing sales volumes but enhancing supply chain resilience and establishing strategic alliances. Particular importance is the integration of service components into a physical product, which represents a significant factor of competitiveness in developed markets [12].

The process of improving strategic activities in foreign markets is based on a thorough analysis of external factors, enabling a company to adapt its decisions to specific market conditions. The structure of the strategy comprises three key elements:

1. A long-term vision of the company's business trajectory defined by top management;
2. An objective internal assessment of the organization's existing challenges and internal capabilities;
3. A set of macro- and micro-environmental factors that directly influence the company's development dynamics.

The application of a systems approach throughout the strategy development and implementation stages enhances a company's competitiveness in foreign markets. This approach contributes both to strengthening the company's current market position and to creating opportunities for its future development and economic growth. Strategic plans are continuously reviewed based on the results of monitoring internal processes and the external environment. This enables the enterprise to respond promptly to market changes while maintaining the adaptability and flexibility required for effective strategic management.

The procedure for developing a strategy for operating in foreign markets consists of the following sequential steps:

1. Specification of the company's long-term objectives regarding its entry into and establishment of competitive positions in foreign markets. This stage involves defining the company's international mission and strategic vision. All objectives are

formulated in accordance with the SMART framework. Target indicators are established for market share in selected countries, export volumes, the profitability of foreign sales, and other key performance measures. As a result, a strategic objective tree is developed to support the effective management of foreign economic activity.

2. Conducting a comprehensive strategic analysis of the enterprise's internal capabilities and assessing the conditions of target foreign markets. The company evaluates its available resources while analyzing external factors in the countries targeted for market entry. In particular, analysts examine market size, consumers' purchasing power, the competitive landscape, regulatory and economic barriers to entry, as well as the associated business risks.

3. Justification and selection of the fundamental international business strategy. Management makes the final decision regarding the appropriate operating model for foreign markets and determines the most suitable market entry scenario. The primary objective is to choose an approach that minimizes risks while maximizing the return on investment and resource utilization. Based on the results of the analysis, a specific type of international strategy is selected and approved.

4. Development of a tactical action plan and identification of the instruments required to implement the approved strategy. The selected strategic model is translated into operational planning. This step involves the detailed development of the company's marketing policy, taking into account the specific characteristics of the target foreign market. Clear implementation timelines or project schedules are established, and the budget for strategy implementation is prepared and approved.

5. Organization of strategy implementation, including resource allocation, assignment of responsibilities, designation of accountable personnel, and monitoring of the execution of strategic decisions. At this stage, the company moves from strategy formulation to its practical implementation. The enterprise transforms its internal processes to ensure sustainable operations in new markets. Management adapts the organizational structure to meet international business requirements, allocates financial and material resources across departments, and introduces a comprehensive system of performance indicators to evaluate the effectiveness of foreign economic activity.

Establishment of a feedback system for the regular monitoring of interim results. International markets change rapidly; therefore, this stage ensures a high level of business flexibility and enables timely adjustments. The primary objective is the rapid development of crisis-response measures and the prompt revision of the current strategy in response to emerging challenges.

The sustainable operation of an enterprise in international markets depends on management's ability to overcome the following challenges:

1. The existing line-and-functional organizational structure often limits the speed of decision-making required for effective operations in foreign markets.

2. Building a workforce with expertise in foreign economic activity, proficiency in foreign languages, knowledge of local legal regulations, and an understanding of the business culture of international partners.

3. Increasing complexity in monitoring and controlling geographically dispersed subsidiaries, which requires the implementation of advanced information channels and management accounting tools.

4. A significant expansion of potential risks, requiring systematic monitoring and timely response.

The process of entering foreign markets is associated with overcoming significant competitive barriers. Foreign markets are already occupied by strong local and international competitors with well-established logistics systems, extensive distribution networks, and a high level of customer trust. Active competition from existing market participants may require a company to promptly adjust its pricing strategy and identify new approaches to cost optimization.

Conducting only a superficial market assessment may lead to adverse consequences, ranging from incorrect market positioning to errors in pricing and strategic planning. Differences in legal and regulatory frameworks, customs restrictions, and specific standardization requirements create additional risks and necessitate further capital investment. Failure to observe local business etiquette and cultural differences may hinder communication with business partners and reduce the effectiveness of the company's market promotion strategy.

The process of optimizing a strategy is hindered by several objective factors, including an insufficient understanding of the fundamental role of strategic planning and management in long-term development; the concentration of managerial efforts primarily on addressing current tactical issues; methodological difficulties in selecting the most appropriate strategic alternative and implementing it effectively; and the gradual erosion of sustainable competitive advantages in the company's core market.

A company's entry into international markets and the strengthening of its competitive position require more than simple business expansion; they demand a comprehensive transformation and adaptation of the existing management model. An effective foreign market strategy should combine clearly defined objectives with practical implementation tools specifically designed to address the unique characteristics and potential risks of each target foreign market.

To overcome these challenges, the following measures are recommended: strengthening the role of top management in strategic planning and forecasting; developing an effective and sustainable strategic model for foreign economic activity; focusing the enterprise's resources on the achievement of long-term strategic objectives; and ensuring continuous monitoring and timely adjustment of the strategy in response to changes in the market.

Entering foreign markets is constrained by significant resource limitations. The organization of foreign economic activity requires substantial financial investment, as enterprises must cover the costs associated with advertising, establishing distribution channels and logistics, as well as adapting and certifying products in accordance with the legal requirements of target markets.

Expansion into foreign markets also requires companies to adapt branding elements and promotional materials to the national and cultural characteristics of local

consumers. An important task is to optimize and establish reliable distribution channels that ensure uninterrupted access to target foreign markets.

The application of the multifactor SPACE analysis method for determining the optimal strategy enables a comprehensive assessment of the current position of a company and its structural units while providing a basis for the development of future managerial actions. This analytical tool facilitates the clear positioning of an enterprise within the competitive environment relative to other market participants. The assessment process involves a detailed evaluation of the key internal and external factors influencing organizational performance. The SPACE methodology is based on a multifactor analysis of a firm's internal resources and the external market environment. The final result is expressed as an integrated indicator, where each evaluation criterion is assigned a specific weight, allowing for a balanced and objective assessment of the company's actual strategic position.

For conducting a strategic analysis of the international business environment, developing an information base, and formulating a long-term strategy, the following evaluation criteria are recommended within the SPACE analysis framework:

- Competitive position in foreign markets (market position of the product);
- Financial strength (internal potential);
- Stability of the external environment in foreign markets (stability of the importing countries' environment);
- Attractiveness of foreign markets (industry potential).

The recommended sequence for implementing the multicriteria SPACE analysis method is presented in Figure 1.

The resulting set of characteristics and indicators should be systematically organized and structured. The subsequent calculation of the weighted impact of these parameters, with due consideration of their relative importance, enables the company's management to develop and implement well-founded strategic decisions that are aligned with the enterprise's current objectives. The implementation of the multicriteria SPACE method for analyzing the business environment and substantiating a foreign economic strategy requires the effective coordination of responsible personnel. The execution of the relevant analytical procedures and the preparation of baseline data should be assigned to specialists in strategic planning and foreign economic activity management.

The evaluation criteria are presented in Table 1.

The specification of the SPACE analysis evaluation parameters is based on the company's key priorities and long-term objectives in international markets. The analytical model relies on the weighted assessment of financial strength, competitive position in foreign markets, as well as the attractiveness and stability of the external environment of foreign markets. The SPACE analysis is conducted by an internal expert team responsible for evaluating the business environment in accordance with the approved methodology. To ensure the effective implementation of this project, it is essential to clearly define areas of responsibility, functional tasks, and the operational roles of the expert team.

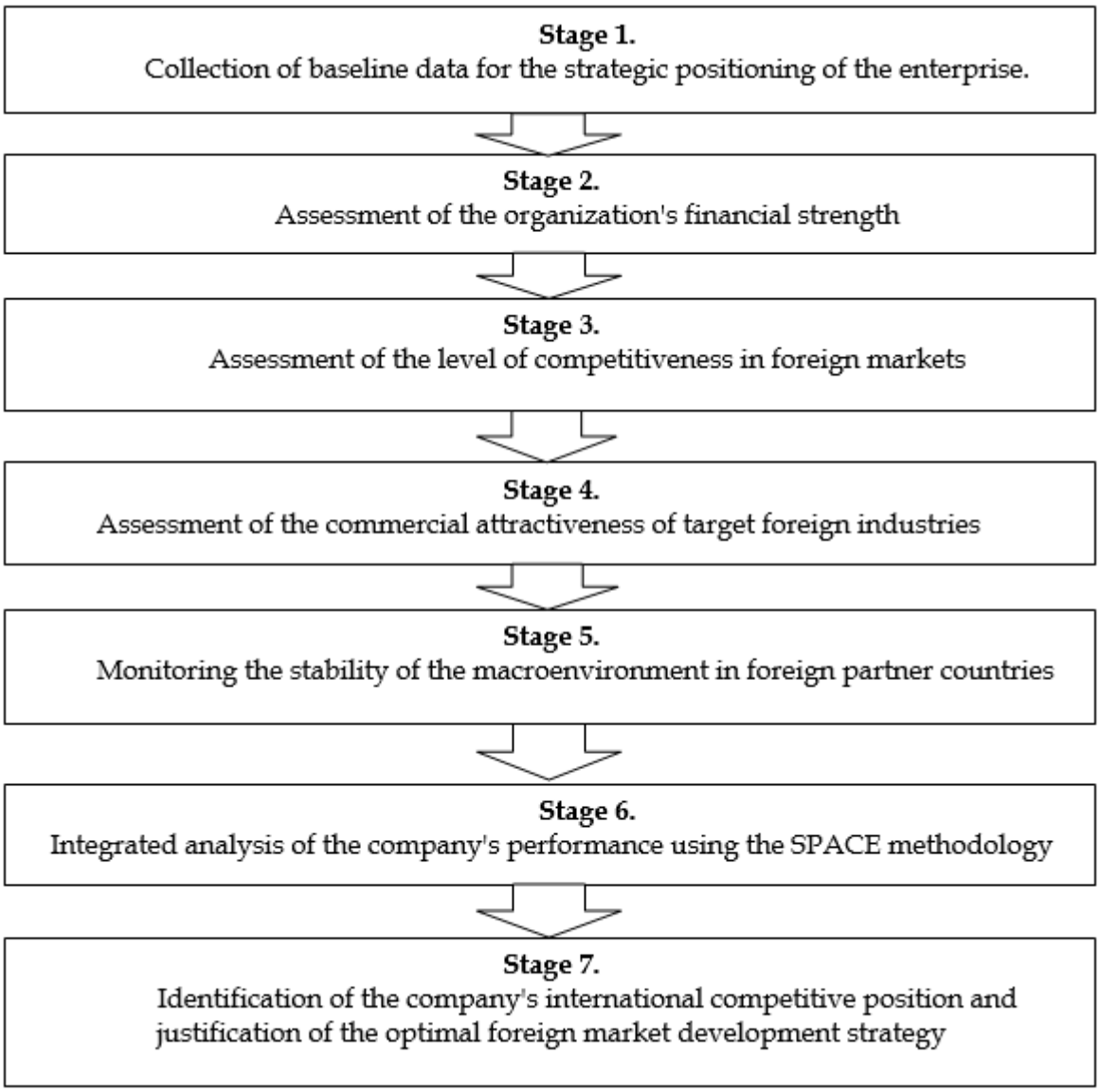

Figure 1. Process of implementing the multicriteria SPACE analysis method

Table 1. Evaluation Criteria for the Multicriteria SPACE Analysis Method

Evaluation Dimension	Recommended Criteria
Competitive position in foreign markets	1. Alignment of product pricing with market expectations in foreign markets. 2. Market share controlled by the enterprise within the selected market segment. 3. Availability of unique product features and protected competitive advantages.
Financial strength	1. Volume, dynamics, and predictability of net cash flow generated from foreign economic activity. 2. Efficiency of the use of investments allocated to the development of foreign economic activity. 3. Liquidity and financial stability indicators of the company.
Stability of the external environment in foreign markets	1. Market sensitivity to cyclical fluctuations and demand elasticity.

	2. Macroeconomic stability, political climate, and the stability of the partner country's national currency. 3. Stability of customs and fiscal regulations governing import operations.
Attractiveness of foreign markets	1. Identification of the target industry's life cycle stage and the growth rate of foreign market capacity. 2. Market capacity and conditions for the development of marketing activities. 3. Intensity of competitive pressure and the level of entry barriers for foreign market participants.

The strategic management process involves the development of a system of SPACE analysis evaluation criteria. For each criterion, its relative importance is determined and a score ranging from 0 to 10 is assigned, forming the basis for calculating the final weighted result. The resulting SPACE analysis matrix for the company's international operations provides a foundation for selecting the most appropriate strategic alternative. The proposed strategy is subsequently approved by the company's director and undergoes corporate review to ensure a shared vision of the company's future strategic direction and the development of its foreign economic activities.

Assessing the combined impact of a company's internal resources and external opportunities in foreign markets makes it possible to determine their precise influence on the management system of the company's strategic business units. Within the strategic planning process, particular attention should be devoted to maintaining positions in foreign markets and consistently strengthening the enterprise's international competitiveness. The justification of strategic choices through the application of analytical methods provides an optimal and well-founded basis for managerial decision-making. Such an approach ensures a balanced consideration of both internal and external factors when formulating strategic development directions for foreign markets and planning the company's future international expansion.

Strategy improvement involves not only external positioning but also profound internal transformation. It is proposed that strategic imperatives be regarded as the foundation for developing the organizational and economic mechanism of enterprise development. Even the most advanced foreign market entry strategy is unlikely to succeed if the enterprise's internal structure is incapable of adapting to change. Improving the strategy requires the establishment of a mechanism that integrates financial, technological, and human resources into a unified, adaptive system.

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1.4. Human Capital as a Factor in Restoring Ukraine's Socio-Economic Potential Amid Demographic Challenges

The full-scale military aggression of the Russian Federation against Ukraine has caused substantial human, economic, and social losses, significantly constraining the country's prospects for further development. One of the key prerequisites for Ukraine's recovery is the preservation and reproduction of its human capital. Population decline, forced migration, falling birth rates, deteriorating health, and learning losses weaken the country's labour, intellectual, and innovative potential.

Human capital encompasses knowledge, professional skills, experience, health status, and personal qualities that determine an individual's capacity for productive activity. Under current conditions, it has become a strategic resource for Ukraine's socio-economic recovery and modernisation. The intensification of demographic problems necessitates a revision of public policy concerning population reproduction, the development of education and healthcare, incentives for citizens to return from abroad, and the creation of conditions for the realisation of their professional potential.

The formation of human capital as an independent economic category occurred gradually – from classical views of labour as a source of societal wealth to contemporary concepts of the knowledge economy. William Petty was among the first to substantiate the decisive role of labour in wealth creation, thereby laying the foundation for further research into human productive capabilities [1]. Adam Smith regarded workers' acquired knowledge and professional skills as a component of social capital, while expenditure on education and training was interpreted as investment capable of generating future income [2].

The works of Karl Marx made a significant contribution to the development of theoretical views on the role of human beings in the economic process. Although he did not explicitly use the term «human capital» Marx distinguished between labour as a process of value creation and labour power as the totality of an individual's physical and intellectual capabilities that enable the production of surplus value [3].

The concept of human capital received its comprehensive theoretical formulation in the twentieth century through the works of T. Schultz and G. Becker. T. Schultz interpreted expenditure on education, healthcare, and vocational training as investment in individuals that contributes to the accumulation of productive capabilities and the growth of social welfare [4; 5]. G. Becker further developed this approach by demonstrating that investment in education, health, and professional development increases labour productivity and individual income while generating broader economic benefits for society [6; 7].

Thus, the evolution of scholarly views on human capital reflects a gradual shift from perceiving individuals primarily as carriers of labour power to recognising their knowledge, competencies, health, and creative abilities as a strategic economic resource. This approach underpins the contemporary human development paradigm, according to which individuals are simultaneously the principal actors, resources, and ultimate beneficiaries of socio-economic growth.

In contemporary academic discourse, human capital is interpreted much more broadly than in classical economic theories. It encompasses not only education, professional knowledge, and skills, but also an individual's physical and psychological condition, social ties, motivation, creativity, and capacity for innovation. From this perspective, human capital extends beyond the aggregate characteristics of an individual worker and emerges as a strategic resource for the socio-economic development of the state.

D. P. Melnychuk defines human capital as a combination of knowledge, skills, experience, health status, and motivational characteristics that contribute to increased

individual productivity and strengthen the economic potential of society. A distinctive feature of this form of capital is its capacity to accumulate, reproduce, and increase throughout a person's lifetime under the influence of individual efforts, the social environment, and public policy in the fields of education, healthcare, science, and culture [8]. Other researchers regard human capital as an accumulated stock of productive qualities whose application contributes to higher individual incomes and greater social welfare. Its content encompasses not only the educated segment of the labour force, but also managerial and intellectual potential, as well as the socio-cultural conditions of work and everyday life [9].

A systemic approach to human capital becomes particularly relevant in the context of Ukraine's wartime resilience and post-war recovery. V. I. Luhova and B. M. Makov view it as an integrated system of knowledge, skills, social ties, trust, and norms of coexistence that underpin economic and social development. The loss of qualified personnel, the destruction of educational and research infrastructure, and the weakening of social trust threaten the vital, intellectual, and social components of human capital, thereby necessitating a comprehensive public policy for its restoration [10].

Yu. I. Pylypenko and A. S. Shvets emphasise knowledge, health, creativity, and the capacity for innovation as key intangible human attributes that shape economic competitiveness. They associate human capital development with investment in higher education, science, healthcare, and digital transformation. In this context, higher education is regarded not merely as a mechanism for knowledge transfer, but also as an environment for developing an individual's intellectual, creative, and adaptive potential [11]. L. M. Yemelianenko and V. V. Pantasenko likewise define human capital as a strategic resource for economic growth, social cohesion, societal adaptability, and innovative development [12].

The synthesis of scholarly approaches provides grounds for viewing human capital simultaneously as the outcome of investment in human development, an economic asset, a driver of social progress, and a dynamic category whose realisation depends on working conditions, institutional quality, and social interactions. Its importance increases substantially in the context of Ukraine's recovery, when the preservation, development, and return of human capital should become one of the priorities of public policy.

Accordingly, human capital may be defined as the totality of knowledge, professional skills, experience, health, values, social engagement, and innovative capabilities accumulated throughout an individual's life. It results from both personal effort and societal investment and contributes to the economic, social, and cultural development of society.

The structure of human capital encompasses not only an individual's professional and economic characteristics, but also their physical, intellectual, socio-cultural, motivational, and innovative potential. Scholarly approaches to this category have evolved from simplified models focused primarily on education and health to

multidimensional systems that incorporate creativity, adaptability, mobility, value orientations, and spiritual development.

In monographic research, human capital is regarded as a complex multilevel system comprising knowledge, skills, qualifications, competencies, professional experience, motivation, mobility, physical and intellectual abilities, culture, morality, creativity, entrepreneurial qualities, and information awareness [8]. This approach makes it possible to integrate an individual's personal characteristics with the social and institutional conditions under which they are formed and realised.

L. Artemenko defines human capital as a dynamic, multidimensional system shaped by the interaction of knowledge, professional competencies, innate abilities, health status, experience, motivation, and capacity for work. Particular importance is attributed to the vital, social, and motivational-psychological components, which influence quality of life, labour activity, and opportunities for self-realisation. The effectiveness of human capital is determined by the interrelationship among its components and changes under the influence of the social environment, public policy, and labour market conditions [13].

Innovative potential occupies an important place in the structure of human capital and is manifested in the ability to generate new ideas, adapt to change, and apply knowledge in practice. Yu. I. Pylypenko and A. S. Shvets associate the formation of creative human capital with the quality of higher education, which should ensure not only the transfer of knowledge, but also the development of intellectual flexibility, creative thinking, and innovative activity [11].

Within the regional approach, the core of human capital consists of educational capital, health capital, and cultural capital [12]. Its key components also include professional qualifications, experience, motivation, initiative, work culture, creativity, and adaptability. Their development requires coordinated investment by the state, business, and individuals themselves [14].

Thus, human capital should be viewed as a multilevel system that integrates knowledge, health, professional competencies, motivation, socio-cultural qualities, innovative abilities, and the institutional conditions necessary for their realisation. The generalised structure of its principal components is presented in Fig. 1.

A synthesis of the theoretical foundations of human capital research provides grounds for considering it a multidimensional and dynamic system, thereby enabling a deeper understanding of its significance for socio-economic development. At the present stage, particularly in the context of post-war recovery and large-scale global transformations, intellectual potential is becoming a key driver of innovation, modernisation, and enhanced economic resilience [15]. The combination of knowledge, professional skills, experience, good health, creativity, and motivation forms the foundation of a knowledge-based economy capable of ensuring stable growth and improving population well-being. Contemporary research confirms a close relationship between human capital development and economic dynamics, since qualified, educated, and mobile workers not only produce goods and services with high added value but also stimulate domestic demand through rising personal incomes.

International practice has established a broad consensus that intellectual and workforce potential constitutes one of the most valuable resources of a state, capable of supporting the balanced development of the economy, social sphere, and infrastructure. For Ukraine, the significance of this resource is even greater, as substantial demographic losses, forced migration, labour market imbalances, and the need for intellectual modernisation make investment in human capital a strategic priority for long-term growth and enhanced national competitiveness.

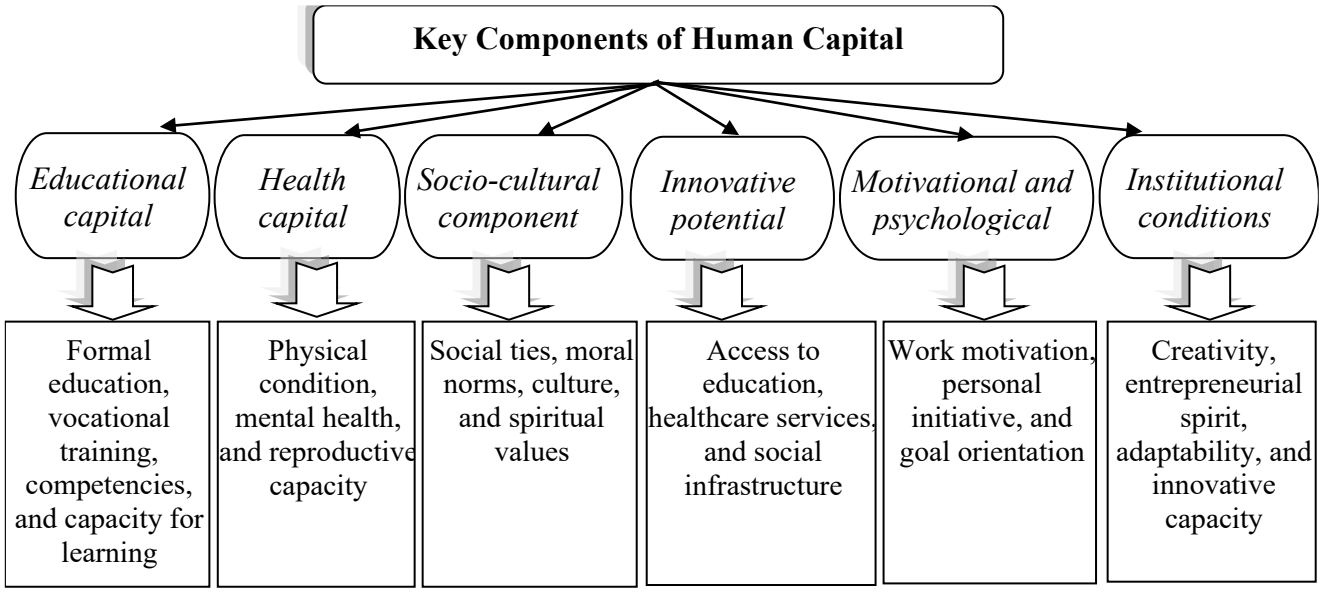

Fig. 1. Key Components of Human Capital
Source: compiled by the author.

A synthesis of the theoretical foundations of human capital research provides grounds for considering it a multidimensional and dynamic system, thereby enabling a deeper understanding of its significance for socio-economic development. At the present stage, particularly in the context of post-war recovery and large-scale global transformations, intellectual potential is becoming a key driver of innovation, modernisation, and enhanced economic resilience [15]. The combination of knowledge, professional skills, experience, good health, creativity, and motivation forms the foundation of a knowledge-based economy capable of ensuring stable growth and improving population well-being. Contemporary research confirms a close relationship between human capital development and economic dynamics, since qualified, educated, and mobile workers not only produce goods and services with high added value but also stimulate domestic demand through rising personal incomes. International practice has established a broad consensus that intellectual and workforce potential constitutes one of the most valuable resources of a state, capable of supporting the balanced development of the economy, social sphere, and infrastructure. For Ukraine, the significance of this resource is even greater, as substantial demographic losses, forced migration, labour market imbalances, and the need for intellectual

modernisation make investment in human capital a strategic priority for long-term growth and enhanced national competitiveness.

In view of the above, human capital should be regarded not only as a major economic asset but also as a critically important component of national security, social stability, and the country's capacity for innovation. At the same time, the opportunities for its formation, reproduction, and effective utilisation depend directly on the demographic situation. Accordingly, the logical continuation of this study is an analysis of Ukraine's demographic challenges, which significantly constrain the full reproduction of human capital and the efficient use of its potential. One of the key indicators in this context is population dynamics, which make it possible to assess the scale of changes in the structure of human resources, the intensity of population ageing, the extent of migration flows, and other critically important characteristics of the country's demographic development (Fig. 2).

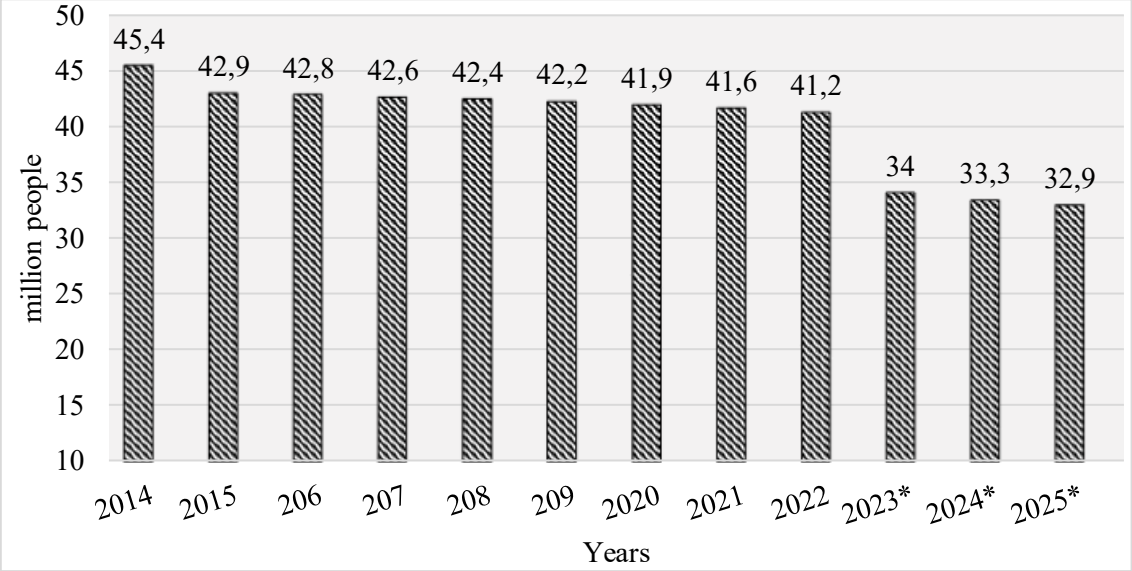

Fig. 2. Population Dynamics in Ukraine, 2014-2025, million people

Note: * – for the period after 2022, population figures are based on estimates by international organisations, as the collection of official statistics has been partially disrupted by the hostilities.

Source: compiled from data in [16; 17].

Ukraine's population has shown a persistent downward trend over recent decades. While it exceeded 51,9 million in 1991, a prolonged decline began in the mid-1990s, driven by natural population decrease and labour migration. Since 2014, official statistics have excluded the temporarily occupied territories, while population estimates have relied primarily on administrative data concerning births, deaths, and changes in place of residence. According to the State Statistics Service of Ukraine, at the beginning of 2022 the de facto population stood at 41,17 million, while the permanent population was almost 41,0 million. By 1 February 2022, the de facto population had declined to 41,13 million [16].

Following the outbreak of the full-scale war, the demographic situation deteriorated sharply. According to estimates by the International Monetary Fund,

Ukraine's population amounted to approximately 34 million in 2023, 33,3 million in 2024, and 32,9 million in 2025, excluding the temporarily occupied territories [17]. Other estimates suggest that demographic losses since the beginning of the war may have reached at least 10 million people, equivalent to almost one-quarter of the pre-war population. A substantial proportion of those who left the country are women, children, and older persons, which has significantly altered the age and sex structure of the population. Prolonged residence abroad and the integration of Ukrainian citizens into host societies also reduce the likelihood of their large-scale return after the cessation of hostilities [18].

If current trends persist, natural population decline and intensive migration may further deepen the demographic crisis in the medium term. This creates risks for labour force reproduction, economic growth, the functioning of the social protection system, and social stability. The most significant manifestations of the demographic crisis are large-scale migration, population ageing, and declining birth rates, whose combined effects weaken both the quantitative and qualitative characteristics of human capital.

Migration activity among the Ukrainian population had already been increasing before the full-scale invasion under the influence of economic instability, unemployment, and uneven socio-economic development. After 2022, however, forced migration reached an unprecedented scale, resulting in a substantial outflow of people abroad (Table 1). Since the beginning of the full-scale war, more than 6 million Ukrainians have left the country, primarily for European Union member states. According to the Office of the United Nations High Commissioner for Refugees, by the beginning of 2024 more than 6,5 million Ukrainian refugees had been officially registered in European countries and elsewhere [19].

Table 1

Migration Dynamics of the Ukrainian Population in the Post-2022 Period

Year/Period	Estimated Number of Ukrainians Who Left the Country	Source
24 February 2022 – February 2024	Approximately 6,5-6,9 million Ukrainians were registered as refugees abroad	UNHCR data as of 15 February 2024 [19]
December 2023	Approximately 6,17 million Ukrainian refugees in European countries	UNHCR data [20]
2025 estimate	Approximately 5,2-8,5 million Ukrainians residing abroad	Estimates by the Centre for Economic Strategy and sociologists: 5.2 million refugees as of November 2024 and 5-8 million Ukrainians abroad in total [21]
2025 alternative estimate	Approximately 8,5 million citizens registered with Ukrainian consular authorities abroad	Data from the Ministry of Foreign Affairs and the Ukrainian Parliament Commissioner for Human Rights [22]
2025 extended estimate	Approximately 11 million Ukrainians may have left the country since the beginning of the war	Statement by Ombudsman D. Lubinets, including persons not registered with consular authorities [23]
2024 return trend	Approximately 3 million Ukrainians left the country and had not returned over the three years of the war	State Border Guard Service of Ukraine data, cited by Forbes in 2025 [24]

Source: compiled by the author based on data from [19-24].

The figures on registered refugees presented above reflect only part of the overall scale of external migration. According to the Ministry of Foreign Affairs of Ukraine, approximately 8,5 million Ukrainians were residing abroad; however, this estimate does not include citizens who left the country without official registration [22]. Other estimates suggest that the total number of people who have left Ukraine since the beginning of the full-scale war may have reached 11 million [23]. The differences between these figures stem from the use of varying accounting methodologies, including the registration of refugees, persons under temporary protection, citizens registered with consular authorities, and other categories of migrants.

The scale of migration losses is also confirmed by data on non-return. According to the State Border Guard Service of Ukraine, approximately 3 million citizens who left the country during the first three years of the full-scale war had not returned [24]. This indicates the gradual formation of sizeable Ukrainian communities in Poland, Germany, Czechia, and other countries that granted temporary protection to Ukrainian citizens.

Despite some adaptation of public policy to migration-related challenges and the introduction of measures aimed at encouraging return, the scale of external migration remains substantial. The prolonged residence abroad of the working-age population and young people constrains demographic reproduction, deepens labour shortages, accelerates population ageing, and reduces economic activity in the domestic labour market.

The likelihood of return gradually decreases as Ukrainian citizens become integrated into the labour markets, education systems, and social environments of host countries. Under these conditions, public migration policy should focus not only on creating favourable conditions for re-emigration, but also on maintaining ties with the Ukrainian diaspora and engaging its professional, intellectual, and investment potential in the country's recovery. Thus, migration processes create risks not only of temporary population loss, but also of long-term depopulation. A strategic response to these threats should involve a comprehensive policy aimed at preserving and restoring human capital, integrating internally displaced persons, and encouraging Ukrainian citizens to return.

Alongside migration, population ageing constitutes another major demographic threat to the reproduction of human capital. It is reflected in the growing proportion of older age groups and the simultaneous decline in the share of young people. Such a transformation of the age structure increases pressure on the labour market, the pension system, healthcare, and social protection, thereby requiring appropriate adjustments to public policy.

The dynamics of the population aged 65 and over confirm the persistent intensification of demographic ageing. While this age group accounted for 13,9% of Ukraine's population in 2000, its share increased to 15,7% in 2014 and to 17,7% in 2022. According to estimates by international organisations, the figure reached 18,6% in 2023 and 19,0% in 2024 [16; 25]. Thus, over the period under review, the proportion of older

persons increased by 5,1 percentage points, indicating a sustained contraction of the demographic base for labour force reproduction.

Amid the armed conflict and the associated human losses, population ageing has accelerated considerably. A substantial proportion of young people have left the country or become involved in hostilities, while the number of older persons remains consistently high. These trends are particularly pronounced in rural areas, where demographic decline is most severe.

A significant concern is the growing demographic burden on the working-age population. According to World Bank estimates, approximately 60 persons of non-working age correspond to every 100 persons of working age in Ukraine, and this ratio is expected to rise further in the coming years [25].

According to the United Nations classification, a population is considered aged when the share of persons aged 65 and over exceeds 14%. Ukraine crossed this threshold as early as 2017. UN projections indicate that by 2050 the proportion of people aged 65 and over may reach 25% of the country's total population [26].

The intensification of demographic ageing is accompanied by several adverse socio-economic consequences:

– reduction in labour potential and the economically active population;

– increased financial pressure on the pension system;

– higher expenditure on healthcare, long-term care, and social support for older persons;

– changes in the structure of consumption, affecting the pace and nature of economic development.

Another major demographic challenge for Ukraine is the prolonged natural population decline caused by falling birth rates and persistently high mortality, particularly during periods of crisis. After 2014, these trends intensified because of the temporary occupation of Crimea and hostilities in eastern Ukraine, and after 2022 because of the full-scale invasion. The war has resulted in additional human losses, the destruction of healthcare infrastructure, increased migration, a deterioration in the population's psycho-emotional condition, and a decline in quality of life. Trends over the past decade reveal a continuous decrease in the number of births alongside persistently high mortality, resulting in sustained negative natural population growth (Fig. 4).

Analysis of the statistical indicators confirms the systemic nature of Ukraine's natural population decline. Since 2016, the natural increase has remained negative, while demographic losses have progressively intensified – from 184 thousand persons in 2016 to more than 440 thousand in 2021. During 2022-2025, despite a certain reduction in the number of deaths, the situation remained critical because of the substantial decline in births. In 2025, the number of live births was almost half that recorded in 2016. This trend reflects both long-term demographic processes and the consequences of the war, including the emigration of people of reproductive age, the postponement of childbearing because of uncertainty about the future, the deterioration

of household financial conditions, and restricted access to high-quality healthcare services.

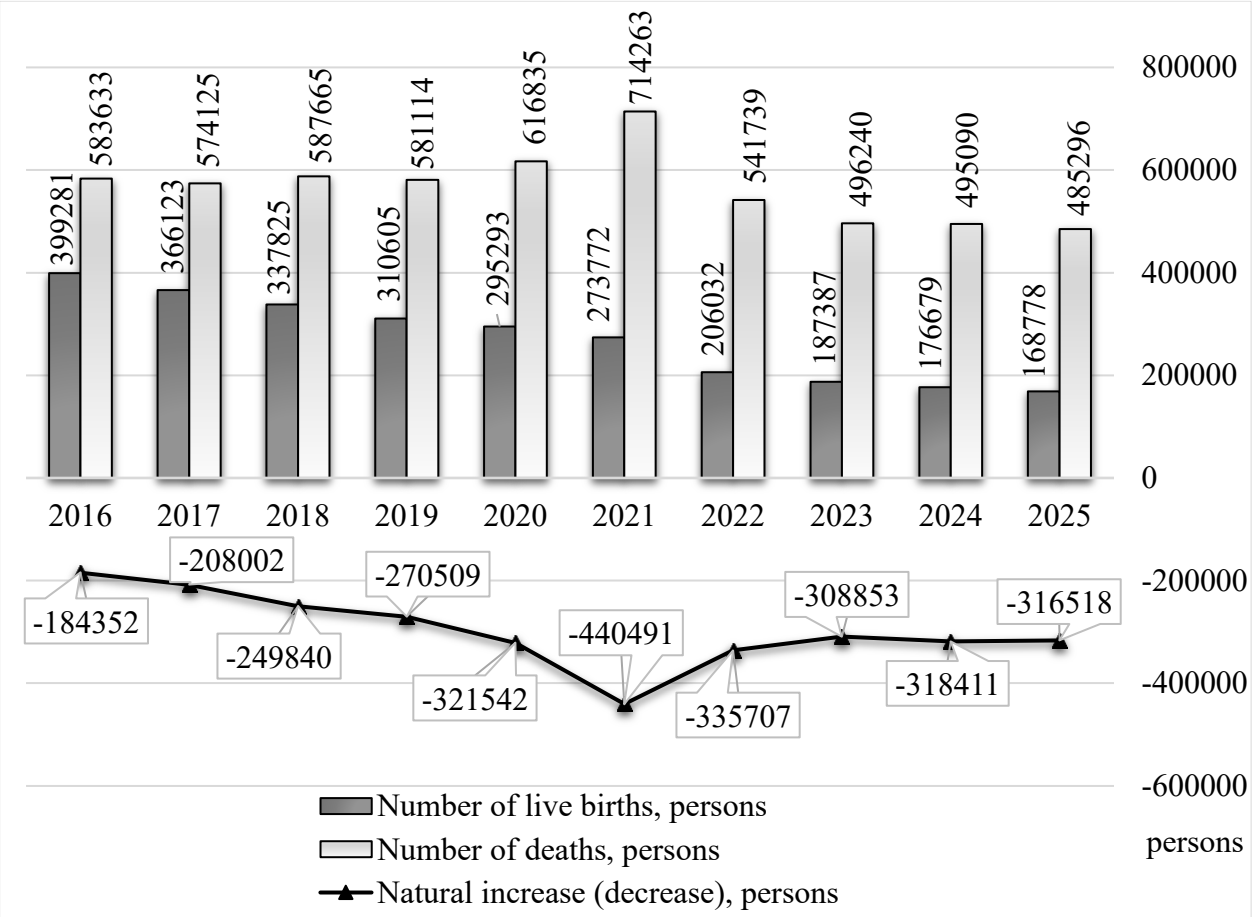

Fig. 4. Birth and Death Dynamics in Ukraine, 2016-2025, persons
Source: compiled by the author based on data from the Ministry of Justice of Ukraine [27].

The analysis demonstrates that the war has substantially transformed the demographic structure of Ukraine's population. Its consequences are reflected in considerable human losses, large-scale migration, declining birth rates, and accelerated population ageing. Under these conditions, demographic processes directly determine the prospects for national recovery, societal resilience, and the country's long-term development.

One of the most acute challenges has been the large-scale displacement of the population both within Ukraine and abroad. Women with children, older persons, and representatives of socially vulnerable groups constitute a substantial proportion of forced migrants. Many of them currently reside in European Union member states, while prolonged adaptation to new conditions may reduce the likelihood of their return to Ukraine.

In addition to migration-related losses, the country has suffered substantial casualties among both civilians and military personnel. Deaths and injuries, the destruction of healthcare infrastructure, and restricted access to medical services in

frontline and temporarily occupied territories have resulted in a deterioration in quality of life and intensified adverse trends in population health.

The persistent decline in birth rates is of particular concern, as it has reached a critically low level during the war. Security threats, economic instability, the emigration of young families, and uncertainty about the future have significantly influenced reproductive behaviour. Consequently, the number of live births continues to decrease each year, further deepening the natural decline of the population.

Thus, the current demographic situation in Ukraine is characterised by profound structural distortions shaped by long-standing adverse trends and substantially intensified by the war. Population decline, large-scale migration, the growing proportion of older persons, falling birth rates, and persistently high mortality are narrowing the country's demographic base. At the same time, the working-age population is shrinking, labour potential is weakening, and pressure on the social protection system is increasing. Taken together, these processes indicate a deepening demographic crisis that is already exerting a significant impact on the economy, the social sphere, and national security.

In this context, challenges in education and healthcare, together with the associated loss of intellectual potential, are becoming particularly acute. Population ageing and large-scale migration complicate access to educational services, reduce participation in education, and adversely affect the quality of human resource development required by the national economy.

The hostilities have caused substantial transformations in the education system, including the destruction of infrastructure and the widespread adoption of distance learning. According to UNICEF, 1,611 schools have been damaged or destroyed since February 2022, while approximately 4,6 million children have faced barriers to accessing education [28]. At the same time, the Ministry of Education and Science of Ukraine reports broader figures: since the beginning of 2022, 3,524 educational institutions have been damaged, of which 360 were completely destroyed. The most severe losses were recorded in communities that had been under occupation or subjected to intensive shelling [29].

The findings of sociological studies conducted by researchers at the State Institution «M. I. Dolishniy Institute of Regional Research of the National Academy of Sciences of Ukraine» indicate a high level of migration aspirations among university students. Positive migration intentions were reported by 51,6% of respondents, 14,9% planned to seek employment abroad in the near future, and 26% had already taken specific steps to implement such plans, including exploring study and employment opportunities, investigating procedures for obtaining permanent residence, or seeking intermediary assistance. Research involving Ukrainian young people residing abroad also revealed a limited willingness to return: 17,0% of respondents intended to remain permanently in their host country, while 16,2% did not associate their future prospects with Ukraine even after the end of the war [30].

Demographic decline, forced migration, and security threats have substantially altered the composition of the student population and weakened the staffing capacity of

Ukraine's education and research sector. According to an analytical report, approximately 7,375 researchers, professors, associate professors, and lecturers were either internally displaced or moved abroad. This has created shortages of qualified personnel in educational institutions and research organisations and has necessitated the adaptation of curricula and teaching formats [31].

The displacement of experienced educators and researchers complicates the implementation of modern educational and research projects, as replacing such specialists quickly is virtually impossible under wartime conditions. At the same time, opportunities for conducting high-quality research and developing international academic cooperation are becoming increasingly limited, adversely affecting the research capacity and competitiveness of Ukrainian higher education [32]. Some lecturers have been compelled to change their professional field or continue working under significantly more difficult conditions, which also influences the quality of training provided to future specialists.

The consequences of demographic change are equally significant for the healthcare system. Problems related to population health, maternal and infant mortality, and life expectancy existed even before the outbreak of the full-scale war, indicating persistent structural imbalances. The hostilities have intensified these problems by restricting access to healthcare, overburdening medical institutions, displacing patients, and creating shortages of medical personnel. Taken together, these factors worsen population health and directly reduce the quality of human capital.

A further threat is the intensification of the «brain drain» – the emigration of qualified professionals in search of safety, stability, and better opportunities for professional fulfilment. This process results in the loss of the most productive segment of human capital, in whose education and training the state has already invested considerable resources. Consequently, the country's research and innovation capacity is weakened, staffing risks increase in education, healthcare, and the technology sector, and the prospects for their effective functioning in the future become more limited.

The interrelationship among the processes discussed above is summarised in Fig. 5, which illustrates the impact of demographic change on the principal components of human capital.

As shown in Fig. 5, the principal demographic challenges – population decline, falling birth rates, intensified migration, and population ageing – exert a complex adverse impact on all components of human capital. The educational, health-related, socio-cultural, innovative, motivational and psychological, and institutional components are weakened by restricted access to essential services, the outflow of qualified professionals, deteriorating health, declining motivation, and the disruption of social ties. The combined effect of these factors leads to both a quantitative reduction and a qualitative deterioration of human capital, which is subsequently reflected in slower economic growth, lower labour productivity, and deepening socio-economic imbalances.

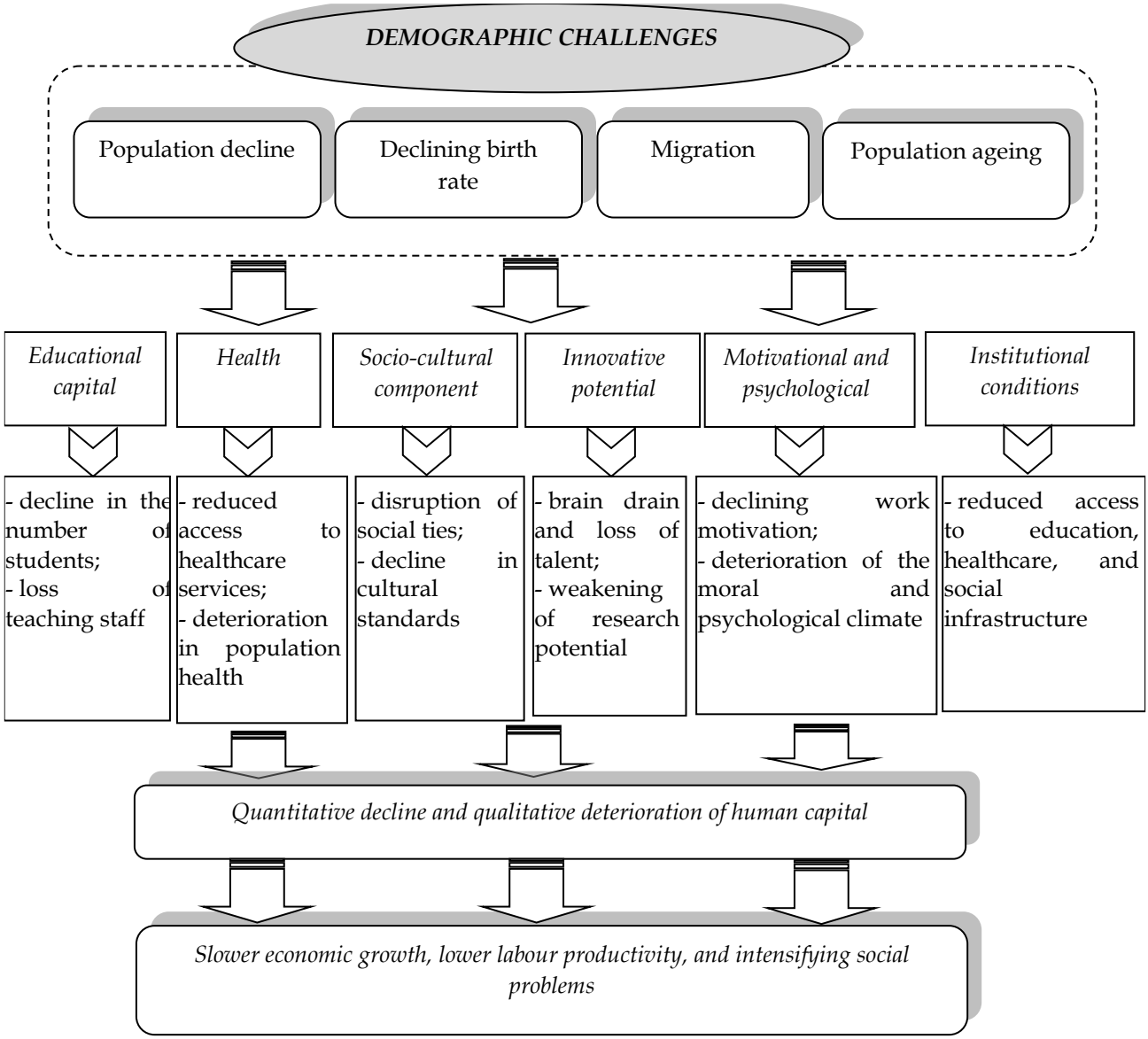

Fig. 5. Impact of the Demographic Crisis on Human Capital
Source: developed by the author.

An analysis of the current state of human capital in Ukraine indicates that these losses are systemic and affect both its quantitative and qualitative dimensions. Demographic decline, large-scale migration, population ageing, and falling birth rates, together with the erosion of the institutional foundations of education, healthcare, and science, create the risk of long-term degradation of the country's workforce, intellectual, and innovative potential.

Under these conditions, Ukraine's post-war recovery strategy should be based on recognising human capital as a key resource that determines not only the pace and quality of economic growth, but also social cohesion, national competitiveness in the global environment, and the country's capacity for innovation [33; 34]. Human capital

forms the foundation of the knowledge economy and digital transformation; therefore, public policy in this area should be systematic and long-term rather than situational. Its priorities should include the creation of a favourable institutional environment, the preservation and enhancement of intellectual potential, and the provision of access to high-quality education, healthcare, and social services.

In view of the above, it is appropriate to identify the strategic directions of public policy aimed at preserving, reproducing, and developing Ukraine's human capital (Table 2).

Table 2

Strategic Directions of Human Capital Recovery Policy in Ukraine

No.	*Policy direction*	*Objective*	*Key measures*	*Expected outcomes*
1	Strengthening demographic potential	Stabilising the population and supporting birth rates	Social support for families, reproductive health programmes, and affordable housing for young people	Higher birth rates and a slower pace of depopulation
2	Re-emigration policy and cooperation with the diaspora	Encouraging the return of qualified professionals and maintaining ties with citizens abroad	Reintegration programmes, return incentives, and digital communication platforms	Increased re-emigration and reduced losses of intellectual potential
3	Recovery of education and science	Improving the quality of human capital and fostering an innovation breakthrough	Reconstruction of schools and higher education institutions, academic mobility, and digitalisation of education	Recovery and modernisation of the workforce training system and stimulation of innovation
4	Development of healthcare	Improving the population's health capital	Restoration of healthcare infrastructure, support for medical professionals, and telemedicine	Increased life expectancy, lower mortality, and improved quality of life
5	Support for labour potential	Increasing employment and adapting the workforce to new conditions	Retraining programmes, support for small businesses, and regional development	Reduced unemployment, higher labour productivity, and integration of internally displaced persons
6	Social integration of displaced persons	Building an inclusive society	Access to education, healthcare, housing, and employment for internally displaced persons	Stronger social cohesion and reduced inequality
7	Institutional support for human capital development	Policy coordination and long-term planning	Establishment of a national agency, regional strategies, and public funding	Effective management of human potential and a stable strategic environment

Source: developed by the author

A key strategic priority for restoring Ukraine's human capital should be the strengthening of its demographic potential, which involves not only stabilising the population but also improving its age, social, and professional structure. In the context of prolonged natural population decline, large-scale migration, and population ageing, demographic policy should shift from fragmented responses to systemic, proactive, and long-term measures.

One of its main priorities is to stimulate birth rates through comprehensive support for young families. Such support may include childbirth allowances, tax incentives, affordable housing programmes, and the expansion of preschool institutions and childcare services. The experience of European countries indicates that the most effective results are achieved by combining financial instruments with social guarantees and well-developed family support infrastructure.

Particular attention should also be paid to protecting reproductive health. Public programmes should ensure access to high-quality medical care, prevention of reproductive disorders, information and counselling services, and family planning support. These measures should be targeted primarily at young people and the population of reproductive age.

During the post-war period, support for demographic recovery will be especially important in territories that have suffered the greatest population losses, particularly rural areas, frontline communities, and de-occupied regions. Regional demographic development programmes should therefore be designed with due regard to population size, labour market conditions, the level of social infrastructure, and access to essential services.

At the same time, comprehensive demographic recovery will be impossible without the return of at least part of the population that left Ukraine during the war. The return of young people, working-age citizens, qualified professionals, researchers, students, and entrepreneurs is particularly important. Re-emigration policy should combine housing, employment, educational, and social support, thereby creating conditions not only for return but also for the long-term retention of citizens in Ukraine.

The principal instruments of such a policy should include:

– priority access to housing, tax incentives, and grant support for entrepreneurial initiatives;

– professional reintegration programmes designed to facilitate the recognition and application of knowledge, skills, and experience acquired abroad;

– support for families with children through access to education, healthcare services, and social infrastructure;

– the development of digital platforms providing citizens with information on job vacancies, housing programmes, available benefits, and return conditions;

– the introduction of mechanisms for the adaptation and integration of return migrants within territorial communities.

The institutional framework for demographic policy requires effective coordination between central executive authorities and local self-government bodies. It would be appropriate either to establish a specialised coordination mechanism or to

strengthen the mandate of existing institutions responsible for developing and implementing a national demographic development strategy. Such cooperation should involve the Ministry of Social Policy, the Ministry of Health, the Ministry of Education and Science, and local self-government bodies.

Another important area is systematic cooperation with the Ukrainian diaspora, which represents a source not only of financial support but also of intellectual, investment, diplomatic, and cultural resources. The relevant strategy should provide mechanisms for engaging diaspora representatives in economic recovery, the implementation of investment and research projects, the development of international partnerships, and the promotion of Ukraine's national interests abroad.

The experience of Israel, Ireland, and Armenia demonstrates that an active re-emigration policy can strengthen a country's intellectual potential by encouraging the return of citizens who have acquired international experience. At the same time, the effectiveness of such a policy depends directly on tangible improvements in domestic living conditions, particularly security, employment opportunities, legal stability, and the quality of public institutions.

The development of education and science is an essential prerequisite for the formation of high-quality human capital, as these sectors determine innovation capacity, economic competitiveness, and societal resilience. Accordingly, the restoration of educational infrastructure should be combined with improvements in safety, inclusiveness, and digital capacity.

The content of education must also be updated in line with labour market requirements. Priority should be given to the development of STEAM competencies, critical thinking, digital and entrepreneurial skills, and the training of professionals capable of operating effectively amid technological change and global competition.

Particular attention should be paid to restoring the human resource capacity of the education and research sector. Public policy should provide incentives for the return of lecturers and researchers, support for their professional activities, opportunities for continuing professional development, academic mobility, and access to international research placements.

The development of science in the post-war period requires increased research funding, greater support for early-career researchers, and broader participation by Ukraine in international programmes, particularly Horizon Europe. Interdisciplinary research focused on reconstruction, digitalisation, and economic modernisation is of particular importance. Investment in education and science should be regarded as a strategic prerequisite for innovation-driven development, job creation, and stronger national competitiveness.

Population health is an equally important component of human capital, as it determines labour productivity, the duration of active working life, and employment capacity. In the post-war period, restoring the healthcare system will be a priority, particularly because it has suffered substantial infrastructural and workforce losses in frontline, de-occupied, and rural communities.

The principal priorities of public policy should include:
– the restoration and modernisation of healthcare infrastructure;
– the creation of conditions conducive to the return of healthcare professionals;
– expanded access to primary healthcare and preventive services;
– the development of telemedicine for remote areas.

A separate priority should be the strengthening of the mental healthcare system, particularly the diagnosis, treatment, and rehabilitation of military personnel, civilians, children, and young people. At the same time, disease prevention, public health programmes, and infrastructure for physical activity and recreation should be expanded.

Improving population health will help reduce social expenditure, minimise working-time losses caused by illness, extend active life expectancy, and increase labour productivity. Therefore, the healthcare system should be viewed not only as part of the social sphere but also as an integral component of the state's economic strategy.

The development of labour potential is another important factor in post-war recovery and requires adaptation to structural changes in the labour market caused by enterprise destruction, internal displacement, and declining employment. The priority should be not only to reduce unemployment but also to create sustainable, productive, and flexible jobs aligned with the needs of the emerging economy.

Professional retraining, the development of modern skills, and the establishment of a lifelong learning system are of particular importance. These measures will provide the sectors driving post-war reconstruction with the required workforce and strengthen employees' adaptability to labour market changes.

At the same time, productive employment must be ensured for socially vulnerable groups, including internally displaced persons, young people, and persons with disabilities. This requires professional adaptation programmes, individualised support, inclusive working conditions, and equal access to employment.

Entrepreneurship represents an important source of new employment, particularly in regions where the production base has been destroyed or traditional forms of employment have declined. Support for small and medium-sized enterprises, improved access to finance, business incubators, and entrepreneurship education programmes can become effective instruments for revitalising local economies.

A separate priority should be the enhancement of internal labour mobility and the reintegration of citizens returning from abroad. The professional experience they have acquired can contribute to the modernisation of production, management practices, and innovation activities.

Accordingly, labour potential development policy should aim to create flexible, innovative, and socially responsible employment that combines individual professional development with the needs of the economy and increases the effectiveness of investment in human capital.

Internally displaced persons occupy a special place in the structure of human capital, as a considerable proportion of them are of working age. Large-scale internal displacement has altered the demographic distribution of the population, increased

pressure on social infrastructure, and intensified the need to ensure equal opportunities for displaced persons.

The integration of internally displaced persons should not be limited to short-term assistance. It should ensure access to housing, education, healthcare, employment, and participation in the life of host communities. This requires targeted national and local programmes, financial support, and an appropriate institutional framework.

An important component of integration policy is the professional adaptation of internally displaced persons through retraining, career counselling, and support for micro-entrepreneurship. Their inclusion in the formal economy will help preserve labour potential and reduce dependence on social assistance.

At the same time, successful integration depends on the capacity of host communities. Population growth increases pressure on education, healthcare, housing and communal services, and social provision. Therefore, policies for the integration of internally displaced persons should be coordinated with regional development, additional funding for communities, and consideration of the new demographic and socio-economic conditions.

The social and psychological adaptation of internally displaced persons is also a vital component of integration. It requires not only individual support but also the creation of an environment of trust and cooperation within host communities. Local initiatives, volunteer projects, dialogue platforms, and shared community spaces can contribute to this process.

The implementation of human capital recovery policy requires a coherent institutional approach and coordinated action across the fields of demography, education, healthcare, employment, social protection, and regional development. The existing fragmentation of governance reduces the effectiveness of public decision-making; therefore, inter-agency cooperation should be strengthened and a specialised body should be designated to monitor and coordinate policy in this area.

It is advisable to develop a National Human Capital Development Strategy with clearly defined objectives, priorities, performance indicators, and implementation mechanisms. Such a strategy should take into account regional disparities, demographic risks, social differentiation, and the requirements of innovation-driven development, while its implementation should be supported by continuous monitoring.

Territorial communities, businesses, and civil society should play an important role in this process. At the local level, targeted programmes should be implemented, human potential development centres established, and partnerships promoted among communities, enterprises, and educational institutions. Businesses may contribute through dual education, corporate training, and research support, while civil society organisations may participate through adaptation and educational initiatives.

Under wartime conditions, human capital is becoming not only a driver of innovation, but also a resource for national survival and recovery. Accordingly, policy in this area should combine demographic reproduction, the return of citizens from abroad, the modernisation of education and science, the strengthening of the healthcare

system, the integration of internally displaced persons, and the development of labour potential.

These priorities should be implemented as interrelated components of a unified human development strategy. Particular importance should be attached to the regional level, where access to essential services, employment, and opportunities for self-realisation is directly ensured.

Thus, under current conditions, human capital should be regarded not merely as an object of investment, but as a crucial prerequisite for Ukraine's sustainable post-war recovery, capable of supporting economic mobilisation, social cohesion, and the state's strategic adaptation to global challenges. Accordingly, the development and implementation of an effective policy in this area should become a central component of the national agenda for the coming decades.

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1.5. Development of Warehousing Activities in the Cold Logistics System: Modern Logistics Solutions

Problem statement. The growing trade in food products, pharmaceuticals, and other goods requiring low-temperature storage is driving demand for cold logistics services. This growth is reflected not only in higher freight volumes but also in a broader range of products that must be stored and transported within precisely defined temperature limits. Under these conditions, warehousing becomes a key link in the cold supply chain, since the main risks of temperature excursions, product quality deterioration, and avoidable logistics costs arise during receiving, put-away, storage, order picking, and dispatch. From an economic perspective, the cold logistics market remains attractive to developers and logistics service providers; however, it requires substantial investment in specialized infrastructure, energy-efficient equipment, and monitoring and control systems [1].

Modern cold supply chains comprise a set of interconnected operations designed to maintain an uninterrupted temperature regime from production through delivery to the final consumer. Even a short-term deviation from the prescribed parameters may accelerate product spoilage, impair consumer properties, shorten shelf life, or require the withdrawal of an entire batch from circulation. The effectiveness of cold logistics therefore depends not only on the availability of refrigeration equipment, but also on the coordination of warehouse processes, cargo-handling speed, appropriate facility zoning, inventory-record accuracy, compliance with the FIFO and FEFO principles, batch traceability, and the ability of personnel to respond promptly to deviations. Automated warehouse management systems (WMS), temperature and humidity sensors, remote monitoring systems, backup power supply, and digital recording of all cargo-handling operations are becoming particularly important.

The development of temperature-controlled warehousing infrastructure is closely linked to broader changes in the warehouse real estate market. During 2022–2024, the

Ukrainian market was shaped by the destruction of logistics facilities, business relocations, shifts in the geography of freight flows, and the growing role of the western regions as transit and distribution hubs. A shortage of high-quality Class A and Class B space, low vacancy rates, and limited additions to new supply intensified competition among tenants for modern warehouse premises. The problem is even more acute in cold logistics, because chilled, frozen, and multi-temperature facilities account for only a limited share of total warehouse stock and are characterized by higher construction costs, more complex engineering systems, and substantial operating expenses.

In 2024, Ukraine's warehouse real estate market experienced a gradual recovery in leasing activity and renewed investor interest. At the same time, the supply of high-quality warehouse space expanded more slowly than demand, which kept vacancy rates low and encouraged the modernization of existing facilities. Demand was driven primarily by retail chains, distributors, e-commerce operators, postal and logistics companies, and third-party logistics (3PL) providers. For cold logistics facilities, traditional requirements related to location, transport accessibility, and clear warehouse height were supplemented by requirements for energy autonomy, backup generators, redundant refrigeration circuits, enhanced thermal insulation, sanitary safety, and flexible temperature zoning. Thus, market conditions at the end of 2024 supported investment not only in new construction but also in the refurbishment and conversion of existing warehouses for temperature-controlled storage.

According to Prologis Research, global demand is increasing for new and more resilient supply chains. The most promising segments remain the production and distribution of food, consumer, medical, and pharmaceutical products. Companies seek to locate warehousing capacity closer to final consumers, increase inventories of critical goods, and reduce dependence on individual suppliers and routes. During transition periods, increasing inventories by 5–10% creates additional demand for warehouse space; for perishable products, this demand is accompanied by the need to establish dedicated temperature zones. In practice, therefore, upgrading existing warehouse infrastructure by installing cold rooms, automated control systems, and energy-saving technologies is often as important as constructing new facilities [2, 3].

Industry experts report a persistent shortage of modern cold-storage facilities capable of maintaining temperature regimes ranging from chilled conditions for meat, dairy products, and vegetables to deep-freezing. The shortage is attributable to the high capital intensity of such projects, long implementation periods, substantial energy costs, the need for specialized equipment, and stringent sanitary requirements. Moreover, the effectiveness of these investments depends on the stability of freight flows, capacity utilization, the structure of the customer portfolio, and the operator's ability to maintain the required service level. Decisions to expand cold-storage capacity should therefore be based on a comprehensive assessment of projected revenue, cash flows, the payback period, and project risks [4].

Literature review. Cold logistics, as an increasingly important area of logistics management aimed at meeting consumer needs, has attracted considerable attention from researchers and practitioners. Ye. V. Krykavskyi and N. V. Chornopyska define

the cold chain as a sequentially organized structure in which the required temperature must be maintained throughout the logistics chain. They note that cold-chain reliability is particularly important in the pharmaceutical market, which is closely linked to biotechnology. If even one element of the cold chain is unreliable according to a critical criterion, the integrity of the entire system is compromised [5, 6]. T. Moskvitina argues that goods handled within Fresh Logistics are highly vulnerable and require stringent conditions during handling and transportation; therefore, reliable logistics performance and the advantages embedded in procurement and handling processes are essential for these products [7]. M. A. Saiensus emphasizes that, despite limitations on storage duration and order-processing efficiency, the market still has an underserved niche for high-quality refrigerated facilities suitable for efficient logistics operations [1]. The topic has also been examined by international scholars, including D. J. Bowersox and D. J. Closs [8], J. R. Stock and D. M. Lambert [9], and D. Waters [10]. Nevertheless, decision-making in specific functional areas, particularly warehousing, remains insufficiently explored. Accordingly, identifying ways to improve the performance of the entire cold chain by enhancing each individual link remains a priority for further research.

Main results and discussion. Maintaining food quality over extended periods is one of the key challenges in production, transportation, and subsequent distribution. Temperature is the most critical factor for chilled and frozen products, while warehouse facilities play a central role in maintaining the required conditions.

The refrigerated warehouse market has not demonstrated rapid growth. Supply has consistently lagged behind demand, particularly for modern Class A facilities. The expansion of refrigerated warehouses and fruit-storage facilities is constrained by high construction, engineering, and operating costs. In general, temperature-controlled facilities may be classified as chilled, frozen, and multi-temperature warehouses. Chilled warehouses are used to store berries and vegetables, alcoholic beverages, confectionery, pharmaceuticals, chilled meat, seafood, and semi-finished products, and typically maintain temperatures at or above 0°C. Frozen warehouses operate at lower temperatures, generally from 0°C to −24°C, and accommodate frozen meat, semi-finished products, ice cream, and other frozen goods. Multi-temperature warehouses combine chilled and frozen zones and may also form part of an ambient warehouse [11].

Market operators are imposing increasingly stringent quality requirements on refrigerated warehouses. Each product category requires a specific temperature regime, and storage parameters vary considerably across products. The principal storage conditions for major product groups are presented in Table 1.

Upon receipt of inbound goods, warehouse personnel verify quantities against the accompanying shipping documents, check product temperature, and register each item using barcodes. Internal material flows involve sorting incoming goods and moving them to the relevant warehouse zones, such as order-picking, cross-docking, packing, and outbound staging areas. The outbound flow is the final stage of warehouse handling and includes loading refrigerated vehicles with goods received through the inbound flow or dispatching goods and raw materials to production facilities.

Table 1

Standard storage temperatures for the principal product categories handled in refrigerated warehouses

#	Product category	Product temperature condition	Storage temperature (°C)
1	Confectionery products	positive temperature range	Up to +18
2	Cakes and pastries		0 to +5
3	Chocolate and chocolate products		+14 to +16
4	Vegetables and fruit	moderate temperatures	+4 to +10
5	Citrus fruit		+2 to +6
6	Meat and fish delicatessen products		+2 to +7
7	Dried fruit, vegetables, and mushrooms	broad temperature range	0 to +10
8	Dairy products and cheese	chilled	+1 to +7
9	Seafood		0 to +5
10	Fermented, salted, and marinated vegetables	superchilled	−1 to +4
11	Semi-finished meat products		−1 to +1
12	Fresh meat and fresh fish		−1 to +2
13	Frozen products, meat, fish, and dumplings	frozen	−18 to −8
14	Soft ice cream		−15 to −18
15	Ice cream		−24
16	Special regime for rapid freezing and medical purposes	deep-frozen	−45

Source: [1]

Before goods requiring special handling during loading, unloading, and storage are handed over for transportation, the consignor must affix appropriate handling labels to each cargo unit, such as “Liquid,” “Protect from light,” “Hermetically sealed packaging,” “Protect from freezing,” and “Do not stack.” Such requirements are communicated through standardized handling symbols.

Raben Ukraine is active in the market for perishable products and provides integrated logistics services that meet European quality standards, including Fresh Logistics services. The company is one of the leading logistics operators and draws on proprietary know-how and 75 years of experience within the Raben Group. Raben Ukraine provides logistics services for fresh products requiring a temperature range of 2–6°C and applies cross-docking technology, which increases cargo-handling speed, reduces rates for less-than-truckload consignments, eliminates storage costs, and is supported by modern IT solutions, including scanning, 24/7 video surveillance, the Track & Trace cargo-tracking system, and the Web Order Entry order-registration system [7].

In 2024, road freight traditionally accounted for the largest share of the Raben Group's services (66%), followed by contract logistics (13%), full truckload (FTL) transport (8%), fresh logistics (8%), lead logistics provider services (4%), and sea and air freight (1%) (Figure 1).

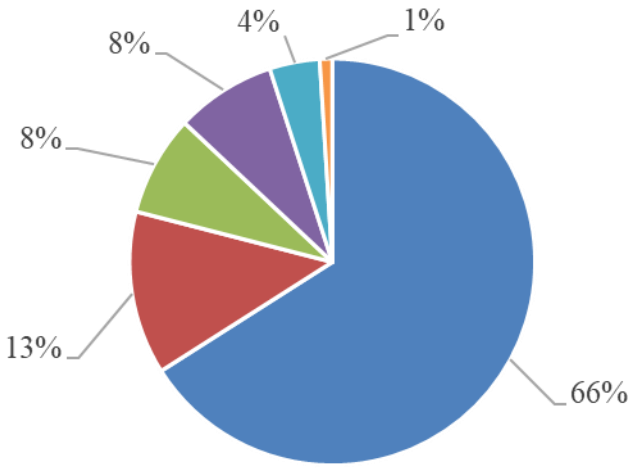

Figure 1. Service portfolio of Raben Ukraine LLC in 2024

Source: compiled by the author based on [12]

To examine warehousing within fresh logistics, the customer portfolio of the Lviv branch of Raben Ukraine LLC is considered in greater detail; this branch serves as the object of the present study (Table 2).

Table 2

Revenue from Fresh Logistics customers of the Lviv branch of Raben Ukraine LLC in 2024

#	Customer	Revenue, UAH
1	2	3
1	APK-Invest LLC	1,560,887
2	Ichnianskyi Milk Canning Plant LLC	921,281
3	Hurmandis LLC	647,333
4	Klub Syru LLC	635,105
5	Koziatyn Meat Processing Plant PJSC	623,231
6	Khodoriv Meat Processing Plant LLC	512,345
7	Yarych Confectionery Factory LLC	483,419
8	Lviv Cold Storage Plant LLC	478,565
9	Barkom LLC	347,225
10	Bukovynskyi Sad LLC	286,031
11	Svit Miasa LLC	189,215
12	Iberia Ukraine LLC	107,363

Source: compiled by the author based on [12]

Table 3 presents the revenue generated from Fresh Logistics customers whose goods require transportation under a controlled temperature regime.

Table 3

Revenue from Fresh Logistics customers of the Lviv branch of Raben Ukraine LLC

Year	2020	2021	2022	2023	2024
Revenue, thousand UAH	2,159	2,497	3,517	4,918	6,792

Source: compiled by the author based on [12]

To assess the feasibility of additional capital investment, it is necessary to estimate projected revenue from Fresh Logistics customers for subsequent periods. A comparative trend analysis showed that a polynomial trendline best represented the future dynamics of this indicator, as it produced the highest coefficient of determination (R^2) among the models considered (Figure 2).

The adequacy of the model was tested using Fisher's F-test, which confirmed that the model was suitable for further calculations. Forecast values were calculated for 2025 and 2026, together with a confidence interval for the 2025 forecast: 6,984; 9,209; and 11,434 thousand UAH [15].

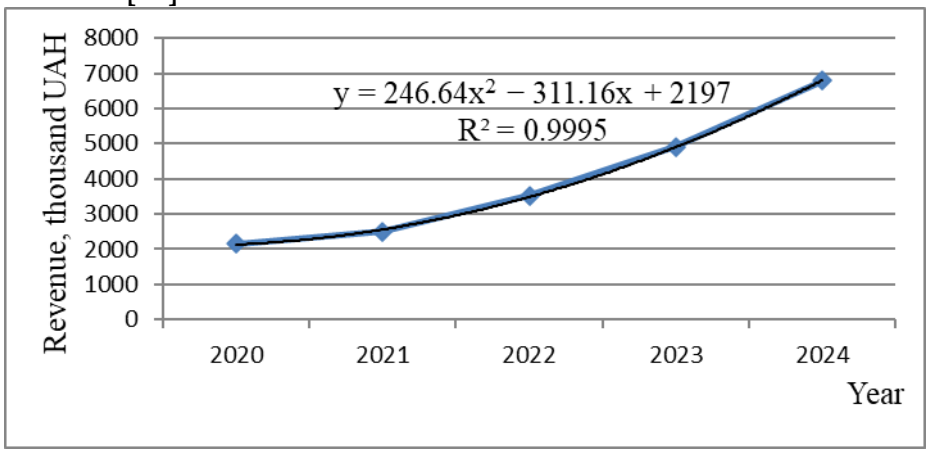

Figure 2. Revenue from Fresh Logistics customers of Raben Ukraine LLC with a polynomial trendline

To justify the expansion of warehousing operations at the Lviv branch of Raben Ukraine LLC, the existing warehouse capacity is assessed (Tables 4 and 5).

Table 4

Input data for calculating warehouse floor area at the Lviv branch of Raben Ukraine LLC

#	Indicator	Symbol	Value	Unit
1	Number of warehouse operating days	T	250	days
2	Average cargo storage period	t_s	1	day
3	Annual warehouse throughput	Q	6,500	t
4	Warehouse height	h	1.8	m
5	Floor-space utilization factor		0.75	–
6	Average load per 1 m² of floor area	q	1	–

Table 5

Warehouse capacity and floor-area calculation for the Lviv branch of Raben Ukraine LLC

#	Indicator	Calculation formula	Value
1	Warehouse capacity, units	$E = (Q \times t_s) / T$	26
2	Total warehouse floor area, m²	$S_{total} = E / (q \times K_u \times h)$	19.26

Source: calculated by the author based on [13]

The calculations indicate the need to purchase one additional cold-storage chamber. The economic feasibility of investing in the additional unit is therefore assessed using the net present value method [14, 15].

The input data for the calculations are presented in Table 6.

Table 6

Input data for evaluating capital investment in a cold-storage chamber

Indicator	Value
Cost of the cold-storage chamber, UAH	2,000,000
Projected revenue in 2025, UAH	9,209,000
Projected revenue in 2026, UAH	12,104,240

Source: calculated by the author based on [14, 15]

To determine the present value of future cash flows, an expert-assessment method was used to set the discount rate at 20%. The corresponding discount factors for 2025 and 2026 are 0.833 and 0.694, respectively.

The project payback calculation is presented in Table 8.

Net present value is the difference between the present value of the project's future cash flows and the initial investment:

NPV = 2,031,759 − 2,000,000 = UAH 31,759.

Table 8

Discounted payback calculation

Year	Cash flow, UAH	Discount factor	Present value, UAH	Cumulative present value, UAH
2025	1,168,707	0.833	973,533	973,533
2026	1,524,822	0.694	1,058,226	2,031,759
Total	–	–	2,031,759	–

Source: calculated by the author based on [14, 15]

The project's payback period is 0.97 years, or 355 days.

Thus, the present value exceeds the project's initial cost, resulting in a positive net present value; therefore, implementation of the proposed project is economically feasible.

Conclusions. The study confirms that warehousing is a critical link in the cold supply chain, as its efficiency directly affects the preservation of the quality and consumer properties of perishable products, compliance with established temperature

requirements, loss minimization, and the overall level of logistics service. Amid a shortage of high-quality refrigerated, freezer, and multi-temperature storage facilities, rising energy costs, and increasingly demanding customer requirements, the competitiveness of logistics operators is determined to a growing extent by their ability to combine the technological modernization of warehouses with efficient cost management. The key prerequisites for such modernization include the implementation of warehouse management systems (WMS), remote temperature and humidity monitoring, digital batch traceability, the FIFO and FEFO inventory management principles, backup power supply systems, and flexible zoning of warehouse premises in accordance with product characteristics.

The analysis of the warehousing operations of Raben Ukraine LLC demonstrates that the development of the Fresh Logistics business segment is of practical importance for expanding the company's service portfolio and improving the quality of service provided to customers whose products require continuous temperature control. The dynamics of revenue generated from Fresh Logistics customers during 2020–2024 indicate growing demand for the relevant logistics services. The economic and mathematical model applied in the study made it possible to forecast revenue for 2025–2026 and provided an analytical basis for assessing the feasibility of expanding the warehousing capacity of the company's Lviv branch. The results confirm that investment decisions in cold logistics should be based not only on the expected increase in cargo flows but also on a comprehensive assessment of equipment utilization, the structure of the customer portfolio, operating costs, power supply risks, and logistics service quality requirements.

The calculations concerning the acquisition of an additional cold-storage chamber yielded a positive net present value of UAH 31,759, indicating the economic feasibility of the proposed investment under the baseline assumptions adopted in the study. The implementation of the project would increase warehouse throughput capacity, reduce the risk of turning away prospective customers because of insufficient temperature-controlled storage space, improve service reliability, and create the conditions for further revenue growth in the Fresh Logistics segment. At the same time, the final managerial decision should be supported by scenario analysis accounting for possible changes in electricity prices, logistics service rates, demand volumes, and the discount rate.

Therefore, the improvement of warehousing activities within the cold logistics system should be based on an integrated combination of organizational, technological, and investment decisions. Their coordinated implementation will contribute to reducing logistics costs, improving cold-chain reliability, enhancing customer service quality, and strengthening the company's competitive position. Further research should focus on assessing the sensitivity of the investment project to market risks, comparing alternative options for expanding warehousing capacity, evaluating the effects of warehouse automation, and developing a system of indicators for measuring cold supply chain resilience.

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1.6. Methodological Toolkit for Evaluating Business Plans of Enterprises: Current Trends and Directions for Improvement

A business plan is a comprehensive strategic document that reflects the goals of a business entity, ways to achieve them, necessary resources, expected results and possible risks of project implementation. It serves as a tool for substantiating an entrepreneurial idea and provides a systematic approach to the organization and development of economic activity. Thanks to a business plan, business entities are able to assess the prospects of a future project, determine its competitive advantages and calculate the need for financial, material and labor resources [1].

The main purpose of a business plan is to substantiate the economic feasibility of creating, expanding or modernizing a business. It provides an information basis for making management decisions, promotes the rational use of resources and allows for timely identification of potential risks, and helps coordinate the activities of all project participants, determine priority areas of development and form a long-term strategy of the enterprise [3].

One of the most important stages in the implementation of a business plan is the evaluation process, as it allows you to determine the realism, effectiveness, and prospects of the proposed project.

In the practical sphere and scientific literature, several approaches to evaluating business plans have been formed, each of which focuses on individual aspects of the future activities of a business entity.

I. Expert approach, which involves involving specialists to analyze the content of the business plan and form conclusions about its quality. Experts assess the logical structure of the document, the validity of the initial assumptions, compliance with market conditions, the level of risk processing, and the realism of forecast indicators. The advantage of this approach is the ability to take into account the qualitative characteristics of the project, which are difficult to express quantitatively.

However, the main disadvantage of the expert approach to business plan assessment is its subjectivity, since the assessment results largely depend on the experience, professional knowledge, competence and personal judgments of experts. Thus, with the same initial data, different experts may reach different conclusions about the prospects and effectiveness of the same project.

The significant disadvantages of the expert approach include:

- high probability of bias in assessments due to personal beliefs or conflict of interest of experts;
- the difficulty of verifying the results, since some of the conclusions are based on professional judgment, rather than on clear calculations;
- significant expenditure of time and money on attracting qualified specialists;
- the dependence of the quality of the assessment on the competence of experts and their awareness of the specifics of the industry;
- limited possibilities for quantitative substantiation of conclusions, which may complicate the comparison of alternative business projects.

In general, the expert approach allows you to take into account the qualitative characteristics of the business plan, its main drawback remains the subjectivity of the assessment, which can affect the objectivity and reliability of the decisions made.

II. Financial and economic approach, based on the analysis of the projected financial results of the business project. The indicators of profitability, liquidity, profitability, investment payback period, net present value (NPV), internal rate of return (IRR) and profitability index (PI) are evaluated, which allows determining the economic feasibility of the project and its investment attractiveness.

However, this approach has a number of disadvantages.

- depends on the quality of forecast data. Errors in forecasting sales volumes, costs, inflation or the cost of capital can significantly affect the assessment results and lead to erroneous management decisions.

- focus on quantitative parameters and limited use of qualitative parameters (level of managerial competence, innovative potential, reputation, social effect of the project).

- high sensitivity of results to changes in the external environment. Fluctuations in exchange rates, interest rates, inflation rates, or changes in market conditions can significantly change the actual effectiveness of the project compared to the forecast.

- the complexity of using individual financial indicators requires a high-quality information base and specialized knowledge in the field of financial analysis.

III. The marketing approach to assessing a business plan involves analyzing the market environment and determining the prospects for the sale of products or services offered within the framework of a business project, with the main goal of this approach being to assess the compliance of the business idea with market needs, the level of competitiveness of the enterprise and the possibilities of achieving planned sales volumes. The assessment process examines market capacity, demand trends, characteristics of target consumers, competitors' activities, pricing policy, sales channels and the effectiveness of marketing activities. This approach is of particular importance for new enterprises and startups, the success of which largely depends on the correct definition of the market niche and consumer needs.

At the same time, the marketing approach has a number of significant drawbacks.

- forming estimates based on forecasting consumer behavior and market trends, which can change rapidly under the influence of economic, social, technological or political factors, which increases the level of uncertainty and may reduce the accuracy of the results obtained.

- the dependence of the assessment on the quality of marketing research. An insufficient sample of respondents, errors in data collection, or the use of outdated information can lead to distorted conclusions about the prospects of the project. Also, the marketing approach mainly focuses on the market aspects of the entity's activities and does not sufficiently take into account the financial, production, and organizational capabilities of implementing the business plan.

- some marketing indicators are qualitative in nature and are not always amenable to precise quantitative measurement (consumer loyalty, brand awareness and

popularity, competitive advantages) and are often based on assumptions and expert judgments.

IV. The risk-based approach to business plan assessment is based on the identification, analysis and assessment of possible risks that may affect the implementation of the business project and the achievement of planned results. Its main purpose is to determine the level of uncertainty of the external and internal environment, as well as assess the ability of the enterprise to counteract potential threats. Within the framework of this approach, financial, production, marketing, investment, organizational, legal and other types of risks are analyzed.

Risk assessment is analyzed using the following tools: sensitivity analysis, scenario analysis, expert assessments, SWOT analysis, decision tree method, risk matrix construction and simulation modeling. The use of these methods allows to identify the most critical factors that can negatively affect the effectiveness of the project, as well as to develop measures to minimize them.

The main advantage of a risk-based approach is the ability to take into account uncertainty and assess the resilience of the business plan to changes in the market environment. It helps to increase the validity of management decisions and reduce the likelihood of financial losses during the project implementation process.

However, this approach has a number of disadvantages:

- difficulty in determining the full list of risks and objectively assessing the probability of their occurrence. A significant part of the risks is predictive in nature, so the results of the analysis often depend on assumptions and expert assessments, which in turn may reduce the accuracy of the conclusions obtained.
- high labor intensity and complexity of the analysis. For a high-quality risk assessment, significant information resources, specialized software and the involvement of specialists with appropriate qualifications are required.
- detailed risk analysis requires additional time and money.
- excessive concentration on potential threats, which can lead to underestimating the prospects of a business project and hindering the adoption of innovative or strategically important decisions.
- lack of accurate prediction of a number of risks: economic crises, trade conflicts, military actions, pandemics, changes in state policy.

V. A comprehensive approach to evaluating business plans provides a comprehensive analysis of the project and allows you to take into account both financial results and non-financial success factors, as it provides a combination of expert assessments, financial and economic analysis, marketing research and risk assessment, creating a reliable basis for making informed management decisions regarding the implementation of a business project.

The integrated approach is based on the simultaneous use of several assessment methods and involves the analysis of all key components of the business plan without necessarily combining the results into a single indicator, with the main advantage being the comprehensiveness of the study of the business project.

A comprehensive approach allows you to take into account not only financial results, but also marketing prospects, production capabilities, organizational support, human resources potential, level of innovation and risks.

An important advantage is the preservation of the detail of the assessment results. Unlike the integrated approach, each component of the analysis is considered separately, which allows you to identify specific problematic aspects of the project and develop targeted measures to eliminate them. It is characterized by high flexibility of application, since the composition of the criteria and assessment methods can change depending on the field of activity, business scale, analysis objectives and investor requirements, which allows you to adapt the assessment system to the specifics of a particular project.

The advantage of the method is to increase the reliability of the results by cross-checking the conclusions obtained by different analysis methods. If the results of financial, marketing, and risk analysis confirm each other, this increases the level of confidence in the business plan.

A comprehensive approach also provides the opportunity to take into account qualitative factors that are difficult to formalize or translate into quantitative form, which is especially important when evaluating startups, innovative projects, and socially oriented business initiatives.

Disadvantages of an integrated approach

- high labor intensity. Conducting a comprehensive analysis requires significant time, financial and human resources, which requires the involvement of specialists of various profiles: financiers, marketers, technologists, lawyers and risk management experts.

- the need to collect a large amount of information, since analyzing all aspects of the business plan requires detailed data on the market, the financial condition of the enterprise, production facilities, the competitive environment, and other factors.

- lack of a single generalizing indicator, which can complicate management decision-making. Different components of a business plan may demonstrate contradictory results: for example, a high level of financial efficiency may be combined with increased risks or an insufficiently developed marketing strategy.

- a comprehensive approach may also contain elements of subjectivity, especially when conducting expert analysis of the qualitative characteristics of the project. The results of the assessment may depend on the professional experience and competence of the experts involved, which complicates the interpretation of the results.

A comprehensive approach, on the contrary, allows for a deep multifaceted analysis of all components of the business plan, but requires significant resources and does not always ensure ease of making a final decision.

VI. The integrated approach involves a comprehensive assessment of the business plan by combining a set of financial, marketing, production, organizational and risk indicators into a single general indicator. Each criterion is given a certain weight depending on its significance, after which an integrated assessment is calculated, which characterizes the overall quality and prospects of the business project.

The advantages of the integrated approach are the ability to obtain a generalized quantitative assessment of the business plan. By combining many indicators into one integrated index, the decision-making process regarding financing or project implementation is simplified. Investors, lenders, and business managers are able to quickly assess the overall level of attractiveness of the project without having to analyze a significant number of individual indicators.

An integrated approach ensures comprehensive consideration of various aspects of an enterprise's activities. The evaluation system may include financial, marketing, production, organizational, innovative, social and environmental indicators. This allows taking into account a wide range of factors that determine the success of a business project.

An important advantage is the ability to compare alternative projects. Using a single integral indicator allows you to rank business plans by level of efficiency and identify the most promising investment areas. This is especially important for financial institutions and investors who select projects from a large number of applications.

An integrated approach also helps reduce the influence of individual random factors, since the assessment is formed on the basis of a large number of criteria, which allows for a more stable and substantiated result compared to the analysis of one or several indicators.

Disadvantages of the integrated approach

- the complexity of defining the system of criteria and their weighting. The selection of indicators and the establishment of weighting coefficients are often carried out by experts, which creates a risk of subjectivity and may affect the final results of the assessment.

- there is a loss of detail in information. Consolidating a large number of indicators into one integral index can hide individual shortcomings of the business plan.

- high sensitivity to the calculation method. Changing the method of normalizing indicators, choosing criteria or weighting factors can significantly affect the final result. This makes it difficult to standardize the assessment and compare the results obtained using different methods.

- the need for a significant amount of information and complex calculations. For high-quality analysis, it is necessary to ensure the reliability of all source data, which is not always possible at the early stages of business project development.

The integrated approach provides a single, general assessment of the business plan and is convenient for comparing alternative projects, but may lead to the loss of important detailed information and depends on the calculation method.

In modern practice of evaluating business plans, the most appropriate is to combine the advantages of both comprehensive and integrated approaches, when comprehensive analysis is used to study individual aspects of the project, and integrated assessment is used to form a final conclusion regarding its feasibility and prospects.

VII. The comparative (benchmarking) approach to business plan evaluation is based on comparing the indicators, characteristics and expected results of a business

project with similar projects, enterprises or industry standards that are already operating on the market. The main goal of this approach is to determine the competitiveness and realism of the business plan by comparing its parameters with the best practices and achieved results of successful business entities.

The evaluation process analyzes indicators such as product sales, profitability, cost structure, labor productivity, return on investment, market share, marketing effectiveness, and other characteristics. The results are compared with industry averages or indicators of leading enterprises, which allows assessing the potential advantages and disadvantages of the business project.

The main advantage of the benchmarking approach is its clarity and practical orientation, which allows you to use the real experience of successful enterprises, identify reserves for improving efficiency and form more informed management decisions. In addition, comparison with best practices helps increase the competitiveness of a business project and helps set realistic targets.

However, this approach has certain drawbacks. First of all, its effectiveness depends on the availability of reliable information about the activities of similar enterprises. In addition, not all business projects have direct analogues, especially when it comes to innovative or unique business ideas. There is also a risk of mechanically copying someone else's experience without taking into account the specifics of a particular enterprise, market or region of activity.

VIII. The scenario approach to business plan assessment involves analyzing possible project implementation outcomes under different scenarios of internal and external environment development. Its essence lies in the formation of several alternative business operation scenarios and assessment of their impact on key performance indicators of the enterprise, and the development of three basic scenarios: optimistic, basic (realistic), and pessimistic.

Within the framework of the scenario approach, the impact of changes in factors such as sales volumes, cost levels, product prices, inflation, exchange rates, interest rates, tax burden, competitive environment and other parameters that may affect the implementation of a business project is assessed and forecast financial results, profitability indicators, return on investment and liquidity are calculated.

However, the scenario approach has a number of disadvantages.

- the results of the assessment largely depend on the correctness of the assumptions made regarding the future operating conditions of the business. Errors in selecting key factors or establishing their possible values may distort the results of the analysis.

- the formation of multiple scenarios requires significant time and analytical resources, which makes it difficult to apply this approach for small enterprises.

- the scenario approach does not determine the probability of each scenario being implemented, but only demonstrates the possible consequences of different options for the development of events, therefore it does not give an unambiguous answer regarding the prospects of a business project, but requires the additional use of other assessment methods.

The quality of business planning largely determines the success of the implementation of an entrepreneurial idea and the effectiveness of management decisions. That is why the assessment of a business plan should be carried out on the basis of clearly defined criteria and principles that allow establishing the degree of its validity, realism and practical value. A comprehensive assessment of the quality of business planning makes it possible to timely identify project shortcomings, reduce the level of risk and increase the efficiency of resource use.

The main criteria for assessing the quality of a business plan include, first of all, the completeness of information, which characterizes the level of disclosure of all key aspects of the enterprise's activities. The business plan should contain a detailed description of the project, market analysis, production plan, organizational structure, financial calculations and risk assessment. The absence or insufficient detail of individual sections can significantly reduce its practical value.

An important criterion is the validity of the indicators, which involves the use of reliable initial data and logically reasoned forecasts. All calculations should be based on the results of marketing research, statistical data, financial statements and real conditions of the enterprise's operation. Unfounded assumptions can lead to erroneous management decisions and negative financial consequences.

Table 1

Comparative characteristics of approaches to evaluating business plans

Approach	Terms of use	Scope of application
Expert	Insufficient statistical data, the need to assess the qualitative characteristics of the project, the availability of qualified experts	Startups, innovative projects, management team assessment, strategic decision analysis
Financial and economic	Availability of reliable financial data and forecasts, the ability to conduct economic calculations	Investment projects, lending, assessment of business profitability and payback
Marketing	Availability of information about the market, consumers and competitors, the need to assess market prospects	Launching new products on the market, developing a marketing strategy, assessing demand
Risk-oriented	High level of uncertainty in the external environment, the need to assess possible threats	Innovative, investment and high-risk projects, anti-crisis management
Integral	The need to generalize the results of evaluations based on many criteria and indicators	Selection of investment projects, rating of business plans, making strategic decisions
Complex	The need for a comprehensive analysis of the business plan and the availability of a sufficient information base	Business plan review for investors, banks, and government business support programs
Comparative (benchmarking)	Availability of similar implemented projects for comparison	Competitiveness analysis, assessment of the company's market position
Scripted	The presence of several possible scenarios and a high level of uncertainty	Strategic planning, investment risk assessment, performance forecasting

Developed by the author

The next criterion is the realism of the forecasts, which reflects the compliance of the planned indicators with the actual capabilities of the enterprise and the market situation. During the assessment, special attention is paid to the forecasts of sales volumes, costs, profits, investment needs and project payback periods. A realistic business plan should take into account potential limitations and risks of the external environment.

Other important criteria include economic efficiency, investment attractiveness, project competitiveness, risk level, and adaptability to changes in the external environment. They allow us to assess the prospects of a business idea, its ability to generate profit, and ensure the long-term development of the enterprise.

The assessment of the quality of business planning should be carried out in compliance with a number of principles. One of the key ones is the principle of systematicity, according to which all sections of the business plan should be interconnected and coordinated with each other. Changes in one element of the project should be reflected in its other components.

The principle of objectivity is important, which involves the use of reliable and verified information when preparing calculations and forecasts. A business plan should not be based on subjective assessments or overly optimistic assumptions. It is complemented by the principle of reliability, which requires confirmation of the initial data with official statistical materials, market research results or financial documents.

The principle of complexity plays a significant role, which involves taking into account the economic, financial, production, marketing, organizational and social aspects of the enterprise's activities. Along with it, the principle of alternativeity is applied, which consists in considering several scenarios of events and possible options for project implementation.

In addition, high-quality business planning should be based on the principle of flexibility, which provides the ability to adjust planned indicators in accordance with changes in the market environment, and the principle of efficiency, which orients the planning process towards achieving maximum economic results through the rational use of available resources.

Business plan assessment is a multi-stage process aimed at determining the level of its validity, realism and prospects for implementation. The effectiveness of a business project largely depends not only on the quality of the business idea itself, but also on the completeness and reliability of the information provided in the business plan. That is why the assessment should be carried out on the basis of a systematic approach that includes the analysis of all key components of the document: from the structure and marketing justification to financial calculations and risk assessment. The complexity of such analysis allows you to get a holistic picture of the prospects for project implementation and minimize the likelihood of making erroneous management decisions.

The first stage of the assessment is the analysis of the structure and content of the business plan, which determines the compliance of the document with generally accepted requirements of business planning and the logical construction of its sections.

A high-quality business plan should contain a project summary, a description of the enterprise, a description of products or services, a marketing plan, a production plan, an organizational plan, a financial plan and a section on risk assessment. Special attention at this stage is paid to the completeness of the presentation of information, the relationship between individual sections and the absence of contradictions between the data provided.

Criteria	Characteristic
Completeness information	Reflects the level of disclosure of all required sections of the business plan.
Validity of indicators	It involves the use of reliable source data and reasoned forecasts.
Realistic forecasts	Determines the correspondence of projected results to actual capabilities and market conditions.
Economic efficiency	The project's ability to provide profitability and growth in business value.
Investment attractiveness	Attracting investors through positive financial results.
Competitiveness	Evaluates the advantages of the project compared to competitors in the target market.

Principles	Characteristic
Objectivity	Based on the use of unbiased information and realistic assumptions.
Certainty	Requires confirmation of source data by official sources and research results.
Complexity	Ensures that the economic, financial, marketing, and production aspects of the project are taken into account.
Alternativeity	It involves the development and evaluation of several scenarios.
Flexibility	The ability to adapt the business plan to changes in the internal and external environment.
Efficiency	Orients the planning process to achieve maximum results with optimal use of resources.
Risk level	The probability of adverse events occurring and their impact on project outcomes.
Adaptability	The ability of the business plan to take into account changes in the external environment and promptly adjust decisions.
Systematicity	Interrelationship and consistency of business plan sections.

Figure 1. Criteria and principles for assessing the quality of business planning
*Developed by the autho*r

The quality of the document preparation, the validity of the sources of information used, the reliability of statistical data and the level of detail of the calculations are also assessed. An important aspect is the presence of clearly formulated project goals and specific mechanisms for their achievement. The business plan should not only describe the future activities of the enterprise, but also demonstrate the practical possibility of implementing the tasks set.

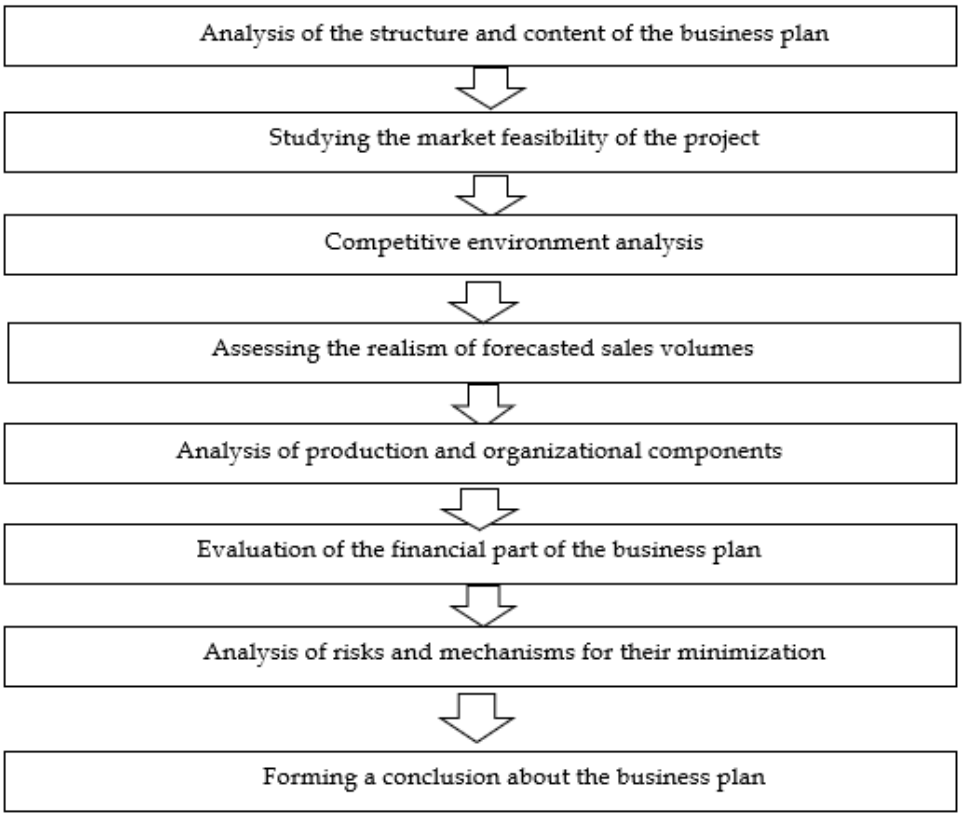

Figure 2. Stages of business plan evaluation

Developed by the author

The next stage is the study of the market feasibility of the project, which is the most important component of the business plan assessment and involves determining the realism of marketing forecasts and the ability of the enterprise to take competitive positions in the market. The assessment process analyzes industry development trends, market capacity, demand dynamics, consumer behavior and competitor activities. The main market segments that the project is focused on are determined, and the level of their attractiveness and prospects is also assessed. Special attention is paid to the study of the target audience and its needs.

An important element of the assessment is the analysis of the competitive environment. The market positions of the main competitors, their advantages and disadvantages, the level of price competition, the features of sales channels and marketing policy are studied. Based on the results obtained, the possibility of achieving the projected market share and forming sustainable competitive advantages is assessed.

The realistic nature of the forecasted sales volumes is assessed separately. To do this, the planned indicators are compared with the industry averages, the results of similar enterprises, and actual market development trends. If the forecast indicators significantly exceed the market averages without proper justification, this may indicate that the business plan developers have overestimated expectations.

Production and organizational components determine the practical possibility of implementing a business project and achieving planned results. Their assessment is

aimed at determining the adequacy of resource provision, the efficiency of production processes and the ability of the management team to achieve the set goals. During the analysis of the production part, production technologies, production capacities, technical condition of equipment, availability of raw materials and materials, logistics processes and the possibility of scaling activities are assessed. The correspondence of production resources to the projected volumes of production and sales of products is determined.

The organizational component includes an assessment of the enterprise management structure, personnel qualifications, distribution of functions between departments, and a system for monitoring the implementation of management decisions. The experience of management, the professional level of key employees, and their ability to ensure the implementation of the business project are analyzed.

Evaluation of the financial part of the business plan. The financial part is the central element of the business plan, since it is it that allows you to determine the economic feasibility of the project and its investment attractiveness. The main purpose of financial analysis is to assess the project's ability to generate profit, ensure the return on invested funds and maintain the financial stability of the enterprise. At this stage, forecasted income and expenses, the structure of investment investments, sources of financing, cash flows and project performance indicators are analyzed. Particular attention is paid to such indicators as net present value (NPV), internal rate of return (IRR), profitability index (PI), payback period and project profitability.

An important area of assessment is the analysis of the liquidity and solvency of the enterprise. It allows determining the ability of a business entity to timely fulfill its financial obligations and maintain an appropriate level of financial stability.

The final stage of business plan evaluation is risk analysis, which allows you to determine the level of uncertainty of the project and its resistance to the influence of adverse factors. In modern business conditions, risks are an integral part of any business activity, therefore their proper assessment is of key importance for making investment decisions.

In the process of analysis, financial, production, marketing, investment, legal, personnel and foreign economic risks are identified. For each risk, the probability of occurrence, possible consequences and the degree of impact on the results of the project are determined. To assess risks, methods of scenario analysis, sensitivity analysis, expert assessments, construction of risk matrices and simulation modeling are used. Of particular importance is the analysis of critical factors, the change of which can significantly affect the financial results of the business project. An important component is the assessment of measures to minimize risks. Such measures may include diversification of activities, insurance, formation of reserve funds, conclusion of long-term contracts with suppliers and consumers, use of modern information management technologies and implementation of internal control systems.

The effectiveness of business plan evaluation largely depends on the presence of a clear sequence of actions, which provides a comprehensive analysis of all components of the project and allows you to form a reasoned conclusion on the feasibility of its

implementation. That is why an important tool for increasing the objectivity of the evaluation is the development of a business plan evaluation algorithm, which determines the procedure for analysis, a list of criteria and a mechanism for making a management decision [10].

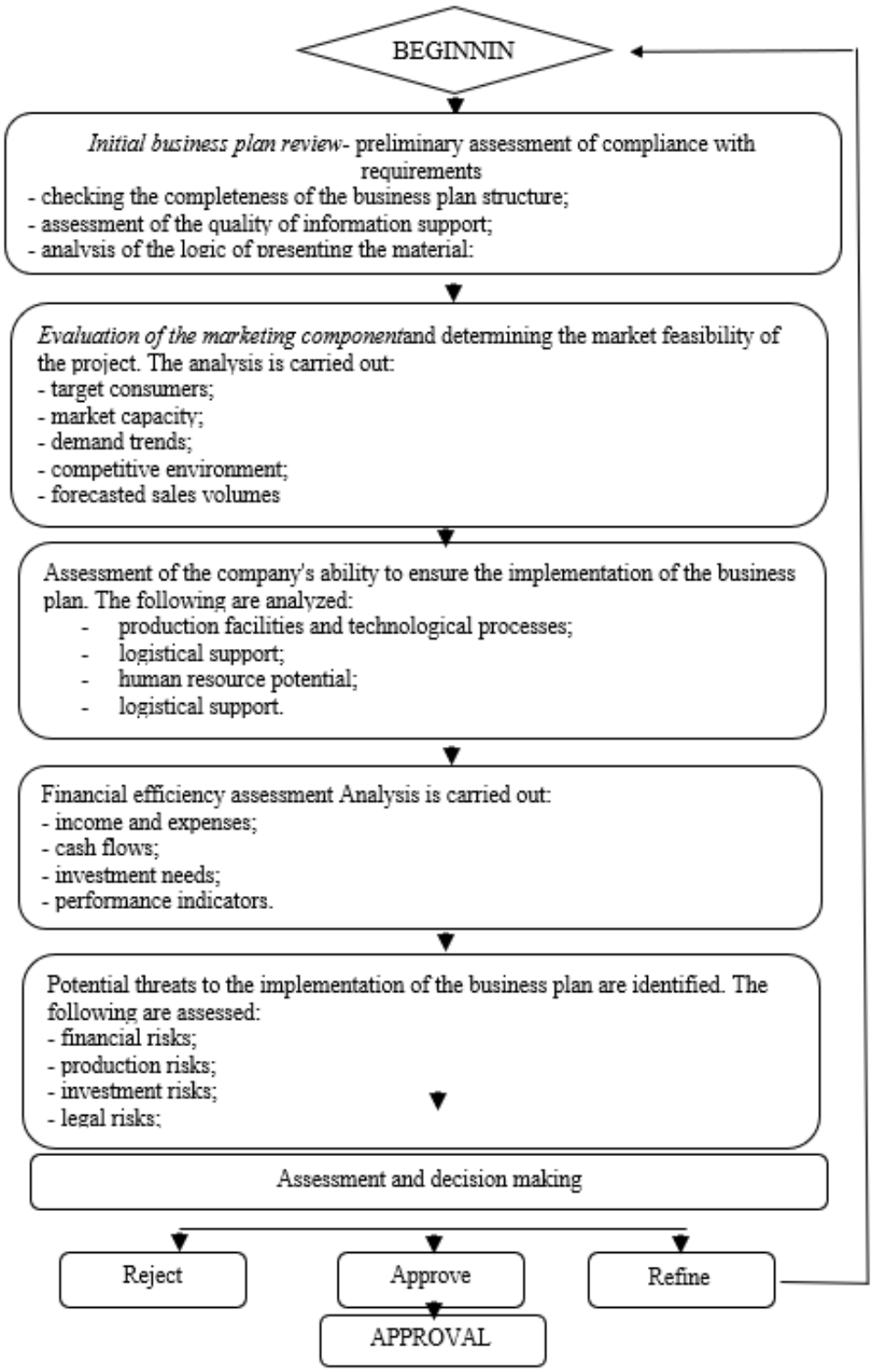

Fig. 3 Flowchart of the business plan evaluation algorithm

Developed by the author

The formed algorithm makes it possible not only to evaluate individual components of a business plan, but also to determine the overall level of its quality using an integral indicator.

In the context of the digital transformation of the economy, increased competition, and growing investor demands for the quality of business projects, traditional approaches to assessing business plans need constant improvement. Modern business planning practice requires not only the analysis of financial indicators, but also the consideration of a wide range of factors related to technological changes, risks, social responsibility, and sustainable development.

In this regard, they become particularly relevant

- digitalization of assessment processes,
- application of multi-criteria analysis methods
- integration of ESG approaches into the business plan evaluation system.

One of the most promising areas for improving business plan evaluation is the implementation of digital technologies and analytical platforms. The use of modern software allows you to automate the processes of data collection, processing and analysis, which significantly increases the speed and accuracy of business project evaluation.

Digital tools enable the rapid calculation of financial indicators, modeling of alternative business development scenarios, sensitivity analysis and risk assessment. The use of business intelligence systems, Big Data technologies and forecasting tools that allow taking into account significant amounts of structured and unstructured information is particularly effective. [6]

Artificial intelligence and machine learning technologies also play an important role, as they can be used to predict market trends, analyze consumer behavior, and identify potential project risks. This increases the validity of management decisions and reduces the level of subjectivity in evaluation.

In addition, the digitalization of the business plan evaluation process contributes to the formation of a single information base for investors, credit institutions, and enterprises, ensuring transparency and accessibility of analysis results.

Traditional methods of evaluating business plans often focus primarily on financial indicators, which does not allow for the full consideration of all factors of success of a business project. Therefore, an important area of improvement is the use of multi-criteria evaluation methods that provide a comprehensive analysis of various aspects of the enterprise's activities.

The essence of the multi-criteria approach is to form a system of interrelated criteria that cover the financial, marketing, production, organizational, innovation and risk components of the business plan. Each criterion is given a certain weight depending on its significance, after which an integral assessment of the project is carried out.

The most common multi-criteria methods include the Analytical Hierarchy Process (AHP), TOPSIS, ELECTRE, expert evaluation, and various rating models. Their

application allows not only to determine the overall effectiveness of the project, but also to identify the strengths and weaknesses of the business plan.[7]

The advantage of multi-criteria evaluation is the ability to take into account both quantitative and qualitative indicators, which helps to increase the objectivity of the analysis results. In addition, the use of such methods allows you to more effectively compare alternative business projects and choose the optimal investment directions.

Current trends in the development of the world economy indicate an increasing role of environmental, social and governance factors in the process of making investment decisions. In this regard, a promising direction for improving the assessment of business plans is the integration of ESG criteria (Environmental, Social, Governance) and sustainable development principles into the project evaluation system.

The environmental component involves assessing the impact of the project on the environment, the level of use of natural resources, energy efficiency of production and the implementation of environmentally friendly technologies. The social component covers the issues of job creation, ensuring proper working conditions, social responsibility of business and interaction with stakeholders. The management component characterizes the quality of corporate governance, transparency of the enterprise's activities, the effectiveness of the internal control system and compliance with ethical standards of business conduct.

Integrating ESG criteria into the business plan assessment process allows assessing not only the economic efficiency of the project, but also its long-term impact on society and the environment. This approach helps attract investments from international financial institutions, increases the reputational attractiveness of the enterprise, and ensures its competitiveness in the long term.

The use of digital analysis tools, the application of multi-criteria assessment methods and the integration of ESG criteria form the modern direction of development of the business plan assessment system. Their comprehensive implementation allows to improve the quality of analytical procedures, to ensure a more objective assessment of business projects and to facilitate the adoption of effective management and investment decisions in a dynamic market environment. [8,9]

Conclusions. As a result of the conducted research, it was established that the assessment of the business plan is one of the key stages in the process of making management and investment decisions, since it is precisely the quality and validity of the business plan that largely determines the success of the project implementation, the level of attraction of investment resources and the achievement of the strategic goals of the enterprise. Modern business conditions are characterized by a highly dynamic market environment, increased competition and increasing uncertainty, which necessitates the improvement of methodological approaches to the assessment of business plans and the introduction of complex analytical tools.

The study summarized theoretical approaches to evaluating business plans and identified their main features. It was found that the expert approach is effective for analyzing the qualitative characteristics of the project, but is characterized by a high

level of subjectivity. The financial and economic approach provides a quantitative determination of the effectiveness of the business project, but does not take into account a number of non-financial factors. The marketing approach allows you to assess the market prospects of the project, but largely depends on the reliability of market development forecasts. The risk-oriented approach ensures that the uncertainty of the external environment is taken into account, although it requires significant analytical resources. The most comprehensive are the integral and complex approaches, which provide a multifactor analysis of the business plan and allow you to form more objective conclusions about the prospects for project implementation.

It is substantiated that an effective assessment of a business plan should be based on a systematic analysis of its main components. In particular, the important areas of assessment are the analysis of the structure and content of the business plan, the assessment of the market feasibility of the project, the study of production and organizational support, the analysis of financial efficiency and the assessment of risks. This approach allows taking into account both the internal capabilities of the enterprise and external factors that affect the success of the business project.

The key result of the study was the development of a business plan assessment algorithm, which involves the sequential passage of six interrelated stages: initial examination of the business plan, assessment of the marketing component, analysis of the production and organizational component, assessment of financial efficiency, risk analysis and integral assessment of results. The proposed algorithm ensures the complexity of the analysis and allows minimizing the influence of subjective factors when making a decision on the feasibility of implementing a business project. A feature of the algorithm is the use of a system of indicators grouped by the main areas of assessment, as well as the use of an integral indicator to form a general conclusion on the quality of the business plan.

The study also confirmed the feasibility of using a multi-criteria approach to evaluating business plans. Unlike traditional methods, which are mainly focused on individual groups of indicators, the multi-criteria model allows you to simultaneously take into account the financial, marketing, production, organizational and risk aspects of project implementation. This provides a more objective assessment of the prospects of the business plan and improves the quality of management decisions.

An important direction in the development of business plan assessment methodology is the digitalization of analytical procedures. The use of modern digital platforms, business analytics tools, Big Data technologies, artificial intelligence and automated decision support systems allows to significantly increase the efficiency, accuracy and reliability of the assessment. Digital technologies create the prerequisites for automating the process of business plan analysis and provide the possibility of rapid modeling of alternative project development scenarios.

The study paid special attention to the integration of ESG criteria into the business plan assessment system. It was found that the modern requirements of investors and international financial organizations are increasingly focused not only on the economic efficiency of the project, but also on its environmental, social and management impact.

Taking into account ESG factors allows assessing the long-term sustainability of the business model, increasing the investment attractiveness of the project and ensuring its compliance with the principles of sustainable development.

Thus, the proposed business plan evaluation algorithm forms a holistic methodological basis for a comprehensive analysis of business projects and can be used by enterprises, financial institutions, investors, government agencies and other stakeholders when making decisions on financing and implementing business initiatives. The practical implementation of the proposed approach will contribute to improving the quality of business planning, reducing investment risks and more efficient use of resources.

Prospects for further scientific research should be linked to the development of adaptive models for evaluating business plans based on artificial intelligence technologies, improving mechanisms for integrating ESG criteria into the business planning process, and creating industry-specific assessment systems that take into account the specifics of the functioning of enterprises in different sectors of the economy. This will contribute to the formation of a modern system of support for management decisions and increasing the efficiency of business project implementation in the conditions of the digital economy and sustainable development.

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1.7. Financial Instruments for Ensuring Economic Recovery Under Global Challenges

The contemporary development of the economy is taking place under the influence of complex and interrelated challenges that significantly change the conditions under which national economic systems operate. Geopolitical tensions, energy instability, inflationary pressure, limited investment resources, and rising financial risks affect the behavior of the state, businesses, financial institutions, and households. Under such circumstances, economic recovery acquires a broader meaning than a simple return to previous levels of production, consumption, or investment activity. It should be considered as a process of restoring financial stability, revitalizing entrepreneurial activity, renewing production potential, strengthening investment capacity, and creating the prerequisites for further economic development.

In this process, financial instruments acquire particular importance, as they ensure the attraction, allocation, and targeted direction of resources to areas that are crucial for restoring economic activity. Such instruments include budgetary, tax, banking, investment, insurance, international, and digital mechanisms capable of supporting business entities, stimulating business activity, reducing risks, and strengthening macrofinancial stability. The effectiveness of their application is determined not so much by the amount of funds raised as by the quality of financial policy, the coordination of financial institutions, the availability of resources for the real sector, and the economy's ability to adapt to an unstable environment. Therefore, the study of financial instruments for economic recovery is of considerable theoretical and practical significance.

Economic recovery is a complex process of restoring the functional capacity of an economic system after the impact of crisis factors that disrupt the normal course of production, investment, employment, consumption, and financial circulation. In the current context, this concept should not be reduced merely to the return of key macroeconomic indicators to their previous levels. It refers to a broader process that encompasses the restoration of economic linkages, the resource base, entrepreneurial activity, institutional trust, and the economy's ability to operate under new conditions. Therefore, economic recovery should be viewed as a transitional stage between crisis destabilization and the subsequent development of the economy.

In the academic literature, economic recovery is often analyzed in connection with the consequences of large-scale crises, military conflicts, structural imbalances, and external shocks. In particular, S. Ivanov, examining the experience of countries after armed conflicts and wars, emphasizes that successful recovery is associated not merely with the reconstruction of destroyed potential, but with the formation of a new

development model capable of ensuring employment, labor productivity, and long-term economic dynamics [1]. This approach provides grounds for considering recovery not as a technical reproduction of the previous state of the economy, but as a qualitative renewal of its key structural elements.

It is also important to distinguish between the concepts of economic stabilization, economic recovery, and economic growth, since they reflect different states of the economic system. Economic stabilization involves reducing the intensity of crisis manifestations, restraining macroeconomic imbalances, and ensuring a minimum level of manageability of economic processes. Economic recovery is the next stage, during which production, investment activity, business initiative, and financial and economic linkages gradually revive. Economic growth, in turn, reflects a more stable positive development trend, when the economy compensates for previous losses and creates new opportunities for expanded reproduction. Thus, stabilization primarily answers the question of how to prevent the crisis from deepening; recovery explains how to return the economy to active functioning; and growth determines how to ensure its further development.

A. Danylenko and H. Yershova, analyzing the post-war recovery of Ukraine's economy, emphasize that recovery processes should take into account current realities together with the strategic objectives of the country's future development. The researchers highlight the importance of revising economic development priorities, overcoming accumulated systemic problems, and creating the prerequisites for a qualitative renewal of the economy [2]. This argument is important because it shows that economic recovery has both a compensatory and a transformational character.

In the current context, economic recovery increasingly depends on the ability of the economic system to adapt to global challenges. Such challenges alter the usual conditions under which markets operate, influence the behavior of investors, the state, businesses, and households, and raise the requirements for the resilience of economic policy. Considering the conceptual foundations of post-war recovery, N. Pokrovska emphasizes the need to take into account globalization changes, the European integration vector, and the staged nature of economic reconstruction [3]. This interpretation makes it possible to understand recovery as a process that should be consistent, institutionally coordinated, and focused on the modernization of the socio-economic system.

From a theoretical perspective, economic recovery requires a set of necessary prerequisites. These include the preservation of basic economic governability, the functioning of the production sector, the availability of labor potential, the institutional capacity of the state, trust among economic actors, and an adequate level of financial support. The latter prerequisite is of particular importance, since financial resources create the capacity to maintain current activity, restore capital, implement investment decisions, and gradually expand economic activity. Without a financial foundation, recovery remains an intention rather than a real economic process.

At the same time, financial support should not be understood solely as the availability of a certain amount of funds. Its meaning is broader and encompasses the

economy's capacity to generate, attract, allocate, and effectively use financial resources in accordance with recovery priorities. Therefore, the role of the financial system is not limited to financing individual needs; it also involves maintaining overall economic equilibrium, trust, solvency, and predictability of the economic environment. In this context, I. Lunina considers public finance an important element of the macroeconomic policy of growth, emphasizing long-term sustainability, the solvency of the state, and the role of budgetary resources in the development of the national economy [4].

Financial support is one of the key prerequisites for economic recovery, as it affects the pace at which economic actors return to active operations, the extent to which recovery processes are implemented, and the future quality of economic development. When accessible resources are available, businesses are able to restore production, maintain employment, make investments, and meet their financial obligations. Conversely, limited financing narrows the space for recovery, increases dependence on external support, and restrains the modernization of the economy. It is important that financial resources be directed not toward the mechanical reproduction of the previous economic model, but toward the formation of a more resilient, productive, and adaptive economic system.

In this regard, the position of T. Yefymenko is particularly relevant, as she links public finance management under martial law and post-war reconstruction with the formation of internal foundations for the resilience and security of economic development [5]. This approach makes it possible to view financial support not as an auxiliary element, but as one of the fundamental conditions for restoring the economic system. The point is that the financial sphere creates the basis for aligning the current needs of the economy with the long-term objectives of its development.

Based on the analysis of the literature, it can be argued that economic recovery under current conditions has a dual nature. On the one hand, it is aimed at overcoming the consequences of crisis phenomena and restoring disrupted economic processes. On the other hand, it creates an opportunity to reconsider the previous development model, improve the effectiveness of economic policy, and strengthen the economy's resilience to future shocks. Therefore, recovery should not be limited to a short-term response to a crisis; it should be regarded as a stage in the formation of a new quality of the economic system.

Global challenges significantly change the conditions under which national economies operate, as they increase uncertainty, complicate the forecasting of macroeconomic dynamics, and raise risks for the state, businesses, and the financial sector. Under conditions of relative stability, financial support for the economy is usually based on the planned allocation of resources, predictable budget parameters, accessible lending, and the gradual attraction of investment. In a period of global instability, however, such a model loses sufficient effectiveness. Contemporary crises are not isolated but interconnected: geopolitical conflicts affect energy markets, energy shocks intensify inflationary pressure, inflation increases the cost of financial resources, and the rising cost of capital limits investment activity and the possibilities for economic recovery [6; 7]. For Ukraine, the impact of global challenges is combined with

large-scale internal losses caused by the war. According to the RDNA5 assessment, as of the end of 2025, direct damage amounted to USD 195.1 billion, socio-economic losses reached USD 666.7 billion, and total recovery and reconstruction needs over a ten-year horizon were estimated at USD 587.7 billion [8]. This is equivalent to an average of almost USD 58.8 billion annually over ten years, which demonstrates the scale of the gap between recovery needs and available financial capacity.

The specific nature of modern global challenges lies in the fact that they simultaneously affect the demand for financial resources and the possibilities for their mobilization. On the one hand, crisis phenomena increase expenditures on economic support, social stability, security, infrastructure restoration, and the functioning of critical sectors. On the other hand, they narrow the financial base through a slowdown in business activity, a decline in investment, reduced solvency of enterprises and households, and the growth of debt burden. As a result, a contradiction emerges between rising financial needs and limited possibilities for covering them, which requires a revision of approaches to the financial support of the economy [9].

One of the most significant factors transforming financial support is geopolitical instability. It increases the risk premium, complicates capital attraction, changes the investment behavior of economic actors, and forces states to redirect financial resources toward priority needs. Under such conditions, the traditional approach, in which financial resources are allocated mainly according to established budgetary or investment priorities, gives way to a more flexible model. This model must take into account the dynamics of risks, the possibility of rapid resource reallocation, the need to maintain liquidity, and the importance of preserving confidence in the financial system.

Inflationary pressure and the related increase in the cost of financial resources represent an equally important challenge. Rising prices affect consumer demand and investment decisions, as they increase business costs, reduce the predictability of cash flows, and raise the cost of borrowing. Under these circumstances, financial support for economic recovery cannot be limited to increasing the volume of financing [10]. The quality of financial planning, the justification of priorities, the coordination of fiscal and monetary policy, and the ability of the financial system to support economic activity without deepening macrofinancial imbalances become particularly important.

Debt risks also have a significant impact on the logic of financing economic development. During periods of crisis, the state is often forced to increase borrowing in order to cover urgent needs; however, excessive debt burden limits the space for future financial policy. This means that economic recovery requires more than additional resources; it requires a balanced approach to their attraction and use. Financing should be directed toward covering current deficits, creating conditions for expanding the economic base, increasing budget revenues, stimulating entrepreneurship, and strengthening the economy's capacity to generate resources for development independently.

Technological transformation has a distinct impact on the financial support of the economy. The digitalization of financial relations accelerates the circulation of funds, expands access to financial services, and increases the transparency of individual

transactions. At the same time, it creates new risks related to cybersecurity, data protection, digital inequality, and the regulation of emerging financial formats. Therefore, under current conditions, the financial system must provide resource support for the economy while adapting to a new technological reality. This changes the very nature of financial support: it becomes more dynamic, information-intensive, and dependent on the quality of digital infrastructure.

It should also be taken into account that global challenges have a cumulative effect. Their impact is not limited to a particular sector or a short period of time. For example, energy instability may simultaneously increase producers' costs, intensify inflation, reduce the competitiveness of products, and require additional investment in modernization. Disruptions in logistics chains, in turn, complicate foreign trade, reduce enterprise profitability, and affect budget revenues. Therefore, the financial support of the economy should not be built on the principle of responding to a single specific risk, but rather as a system capable of functioning under the simultaneous impact of several shocks.

Financial instruments for ensuring economic recovery should be considered as a set of interrelated financial means, mechanisms, and forms of resource provision aimed at restoring economic activity, supporting business entities, stabilizing the financial environment, and creating prerequisites for further development. Their content is not limited to the financing of individual expenditures or programmes. Under current conditions, financial instruments perform a broader function: they ensure the mobilization of resources, their targeted allocation, the redistribution of risks, the maintenance of liquidity, the stimulation of investment activity, and the strengthening of confidence in the economic system.

Given the complexity of recovery processes, financial instruments should be classified according to the sources of resource formation, implementing actors, functional purpose, and the nature of their impact on the economy. This approach makes it possible not merely to list individual instruments, but to determine their place within the overall system of financial support. In World Bank studies, finance is regarded as one of the key factors of post-crisis recovery, since it is the financial system that provides support for households, businesses, the public sector, and investment activity [11].

Given the multi-component nature of financial support for economic recovery, it is important not only to identify individual financial instruments, but also to systematize them according to their functional purpose. This approach makes it possible to show through which channels financial resources can be mobilized, allocated, and directed toward supporting economic activity. In this context, financial instruments should be considered as a combination of fiscal, banking, investment, international, insurance, and digital financial instruments, each group performing its own role in the process of economic recovery. A generalized classification of financial instruments for ensuring economic recovery is presented in Fig. 1.

Fiscal instruments occupy a fundamental place in the system of financial support for economic recovery, since the state budget and tax policy form the initial financial

response to crisis phenomena. During periods of instability, the state is required to perform several tasks simultaneously: to maintain socio-economic stability, finance critical expenditures, create conditions for business activity, and ensure the minimum necessary level of investment in recovery. This group includes state targeted programmes, budget transfers, subsidies, grants, tax incentives, state guarantees, and compensation programmes for businesses. Their distinctive feature is that they have a direct or indirect impact on the financial capacity of economic actors. For example, budget transfers and grants may support specific sectors or territories, tax incentives reduce the financial burden on enterprises, and state guarantees increase the possibility of attracting borrowed resources. At the same time, the effectiveness of fiscal instruments depends on their targeted nature, transparency of administration, and capacity to generate a long-term economic effect. If such instruments are used only to cover current deficits, their impact on recovery remains limited. Conversely, when resources are directed toward supporting production, entrepreneurship, infrastructure, and employment, they can generate a multiplier effect by strengthening the tax base and stimulating future economic activity.

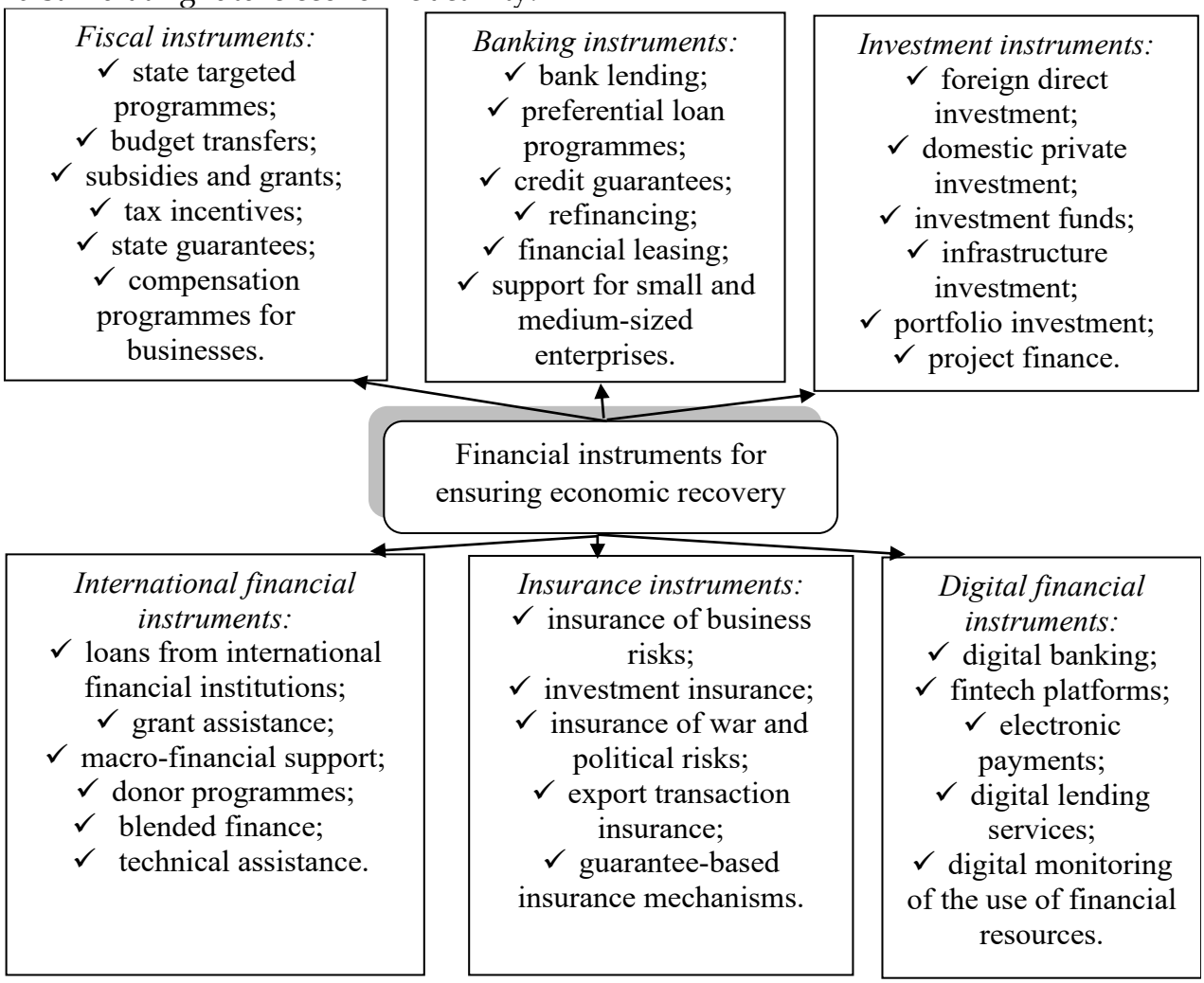

Fig. 1. Classification of Financial Instruments for Economic Recovery

Source: compiled by the author

Banking instruments play an important role in ensuring economic recovery, since the banking system is the main channel for redistributing financial resources among savers, the state, businesses, and households. In crisis conditions, the importance of the banking sector increases, as enterprises often require additional liquidity, working capital financing, debt restructuring, or resources to restore their business operations. Banking instruments include bank lending, preferential loan programmes, credit guarantees, refinancing, financial leasing, and programmes to support small and medium-sized businesses. A practical example of this approach in Ukraine is the state programme "Affordable Loans 5-7-9%", which aims to facilitate entrepreneurs' access to bank financing through interest rate compensation [12]. In addition, the programme provides for the use of partial credit guarantees, which helps address the problem of insufficient collateral on the part of borrowers. From an analytical perspective, banking instruments have a dual nature. On the one hand, they directly support businesses by providing access to financial resources. On the other hand, during periods of high uncertainty, banks themselves become more cautious, tighten borrower requirements, and limit lending due to rising risks. Therefore, the effectiveness of banking instruments largely depends on combining market mechanisms with state or international support, which makes it possible to partially compensate for risks and stimulate lending activity.

Investment instruments provide the long-term foundation for economic recovery. While budgetary and banking mechanisms are often aimed at stabilization and support for current operations, investment instruments are associated with the modernization of production, infrastructure renewal, technological development, and the formation of the economy's future competitiveness. This group includes foreign direct investment, domestic private investment, investment funds, infrastructure investment, portfolio investment, and project finance. Their common feature is their focus on creating or restoring economic potential. Infrastructure investment and project finance are particularly important in the context of recovery, as they allow resources to be directed toward specific facilities or areas with a predictable economic effect. At the same time, investment instruments are highly sensitive to risks. An investor assesses expected profitability along with political stability, legal protection, currency risks, the condition of the financial market, and the predictability of economic policy. Therefore, in order to intensify investment in recovery, it is important to move beyond declaring the need for capital and to create conditions for its safe and effective use.

International financial instruments become particularly important when domestic resources are insufficient to ensure full-scale recovery. They may take the form of loans from international financial institutions, grant assistance, macro-financial support, donor programmes, blended finance, and technical assistance. Their role is to expand the volume of available financial resources while also supporting macrofinancial stability, reforms, institutional capacity, and the confidence of foreign investors. For Ukraine, one of the key contemporary examples of an international financial instrument is the Ukraine Facility, which provides up to EUR 50 billion of stable and predictable European Union support for 2024-2027 aimed at recovery, reconstruction, and

modernization [13]. This format of support demonstrates a shift from one-time assistance to a medium-term financial mechanism that combines resource support with reforms and strategic planning. Blended finance should be considered separately, as it combines public, private, and donor resources. Its importance lies in its ability to reduce risks for private investors and attract capital to areas that are important for development but may be insufficiently attractive in terms of commercial profitability.

Insurance instruments are an important, although often underestimated, component of financial support for economic recovery. Their purpose is to reduce the impact of risks on the activities of businesses, investors, creditors, and other economic actors. Under conditions of global instability, insurance performs both a compensatory and a stimulating function: it increases the willingness of enterprises and investors to participate in recovery processes. This group includes business risk insurance, investment insurance, insurance against war and political risks, export transaction insurance, and guarantee-based insurance mechanisms. Insurance against war and political risks plays a particularly important role in the current environment, since these risks are among the main factors restraining investment activity and long-term financing. In Ukraine, since 2024, the Export Credit Agency has started accepting applications for investment insurance against war and political risks, which is an important step toward strengthening investor protection [14]. MIGA guarantees for war risk insurance in Ukraine through a special trust fund supporting Ukraine's reconstruction and economy are also an important international mechanism [15]. This confirms that insurance instruments are gradually becoming a systemic element of the financial architecture of recovery rather than an auxiliary mechanism. Their use makes it possible to compensate for potential losses and reduce barriers to attracting private and foreign capital.

Digital financial instruments form a modern dimension of financial support for economic recovery. Their emergence is associated with the development of digital banking, fintech platforms, electronic payments, digital lending services, crowdfunding, and digital systems for monitoring the use of financial resources. Compared with traditional financial mechanisms, digital instruments provide greater speed, accessibility, transparency, and flexibility in financial operations.

In the context of economic recovery, digital financial instruments have several important advantages. First, they expand access to financial services for small businesses and households. Second, they reduce transaction costs and the time required to obtain financial resources. Third, they increase the transparency of cash flows, which is especially important when significant amounts of domestic and international support are involved. A World Bank study on fintech emphasizes that digital financial services can play a significant role in maintaining active credit markets and contribute to a more resilient and inclusive recovery. At the same time, digital financial instruments should not be idealized. Their effectiveness depends on the level of digital infrastructure, users' financial literacy, personal data protection, cybersecurity, and the quality of regulation. Therefore, the digitalization of financial support should be viewed not as a replacement

for traditional financial mechanisms, but as a way to modernize them and improve their effectiveness.

Thus, the classification of financial instruments for ensuring economic recovery makes it possible to form a comprehensive understanding of the various channels of financial influence on the economy. Fiscal instruments create the basis for state support; banking instruments provide businesses with access to resources; investment instruments form the long-term foundation for development; international instruments expand the resource capacity of the state; insurance instruments reduce risks; and digital instruments increase the speed and transparency of financial processes. Their effectiveness depends on integrated rather than isolated application, when individual instruments complement one another and form a unified system of financial support for economic recovery.

An analytical assessment of the financial prerequisites for economic recovery should be carried out using Ukraine as an example, since its economy operates under the combined influence of internal crisis factors and external global challenges. The Ukrainian experience is indicative for studying the role of financial support in recovery processes, as the need to restore economic activity is accompanied by a significant budgetary burden, inflationary pressure, high risks for businesses, the need to attract investment, dependence on international financial support, and the necessity of maintaining macrofinancial stability. Therefore, the analysis of Ukraine's key financial and economic indicators makes it possible to assess the real resource potential of economic recovery and to identify the constraints that affect the effectiveness of financial instruments. In this context, particular importance is attached to the dynamics of GDP, inflation, the state of public finances, debt burden, investment activity, bank lending, and the scale of recovery needs. These indicators reflect the financial space of the economy, its level of resilience, and its capacity to mobilize resources.

The real GDP growth of Ukraine in 2023-2025 characterizes a gradual but slowing recovery of economic activity after a deep crisis decline. In 2023, real GDP increased by 5.5%, reflecting the adaptation of businesses, households, and the public sector to the conditions of the full-scale war. In 2024, the growth rate declined to 3.2%, which was associated with the deterioration of the security situation, the renewed electricity deficit, lower harvests, and damage to production infrastructure. In 2025, real GDP grew by 1.8%, confirming the continuation of positive dynamics while also indicating the gradual exhaustion of the economy's initial adaptive potential [16]. This trend suggests that Ukraine's economic recovery remains unstable and depends to a considerable extent on domestic demand, budgetary support, investment activity, the condition of energy infrastructure, and the security environment. Accordingly, the real GDP indicator demonstrates the transition of the economy from a phase of rapid post-crisis recovery to a stage of slower growth, in which the effectiveness of financial support for recovery processes becomes critically important.

An analysis of the execution of the State Budget of Ukraine in 2022-2025 shows that the financial prerequisites for economic recovery were formed under conditions of significant pressure on public finances. In 2022, state budget revenues amounted to

UAH 1,787.4 billion, while expenditures reached UAH 2,705.4 billion. This gap between revenues and expenditures reflects the sharp increase in the budgetary burden during the first year of the full-scale war, when the state had to rapidly redirect financial resources toward defence, security, social payments, support for critical infrastructure, and the maintenance of basic economic governability.

Subsequently, state budget revenues increased from UAH 2,672.0 billion in 2023 to UAH 3,122.7 billion in 2024, and to UAH 3,834.2 billion in 2025. This trend indicates a gradual expansion of the budget revenue base; however, it should not be interpreted solely as a result of the recovery of domestic economic activity. Part of budgetary stability during this period was ensured by external inflows and the specific conditions under which the wartime economy functioned. Expenditures increased at a faster absolute pace: from UAH 4,014.4 billion in 2023 to UAH 5,473.6 billion in 2025, reflecting the continued high demand for state financing of defence, security, social obligations, support for critical infrastructure, and the basic functions of public administration. This forms the key contradiction in the budgetary support of recovery: the state is expanding its resource base while simultaneously being forced to maintain an exceptionally high level of expenditures.

Particular attention should be paid to the dynamics of the state budget deficit. In 2023, its amount was UAH 1,333.1 billion; in 2024, it reached UAH 1,358.5 billion; and in 2025, it increased to UAH 1,635.8 billion. This means that Ukraine's budgetary system remained in deficit throughout the period under review, while financing recovery largely depended on the state's ability to attract additional resources. The ratio of the deficit to budget revenues gradually decreased: from approximately 49.9% in 2023 to 43.5% in 2024 and 42.7% in 2025 [17]. This change may indicate a certain improvement in the proportions between revenues and the deficit; however, the scale of the deficit itself remains substantial and points to the limited capacity of domestic financial resources to ensure full-scale economic recovery. In this context, the budget functions not only as an instrument for redistributing financial resources, but also as a mechanism for maintaining macrofinancial stability, without which the restoration of production potential, investment activity, and socio-economic stability becomes more difficult.

A separate element of the financial prerequisites for recovery is international grant support. In 2023, revenues under the item "From the European Union, foreign governments, international organizations, and donor institutions" amounted to UAH 433.6 billion; in 2024, they reached UAH 475.4 billion, while in 2025 their volume decreased to UAH 174.9 billion. This demonstrates a change in the structure of external support: in 2023-2024, grant revenues played a notable role in the formation of budgetary resources, whereas in 2025 their share in state budget revenues declined significantly [17]. This trend increases the importance of domestic revenue sources, debt instruments, international credit financing, and greater efficiency of budget expenditures. For economic recovery, this is of fundamental importance, since grants reduce the debt burden, while credit financing creates future obligations for the budget. Therefore, the sustainability of financial support for recovery depends on the total

amount of resources attracted as well as on their structure, cost, maturity, and targeted allocation.

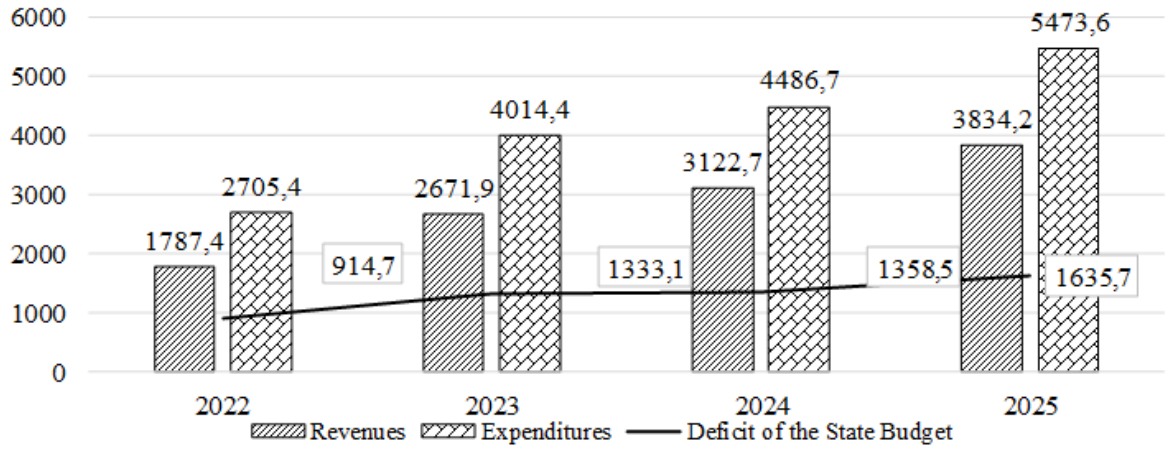

Figure 2. Dynamics of Revenues, Expenditures, and Deficit of the State Budget of Ukraine in 2022-2025, UAH billion

Source: [17].

The persistence of a substantial state budget deficit brings the issue of debt burden to the forefront, as it reflects the scale of additional financial resources attracted to maintain economic resilience and support recovery processes. According to the Ministry of Finance of Ukraine [18], total public and publicly guaranteed debt increased from UAH 4.075 trillion in 2022 to UAH 5.520 trillion in 2023 and UAH 6.981 trillion in 2024, while its ratio to GDP rose from 77.8% to 83.3% and 91.2%, respectively. This indicates a growing debt dependence of the budgetary system under the conditions of a wartime economy and a significant state budget deficit. In 2025, this trend continued: as of 31 December 2025, Ukraine's public and publicly guaranteed debt amounted to UAH 9.0427 trillion, or USD 213.3 billion, which was 29.5% higher than at the end of 2024; according to preliminary estimates, the debt-to-GDP ratio reached 98.4%. Such dynamics should not be viewed solely as a consequence of fiscal imbalance, since in 2022–2025 debt resources performed a stabilizing function by financing critical expenditures, maintaining budget liquidity, and partially compensating for the limited domestic revenue base. At the same time, the debt structure demonstrates growing dependence on external financing: the share of external debt in public debt increased from 63% in 2022 to 72% in 2024, while at the end of 2025 around 75% of public and publicly guaranteed debt consisted of external liabilities. A positive aspect is that a significant share of these liabilities is concessional: in 2025, 66% of the debt consisted of concessional loans from international financial institutions and foreign governments, while the weighted average maturity increased to 13.37 years and the weighted average cost of debt decreased to 4.55%. Thus, Ukraine's debt burden has a dual character. On the one hand, it reflects the objective need of the state to finance the deficit and maintain economic resilience. On the other hand, it creates long-term risks for financial

security related to the currency structure of debt, future debt servicing payments, and dependence on the regularity of international support. Therefore, in the context of economic recovery, the key issue is not only the volume of borrowed resources attracted, but also their cost, maturity, sources of origin, and allocation to areas capable of strengthening the country's production, investment, and budgetary potential.

The increase in the budget deficit and debt burden indicates that economic recovery cannot be ensured solely through public expenditures or external borrowing. Under such conditions, the institutional capacity of the financial system becomes particularly important, namely the ability of the state, the central bank, the banking sector, the insurance market, international financial institutions, investors, and fintech companies to coordinate the allocation of resources toward maintaining economic activity. Financial institutions ensure the practical implementation of financial instruments: they accumulate, redistribute, guarantee, insure, and control the movement of financial resources. Academic studies devoted to corporate finance during wartime emphasize the need for institutional support for financing post-war business recovery, taking into account risks, limited own capital, and the need for enterprise recapitalization [19].

The leading role in shaping the financial prerequisites for recovery belongs to the state, since it determines budgetary priorities, tax conditions, guarantee mechanisms, business support programmes, and directions for attracting international assistance. In a wartime economy, the state effectively acts as a coordinator of financial flows, directing resources toward defence, social stability, support for critical infrastructure, and the gradual restoration of economic activity. Research on the financial support of Ukraine's economic development emphasizes that fiscal and financial stability, effective attraction of public borrowing, rational allocation of financial resources, and the effectiveness of state programmes for supporting entrepreneurship are important for recovery. In this context, the state should not be viewed merely as an administrator of budgetary funds; its function is to create rules under which other financial institutions can operate predictably, responsibly, and with a focus on recovery outcomes.

The National Bank of Ukraine is an important institutional centre for ensuring economic recovery. Its role lies in maintaining monetary stability, regulating the banking system, ensuring the functioning of payment infrastructure, preserving confidence in the national currency, and containing systemic risks. This is of fundamental importance for recovery processes, since monetary instability complicates lending, investment, and long-term financial planning. Commercial banks serve as the main channel for business financing, as enterprises obtain working capital, investment loans, leasing finance, guarantees, and payment services through the banking system. During the recovery period, the role of banks increases, since businesses need rapid access to resources for restoring production capacities, replenishing liquidity, relocation, equipment modernization, and expansion of operations. At the same time, banks remain sensitive to credit, collateral, and security risks; therefore, their activity largely depends on state guarantees, compensation programmes, and the quality of the regulatory environment.

Insurance companies perform the function of risk reduction within the system of economic recovery, without which it is difficult to stimulate private investment and long-term lending. For Ukraine, this issue is of particular importance due to high war-related, political, property, and operational risks. Investment insurance, business risk insurance, export insurance, and guarantee-based insurance mechanisms create conditions under which an investor or creditor can assess risks not as entirely uncertain, but as risks that can be partially transferred to a specialized financial institution. In contemporary Ukrainian studies, insurance of investments against war risks is considered an important prerequisite for attracting capital investment and foreign direct investment into Ukraine's economy [20]. Therefore, in the recovery process, the insurance market should be regarded not as an auxiliary element, but as an infrastructural component of investment security.

International financial organizations and donor institutions occupy a separate place in this system. Their role consists in providing loans, grants, macro-financial support, technical assistance, guarantees, and blended finance. For Ukraine, international support is a factor of budgetary resilience and a source of resources for reforms, infrastructure restoration, social programmes, and macrofinancial stabilization. Under current conditions, international financial institutions perform the role not of an external supplement to the domestic financial system, but of one of its key stabilizers. Investors ensure the transition from financial stabilization to economic development. While budgetary and debt resources are often directed toward maintaining current resilience, investment capital creates the basis for enterprise modernization, renewal of fixed assets, technological development, job creation, and future growth of budget revenues. However, investor activity depends on the protection of property rights, transparency of rules, availability of risk insurance, the quality of the judicial system, stability of the tax environment, and the existence of clear mechanisms for public-private interaction. Therefore, the role of the state, banks, insurance companies, and international partners in this area is interconnected: each of these actors reduces a specific type of risk that influences investment decisions.

Fintech companies form the modern technological framework of financial support for recovery. Their significance lies in improving access to financial services, developing digital banking, electronic payments, online lending, digital identification, crowdfunding models, and monitoring the movement of funds. During the recovery period, this makes it possible to reduce transaction costs, accelerate access to financing, and increase the transparency of resource use. At the same time, the development of fintech requires high-quality regulation, cybersecurity, users' financial literacy, and personal data protection.

Thus, the role of financial institutions in ensuring economic recovery lies in the formation of an integrated system of financial interaction. The state defines priorities and provides guarantees; the central bank maintains monetary and banking stability; commercial banks ensure the functioning of the credit channel; insurance companies reduce risks; international financial organizations compensate for resource shortages and support reforms; investors direct capital toward modernization; and fintech

companies increase the speed and accessibility of financial services. The effectiveness of this system depends on coordination among all participants, since the isolated use of individual instruments cannot ensure sustainable recovery. It is institutional coherence that transforms financial instruments from a set of separate mechanisms into an effective architecture for Ukraine's economic recovery.

An important aspect of further research on financial instruments for economic recovery is the assessment of their effectiveness. Under current conditions, it is not sufficient merely to identify the existence of certain financial mechanisms or the volume of resources directed toward supporting the economy. What is more important is to understand what economic effect these instruments generate, to what extent they correspond to the real needs of economic actors, and whether they are capable of ensuring a long-term strengthening of financial resilience. Therefore, financial instruments should be analyzed not only in terms of resource provision, but also in terms of their impact on the restoration of production activity, employment, investment capacity, budget revenues, and institutional trust. Such an approach makes it possible to move from the formal use of financial instruments to the assessment of their practical value for economic recovery.

The issue of financing prioritization becomes particularly important. Under conditions of limited resources, the state and financial institutions cannot support all areas of economic activity to the same extent. This requires identifying those sectors in which the use of financial resources can generate the greatest recovery effect. Such sectors may include the production of high value-added goods, critical infrastructure, energy resilience, logistics, the agro-industrial complex, the manufacturing industry, export-oriented businesses, as well as small and medium-sized enterprises that provide employment at the local level. Financing priorities should be determined not administratively, but on the basis of an assessment of economic returns, the project's ability to generate income, create jobs, expand the tax base, and reduce dependence on external support.

In this context, it is advisable to introduce a clearer system of criteria for selecting recovery projects. Financing should be directed toward initiatives that have an economic rationale, a transparent cost structure, realistic implementation timelines, and a predictable outcome. It is important to assess not only the need for financing, but also the project's ability to generate a multiplier effect for related industries, territories, and the labour market. For example, investment in the restoration of production infrastructure may create demand for construction materials, transport services, energy equipment, labour, and financial services. In this case, financial resources are not limited to one-time cost coverage, but trigger broader economic activity.

Equally important is the consideration of risks when using financial instruments. Economic recovery takes place under conditions of uncertainty; therefore, every financial decision should be accompanied by an assessment of possible budgetary, debt, currency, credit, investment, and operational risks. Ignoring such risks may lead to inefficient use of funds, an increase in the debt burden, the accumulation of non-performing loans, or a decline in confidence in state support programmes. Accordingly,

financial instruments should be developed on the basis of a risk-oriented approach, in which financing is combined with mechanisms of control, guarantees, insurance, and responsibility of participants.

Separate attention should be paid to aligning the short-term and long-term objectives of financial policy. In crisis conditions, a significant share of financial resources is naturally directed toward covering urgent needs. However, excessive concentration on current financing may restrain the structural renewal of the economy. Therefore, it is important that even anti-crisis financial decisions be linked to future development. Business support should not only preserve current operations, but also create conditions for modernization. Budget expenditures should not merely ensure the functioning of individual sectors, but should support those areas that strengthen economic capacity. International financing should be used not only for stabilization, but also for laying the foundations for self-sustaining economic growth.

An important condition for the effectiveness of financial instruments is improving the quality of financial flow management. This concerns transparency in decision-making, openness of information on the use of resources, a clear distribution of responsibility among participants, and regular assessment of achieved results. In the process of economic recovery, trust in financial institutions is as important as the volume of available funds. When society, businesses, and international partners see that financial resources are used purposefully, reasonably, and effectively, this increases their willingness to continue participating in recovery processes. At the same time, low transparency or weak control reduces the effectiveness of even substantial amounts of financing.

Thus, the further improvement of financial instruments for economic recovery should be based on a combination of resource-based, performance-oriented, and risk-oriented approaches. Financial instruments should be assessed not only by the amount of funds attracted, but primarily by their ability to generate economic returns, reduce the vulnerability of the economy, support entrepreneurial activity, and form long-term financial resilience. This logic makes it possible to regard the financial support of recovery not as a tool of temporary assistance, but as a means of gradually shaping a more resilient, productive, and adaptive economic system.

Improving the financial instruments of economic recovery should be based on a transition from a predominantly reactive financing model to a more integrated and strategically oriented system of financial support. In the current environment, it is important that financial resources be directed primarily toward generating an economic effect capable of strengthening production potential, expanding the tax base, stimulating entrepreneurship, and reducing the economy's dependence on external sources of support. This requires a clear definition of financing priorities, a stronger link between the allocation of resources and the results of their use, and the introduction of continuous monitoring of the effectiveness of financial decisions.

One important direction should be the deepening of financial support for businesses, primarily those economic entities capable of ensuring employment, production, export potential, and local economic recovery. Preferential lending,

guarantee mechanisms, and financial leasing should be oriented toward enterprises whose activities generate a tangible economic result. Particular attention should be paid to small and medium-sized businesses, since this sector responds more quickly to changes in the market environment, supports self-employment, and forms the basis of domestic economic activity. At the same time, business support should be linked to economic feasibility, transparency in the use of funds, and the ability of enterprises to restore or expand their economic activities.

The further development of financial instruments should be closely connected with the activation of investment financing. Economic recovery requires capital directed toward the modernization of production, renewal of fixed assets, infrastructure development, energy resilience, and technological upgrading. For this purpose, it is necessary to create a predictable investment environment in which investors have clear entry rules, protection of invested capital, access to guarantee mechanisms, and the ability to assess risks. Strengthening the role of project finance is appropriate, as it allows resources to be directed toward specific economically justified projects with defined sources of repayment, expected outcomes, and a control system.

An important condition for attracting private and foreign capital is the development of risk insurance. In conditions of high uncertainty, insurance mechanisms should perform the function of reducing barriers to investment and lending activity. This concerns insurance against war, political, property, investment, and export risks. The development of such instruments will make it possible to transform part of the uncertainty into a manageable financial risk, thereby increasing the willingness of investors and creditors to participate in recovery projects. This requires a combination of the capacities of the national insurance market, state guarantee mechanisms, and support from international institutions.

Improving the use of international financing is also of particular importance. External support should be directed toward creating long-term prerequisites for economic self-sufficiency. In this context, it is important to increase the share of grant resources, expand the use of guarantees and blended finance, and channel international funds into investment, infrastructure, and production projects. Credit resources should be used for those areas capable of generating future economic returns, rather than merely covering current expenditures. Such an approach would reduce the risks associated with debt burden and increase the effectiveness of external financial support.

A promising direction for improving financial instruments is the digitalization of financial monitoring. Significant volumes of budgetary, international, and investment resources require a high level of transparency, accountability, and control. Digital platforms should ensure the tracking of cash flows, the status of project implementation, achieved results, and the compliance of expenditures with defined objectives. This will strengthen the trust of society, businesses, and international partners in the recovery process. In addition, digital solutions can reduce administrative costs, accelerate financial decision-making, and improve the quality of recovery programme management.

The development of public-private partnership has significant potential, especially in the areas of infrastructure, energy, logistics, industry, and socially important services. This format makes it possible to combine the resources of the state and business, distribute risks among participants, and attract private capital to the implementation of socially significant projects. The effectiveness of public-private partnership will depend on the transparency of procedures, the economic justification of projects, a clear distribution of responsibilities, and the availability of mechanisms to protect the interests of the parties involved. With proper institutional support, this instrument can become one of the key channels for restoring infrastructure and production potential.

Improving the effectiveness of budgetary instruments should remain a central element of the financial policy of recovery. Under conditions of limited resources, budget financing should have a clearly defined targeted nature and be directed toward areas that generate the greatest economic effect. Priority should be given to projects that support production, employment, critical infrastructure, energy resilience, entrepreneurship development, and the expansion of the domestic revenue base. It is important to strengthen the evaluation of the effectiveness of budget programmes, since the link between the resources spent and the economic results achieved will determine the quality of financial support for recovery.

Thus, improving the financial instruments of economic recovery should involve a coordinated combination of budgetary support, credit mechanisms, investment financing, risk insurance, international assistance, digital monitoring, and public-private partnership. Their effectiveness will be determined not by the number of instruments applied, but by their ability to operate within a unified system, ensure the rational use of resources, and form the long-term financial resilience of the economy. This approach will make it possible to move from short-term financing of needs to the formation of a financial foundation for qualitative economic recovery.

The practical implementation of the proposed directions for improving financial instruments requires the formation of a clear management logic, within which financial decisions are made not situationally, but on the basis of defined economic priorities, efficiency criteria, and expected results. In the process of economic recovery, the ability of the state and financial institutions to distinguish between expenditures that ensure short-term support for the system and financing that generates a long-term economic effect becomes particularly important. This makes it possible to avoid the dispersion of resources and to direct them toward areas where they are capable of strengthening production activity, investment capacity, employment, and future budget revenues.

In this context, it is advisable to introduce a consistent approach to the evaluation of recovery projects. Its basis should not be the formal existence of a need for financing, but the ability of a specific project to generate an economic result. This involves assessing its impact on the development of entrepreneurship, job creation, expansion of the tax base, productivity growth, restoration of critical infrastructure, and strengthening of the financial resilience of territories. Such an approach makes it possible to view financial instruments not as a mechanism for the mechanical distribution of funds, but as a tool for managing economic change. Accordingly, every

financial decision should be linked to a specific objective, an expected effect, and a system of subsequent control.

It is also important to ensure coherence between different levels of financial management. Economic recovery encompasses the national, sectoral, regional, and local levels; therefore, the effectiveness of financial instruments depends on the extent to which the actions of central government authorities, local self-government bodies, the banking sector, insurance companies, international partners, and businesses are coordinated. In the absence of such coordination, even sufficient volumes of financing may fail to produce the expected result due to the duplication of programmes, unclear distribution of responsibility, or the mismatch between financial support and the real needs of economic actors. For this reason, the financial policy of recovery should be based on a transparent distribution of powers, regular information exchange, and a shared vision of priorities.

The issue of trust in the use of financial resources also requires particular attention. Under conditions of significant demand for domestic and external financing, trust becomes an important economic category, since it influences the willingness of businesses to invest, banks to lend, international partners to provide support, and society to perceive financial decisions as justified. Trust is formed through openness of information, clear rules for access to financial resources, public reporting, independent control, and real accountability for the inefficient use of funds. Therefore, transparency should be regarded not as a formal requirement, but as a necessary condition for the effectiveness of financial instruments.

At the same time, the financial policy of recovery should remain flexible. The environment in which recovery takes place is characterized by a high degree of variability; therefore, financial support instruments should be periodically reviewed with regard to new risks, changes in business needs, the state of public finances, investment activity, and international support. Excessive rigidity of financial programmes may reduce their effectiveness, whereas adaptability makes it possible to adjust financing mechanisms in a timely manner and direct resources to where they are most needed. This is especially important for an economy affected simultaneously by security, budgetary, debt, investment, and social challenges.

Thus, the practical significance of financial instruments for economic recovery is determined not only by their availability, but also by the quality of management, transparency of application, coordination of participants' actions, and their ability to generate a measurable economic result. These conditions transform financial instruments from separate support measures into an effective mechanism for restoring economic activity and laying the foundations for future development.

The further effectiveness of economic recovery will be determined by the capacity of the financial system to move beyond maintaining current resilience and toward the formation of long-term sources of development. In this context, the quality of financial decisions becomes particularly important: their validity, consistency with the real needs of the economy, ability to create added value, and capacity to strengthen the country's internal potential. Financial resources should be directed to those areas where they can

generate the greatest recovery effect: production, infrastructure, energy resilience, entrepreneurship, innovation, and human capital. At the same time, it is important to maintain a balance between the need for an operational response to current challenges and the necessity of strategic planning, since excessive reliance on short-term financing may increase the economy's dependence on external support and limit opportunities for future development. Therefore, financial instruments for economic recovery should develop as a flexible, transparent, and institutionally coordinated system in which budgetary, credit, investment, insurance, international, and digital mechanisms work toward a common result. Under this approach, finance will perform not an auxiliary but a strategic function, ensuring the transformation of available resources into sustainable economic growth, strengthening confidence in financial institutions, and creating the foundations for the qualitative renewal of the economy under conditions of global instability.

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1.8. Staff Competency Development as a Foundation for Enterprise Resilience to Change

Under the conditions of the modern economy, enterprise development increasingly depends not only on the availability of material, financial, and technological resources but, above all, on the quality of human capital and employees' ability to respond effectively to changes in both the external and internal environment.

Globalization, economic digitalization, the acceleration of technological innovation, market volatility, geopolitical risks, the consequences of pandemics, and wartime challenges have significantly transformed the operating environment of enterprises. Under these circumstances, organizational resilience is determined less by static competitive advantages than by the ability to adapt rapidly to new conditions, develop innovative solutions, and ensure business continuity. In this context, employees play a pivotal role, as their competencies constitute a key strategic resource for enterprise development [16].

In contemporary academic literature, employee competencies are viewed as an integrated set of characteristics encompassing knowledge, professional skills, practical experience, personal attributes, values, motivation, and behavioral traits that enable individuals to perform their professional responsibilities effectively and contribute to the achievement of an organization's strategic objectives [13]. Unlike the traditional approach to human resource management, the competency-based approach focuses not only on employees' compliance with job requirements but also on their capacity for continuous learning, professional development, innovation, and adaptation to change. Consequently, competency development has become a critical factor in ensuring the long-term competitiveness of enterprises.

Global practice demonstrates that enterprises that systematically invest in employee competency development adapt more rapidly to changing market conditions, implement digital technologies more successfully, execute innovation projects more effectively, and achieve higher levels of labor productivity. Conversely, organizations that pay insufficient attention to the development of human capital often experience declining productivity, shortages of qualified personnel, increased employee turnover, and a growing risk of losing their competitive position [12].

The issue of competency development has become particularly significant in the context of the digital transformation of the economy. The widespread adoption of artificial intelligence, production automation, big data analytics, cloud computing, and digital platforms has fundamentally altered the competency requirements for employees. Whereas professional expertise and specialized knowledge were previously considered the primary prerequisites for effective performance, today's business environment increasingly emphasizes digital literacy, analytical thinking, information management skills, communication abilities, interdisciplinary collaboration, critical thinking, creativity, change management capabilities, and a commitment to lifelong learning. As a result, the concept of lifelong learning has become a fundamental principle of contemporary human resource management.

Another important factor is the increasing uncertainty of the external environment. Modern enterprises operate under conditions characterized by continuous economic, social, political, and technological change, significantly increasing the requirements for organizational resilience. Academic research defines organizational resilience as an enterprise's ability not only to withstand adverse external influences but also to adapt effectively, recover rapidly from crises, and leverage change as a source of new development opportunities [10]. Employees

represent the central element of such resilience, as they are capable of responding promptly to emerging challenges, making effective managerial decisions, and ensuring the continuity of organizational operations.

For Ukrainian enterprises, the development of employee competencies has become particularly relevant. Martial law, structural changes in the economy, large-scale business relocation, shortages of highly qualified professionals, intensified migration processes, and the need for integration into the European economic area have created fundamentally new challenges for human resource management. Under these conditions, enterprises are compelled to reconsider their approaches to workforce development, implement modern learning and development systems, expand the use of digital tools for employee development, and foster a corporate culture that supports continuous professional improvement [9].

In contemporary management theory, competency development is increasingly regarded as an integral component of strategic enterprise management. This perspective is based on the recognition that human capital constitutes one of the most valuable intangible assets of an organization, capable of generating sustainable competitive advantages. Unlike tangible resources, employee competencies are difficult for competitors to replicate or imitate, making them a unique strategic asset of the enterprise. Consequently, the modern resource-based view of the firm and the dynamic capabilities theory place particular emphasis on human capital development as a key determinant of enterprises' strategic adaptation to environmental change [3].

Significant contributions to the development of the competency-based approach have been made by both international and Ukrainian scholars. Contemporary research substantiates the need to shift from traditional personnel administration toward strategic talent management, the development of competency models for positions, the assessment of employees' professional potential, the enhancement of digital competencies, and the establishment of corporate learning systems. Particular attention is devoted to the development of soft skills, which facilitate effective employee interaction, team management, innovation capability, and the successful functioning of organizations under conditions of high uncertainty [1].

Contemporary international research confirms that competency gaps have become one of the major barriers to the economic development of enterprises. According to the forecasts of the World Economic Forum, a substantial proportion of the global workforce will require reskilling or upskilling in the coming years due to the rapid advancement of digital technologies, automation, and artificial intelligence. This indicates that enterprises should move beyond occasional training initiatives and establish comprehensive systems of continuous competency development integrated into their overall organizational management strategies [5].

At the same time, employee competency development should not be regarded solely as a tool for enhancing the professional qualifications of individual employees. Under contemporary conditions, it constitutes an integral component of the enterprise's strategic management system, as a competent workforce ensures the efficient utilization of material, financial, informational, and technological resources. The development of

the required competencies contributes to higher labor productivity, improved managerial decision-making, enhanced innovation capacity, shorter adaptation periods to new business conditions, and stronger competitive positions. In this context, employee competencies represent not only individual characteristics but also a significant element of organizational capability that determines an enterprise's capacity for sustainable development and rapid response to external challenges [7].

The development of employees' digital competencies has become particularly important, as these competencies are essential for the successful digital transformation of business. The application of modern information and communication technologies, automated management systems, digital platforms, cloud services, big data analytics, and artificial intelligence requires employees not only to possess appropriate technical expertise but also to demonstrate a willingness to continuously update their professional competencies. The ability to rapidly master new digital tools has become one of the key determinants of enterprise competitiveness in the digital economy.

Equally important are transferable competencies, commonly referred to as soft skills, which facilitate effective interaction among employees, promote teamwork, and enhance managerial effectiveness. These competencies include communication skills, emotional intelligence, critical thinking, leadership, decision-making ability, conflict management, creativity, responsibility, and adaptability. Academic research indicates that the combination of professional expertise and well-developed transferable competencies generates the greatest benefits for organizational development and strengthens organizational resilience to change [4].

Approaches to employee learning and development have also undergone substantial transformation. Whereas traditional professional development systems primarily focused on the periodic completion of training courses, contemporary competency development models are based on the principles of continuous learning, personalized learning pathways, and the integration of formal, non-formal, and informal learning. Corporate universities, digital learning platforms, distance learning systems, microlearning, adaptive learning technologies, mentoring, coaching, and mentorship programs have become increasingly widespread. These instruments enable enterprises to develop the competencies required to meet their strategic objectives and respond effectively to changing market conditions.

Effective competency development management requires the implementation of modern methods for assessing employees' professional potential. The most widely applied tools include competency frameworks, Assessment Centers, 360-degree feedback, individual professional development plans, Performance Management systems, HR analytics, and digital platforms for monitoring employee development. The application of these approaches enables organizations to identify competency gaps in a timely manner, forecast future training needs, and develop talent pools aligned with the enterprise's strategic objectives.

Contemporary research increasingly emphasizes that employee competency development should be integrated into the strategic change management system. Organizational transformations, regardless of their scale, inevitably require employees

to adapt to new operating conditions. Consequently, the successful implementation of strategic change largely depends on employees' professional qualifications, their readiness for innovation, openness to learning, and ability to work effectively under conditions of uncertainty. Therefore, competency development serves as an important mechanism for mitigating the risks associated with organizational change and ensuring the long-term resilience of enterprises [8].

For Ukrainian enterprises, this issue has acquired particular significance in light of the need for post-war economic recovery, industrial modernization, integration into the European economic area, and the acceleration of digital transformation. The restoration of the competitiveness of domestic businesses will largely depend on their ability to develop modern human capital, establish effective competency development systems, foster employees' innovative capacity, and ensure a high level of organizational adaptability to new socio-economic conditions. Therefore, the study of employee competency development as a foundation of enterprise resilience to change is timely, highly relevant, and of considerable theoretical and practical significance.

At the current stage of the development of management theory and human resource management, employee competencies are regarded as one of the key concepts determining the quality of an enterprise's human capital and the effectiveness of its operations. Despite the widespread use of this concept in both academic literature and management practice, there is still no universally accepted definition among scholars. This can be explained by the interdisciplinary nature of the concept of competency, which has been examined within the fields of management, labor economics, psychology, education, sociology, and organizational theory. Consequently, contemporary academic approaches emphasize different dimensions of competencies, including professional performance, occupational qualifications, behavioral characteristics, learning capacity, adaptability, and value creation for the organization [1].

Historically, the development of the competency-based approach is associated with the work of the American psychologist David McClelland, who demonstrated that traditional employee evaluation criteria based solely on educational attainment, professional experience, or intelligence test scores do not provide reliable predictions of job performance [14]. In contemporary research, the terms "competence" and "competency" are often used interchangeably; however, most scholars emphasize the importance of distinguishing between them. Competence is generally understood as a defined set of knowledge, skills, abilities, experience, behavioral patterns, and personal characteristics required for the effective performance of professional functions. Competency, in contrast, refers to an individual's actual ability to apply these competencies in practice to achieve the desired outcomes. Thus, competence represents the employee's potential, whereas competency reflects the extent to which this potential is effectively realized in professional practice [6].

From the perspective of contemporary management, employee competencies should be viewed as an integrated system of interrelated characteristics that enable employees to perform professional tasks effectively, achieve the enterprise's strategic

objectives, and create added value. This approach reflects a shift away from the narrow interpretation of competencies as merely a combination of professional knowledge and technical skills and instead encompasses cognitive, functional, social and communication, ethical, and personal attributes. It is the comprehensive nature of these competencies that determines employees' ability to perform effectively in highly dynamic environments, make non-standard decisions, and contribute to the innovative development of the organization [13].

Contemporary literature proposes several approaches to the classification of employee competencies. The most widely adopted is the functional approach, according to which competencies are categorized into professional, managerial, social, personal, and digital competencies. Professional competencies comprise the specialized knowledge, practical abilities, and technical skills required to perform specific job functions. Their content depends directly on the nature of the profession, the industry sector, and the employee's level of responsibility. These competencies constitute the foundation of professional qualifications and ensure the quality and effectiveness of operational processes within the enterprise [16].

Managerial competencies refer to the ability to organize team activities, make managerial decisions, perform planning, coordination, control, and employee motivation. They are essential not only for managers at different organizational levels but also for professionals whose responsibilities include project implementation, team leadership, or business process coordination. This group of competencies encompasses strategic thinking, systems analysis, change management, risk management, leadership, delegation of authority, and employee development [10].

Social competencies reflect an employee's ability to interact effectively with other participants in the work process, maintain constructive communication, work collaboratively in teams, resolve conflicts, and build cooperative relationships. In contemporary organizations, the level of social competency development largely determines the effectiveness of teamwork, the quality of internal communication, and the efficiency of knowledge sharing among organizational units. These competencies are particularly important in project-based organizations, where performance depends on collaboration among specialists from different professional fields.

Personal competencies encompass the individual psychological characteristics that influence employees' professional performance. These include responsibility, initiative, self-organization, discipline, emotional resilience, the capacity for self-development, creativity, entrepreneurship, and a results-oriented mindset. This group of competencies largely determines employees' readiness for continuous professional improvement, the acquisition of new knowledge, and effective performance under conditions of uncertainty.

A separate category consists of digital competencies, whose importance has increased substantially with the development of the digital economy. These competencies include the ability to use modern digital technologies effectively, work with information systems, analyze data, apply digital communication tools, utilize cybersecurity practices, and integrate digital solutions into professional activities.

Unlike occupation-specific professional competencies, digital competencies are universal in nature and have become essential for employees across virtually all sectors of economic activity [7].

Alongside the functional classification, the behavioral approach has gained considerable prominence. According to this approach, competencies are understood as a set of behavioral patterns that enable individuals to achieve high levels of job performance. Within this framework, attention is focused not only on what employees know but also on how they apply their knowledge in the course of performing their professional duties. Behavioral indicators make it possible to assess objectively the level of competency development, identify professional development needs, and design individualized learning pathways for employees.

Contemporary scholars increasingly employ an integrated approach to competency classification that combines professional, behavioral, digital, managerial, and strategic characteristics of employees. This approach reflects the complex nature of professional activity in modern organizations, where performance is determined not by isolated knowledge or skills but by their interaction and by employees' ability to apply their capabilities effectively across diverse work situations. This integrated understanding of competencies now forms the basis of most international human resource management models and is widely applied in the development of corporate competency frameworks, employee assessment, career planning, and the design of professional development programs.

The continued evolution of human resource management theory has led to the emergence of the competency-based approach, which is now recognized as one of the fundamental concepts of contemporary personnel management. Unlike the traditional functional approach, which primarily focuses on the fulfillment of job responsibilities in accordance with qualification requirements, the competency-based approach provides a comprehensive assessment of employees' professional potential, their capacity to create value for the organization, and their ability to contribute to the achievement of strategic objectives. This approach is based on the understanding that enterprise performance depends not only on employees' formal compliance with job requirements but, above all, on the level of competency development, which can continuously evolve in response to changes in the external environment and the strategic needs of the organization [3].

The competency-based approach integrates all key human resource management processes into a unified system. It is applied in workforce planning, job profile development, recruitment and selection, performance evaluation, professional development planning, succession planning, compensation system design, and career management. In this way, competencies serve as a universal criterion that aligns human resource processes with the strategic objectives of the enterprise. This approach minimizes subjectivity in HR decision-making and enhances the effective utilization of human capital.

An important feature of the competency-based approach is its focus on the future needs of the organization. Whereas traditional human resource management systems

primarily assess employees' current qualifications, the competency-based approach emphasizes their potential for professional development and their ability to perform new functions in the context of evolving business processes. Consequently, competencies are regarded as a dynamic concept that continuously evolves under the influence of technological progress, labor market developments, organizational transformation, and emerging professional requirements [15].

Contemporary human resource management practice demonstrates that most international companies use corporate competency frameworks as the foundation of their HR policies. These frameworks specify the competencies required for different categories of employees, establish competency assessment criteria and proficiency levels, and ensure consistency in human resource management practices throughout the organization. A distinctive feature of modern competency frameworks is their flexibility, as they are regularly updated to reflect strategic changes, technological innovations, and the evolving demands of the business environment [8].

International professional organizations have made significant contributions to the advancement of the competency-based approach. In particular, the competency model developed by the Society for Human Resource Management (SHRM) identifies eight core competency domains for human resource professionals, including leadership, ethical practice, critical evaluation, relationship management, business acumen, and consultation. Similarly, the competency framework of the Chartered Institute of Personnel and Development (CIPD) emphasizes professional expertise, leadership capabilities, digital literacy, analytical thinking, and the promotion of a culture of continuous learning. Despite differences in their structures, both frameworks are based on the integration of professional, behavioral, and strategic competencies, reflecting contemporary trends in human resource management.

An important direction in the evolution of the competency-based approach is the implementation of international standards for human capital management. In particular, ISO 30414 establishes a system of metrics for measuring human capital, including indicators related to competency development, professional learning, workforce productivity, employee engagement, and the effectiveness of human resource processes. At the same time, ISO 30401 defines the principles for establishing knowledge management systems that facilitate the creation, sharing, and effective utilization of professional competencies within organizations. The application of these standards supports the transition from intuitive personnel management to evidence-based human capital management founded on objective indicators and analytical data.

In contemporary economic literature, employee competencies are increasingly examined through the perspectives of the resource-based view of the firm and the dynamic capabilities framework. According to these theoretical approaches, the unique competencies of employees constitute the primary source of sustainable competitive advantage because they are difficult for competitors to replicate. While tangible resources can often be acquired or reproduced relatively quickly, competency development requires long-term investment, continuous learning, accumulated practical experience, and the establishment of an appropriate organizational culture.

This characteristic underpins the strategic value of human capital as one of the most important intangible assets of the enterprise [16].

The relationship between the level of employee competency development and enterprise resilience is reflected in an organization's ability to operate effectively under conditions of change, rapidly adapt its business processes, ensure business continuity, and recover from crisis situations. In this context, resilience should not be equated with maintaining the enterprise's existing state. Rather, in its contemporary interpretation, resilience refers to an organization's capacity to sustain operational effectiveness through timely adaptation to new conditions, the transformation of internal processes, and the exploration of new development opportunities. Competent employees play a central role in these processes, as they serve as the primary carriers of professional knowledge, innovative ideas, and managerial expertise.

The enhancement of employee competencies has a direct impact on enterprise competitiveness. This is reflected in higher labor productivity, reduced operating costs, improved product and service quality, faster implementation of innovations, greater customer orientation, and more efficient utilization of organizational resources. Furthermore, a highly competent workforce facilitates the faster integration of new employees, reduces the incidence of managerial errors, improves teamwork effectiveness, and contributes to the development of a positive organizational culture. Collectively, these factors generate sustainable competitive advantages that strengthen the enterprise's long-term market position.

The relationship between employee competencies and the innovation capacity of an enterprise is of particular importance. Employees possessing advanced professional, digital, communication, and creative competencies are capable of generating innovative ideas, participating in the implementation of innovation projects, optimizing business processes, and facilitating the adoption of advanced technologies. Accordingly, competency development should be regarded not merely as an instrument of professional training but also as a key mechanism for building the enterprise's innovation potential, thereby determining its capacity for long-term development in a highly competitive environment.

The analysis of contemporary academic approaches leads to the conclusion that employee competencies constitute a multidimensional socio-economic concept encompassing professional knowledge, practical skills, behavioral characteristics, digital capabilities, managerial potential, and personal attributes. The competency-based approach integrates all human resource management functions into a unified system oriented toward the achievement of the enterprise's strategic objectives. At the same time, competency development forms the foundation of organizational resilience, enhances the enterprise's adaptability to change, strengthens its competitive position, and creates the conditions necessary for long-term innovation-driven growth. Therefore, effective competency management should be regarded as one of the strategic priorities of contemporary enterprise management.

Under current conditions, enterprise resilience is understood as a comprehensive characteristic reflecting an organization's ability to maintain effective operations,

achieve its strategic objectives, and ensure business continuity in a dynamic internal and external environment. Unlike traditional approaches, which primarily associated resilience with financial stability or economic security, contemporary management theories conceptualize resilience as a multidimensional phenomenon encompassing economic, organizational, human resource, technological, informational, and innovation-related dimensions. This perspective is based on the recognition that modern enterprises function as open socio-economic systems whose effectiveness depends not only on the availability of resources but also on their ability to adapt rapidly to emerging challenges, transform internal processes, and sustain development even under crisis conditions.

The concept of organizational resilience has gained increasing prominence in the academic literature as a framework for describing an enterprise's ability to anticipate potential threats, respond to them in a timely manner, minimize the adverse effects of crises, and leverage change as a source of future development. Within this framework, employees are viewed not merely as performers of operational tasks but as active contributors to organizational resilience who facilitate the generation of new knowledge, the adaptation of business processes, the implementation of innovations, and the maintenance of business continuity. Consequently, the development of employee competencies has become a strategic priority for ensuring the long-term sustainability and viability of enterprises.

The mechanism through which employee competencies influence enterprise resilience is multidimensional. First, it is reflected in employees' ability to identify changes in the external environment promptly, assess their potential impact on organizational performance, and develop effective managerial responses. A high level of professional competence ensures the efficient execution of operational processes, while advanced analytical, communication, and managerial competencies enable the coordination of organizational units, the rapid adaptation of business processes, and the effective utilization of available resources. As a result, enterprises are better positioned to mitigate the adverse effects of external challenges without experiencing substantial declines in organizational performance.

One of the key mechanisms for strengthening organizational resilience is organizational learning, which is understood as the systematic process of acquiring, sharing, and applying knowledge throughout the enterprise. Unlike the individual professional development of employees, organizational learning facilitates the creation of collective competencies that become shared organizational resources. In this context, knowledge ceases to be the exclusive asset of individual employees and is transformed into a component of organizational capital, thereby significantly enhancing the enterprise's capacity to adapt to change. For this reason, contemporary organizations increasingly establish internal knowledge repositories, corporate universities, digital learning platforms, and professional communities that promote continuous knowledge exchange among employees [1].

Employees' capacity for adaptation plays a particularly important role in ensuring organizational resilience. Employee adaptability is determined by the speed with which

individuals acquire new knowledge, their willingness to modify established work practices, their openness to innovation, and their ability to perform effectively under conditions of uncertainty. However, adaptability does not emerge spontaneously; rather, it is the result of systematic competency development, the cultivation of a learning-oriented organizational culture, and the application of contemporary human resource management practices. Enterprises that consistently develop employees' adaptive capabilities are able to respond more rapidly to crises, accelerate the adoption of new technologies, and reduce the risks associated with organizational change.

Another important factor contributing to organizational resilience is the establishment of a culture of continuous learning. In contemporary academic literature, such a culture is defined as a set of organizational values, behavioral norms, and managerial practices that encourage the continuous professional development of employees. Unlike traditional training, which is typically conducted on an occasional basis, a culture of continuous learning integrates learning activities into the enterprise's everyday business processes. This approach creates favorable conditions for the continuous renewal of competencies in accordance with the organization's strategic priorities, enhances workforce mobility, and facilitates the rapid dissemination of new knowledge throughout the organization.

The effectiveness of knowledge management also has a substantial impact on organizational resilience. Under contemporary conditions, competitive advantage is derived not only from the creation of new knowledge but also from an organization's ability to capture, organize, transfer, and utilize the intellectual capital of its workforce. The loss of critical competencies resulting from employee turnover or inadequate knowledge transfer can significantly undermine enterprise resilience. Consequently, one of the strategic priorities of modern organizations is the implementation of knowledge management systems that ensure the preservation of critical organizational knowledge regardless of personnel changes.

Enterprise resilience also depends to a large extent on the interaction among different groups of competencies. In practice, even a high level of professional expertise does not guarantee effective organizational performance in the absence of communication, digital, or managerial competencies. It is the synergistic combination of these competencies that enables employees to respond rapidly to change, collaborate effectively within cross-functional teams, support innovation, and contribute to the strategic development of the enterprise.

To summarize the relationship between different competency groups and the key dimensions of enterprise resilience, the information is presented in Table 1.

The findings presented in Table 1 indicate that no single competency group can ensure organizational resilience independently. Rather, enterprise resilience is achieved through the comprehensive development of complementary competencies that collectively enable organizations to maintain operational stability, adapt effectively to change, and create the conditions necessary for long-term strategic development.

Table 1. - The Impact of Employee Competency Groups on Enterprise Resilience

Competency Group	Primary Area of Impact	Contribution to Enterprise Resilience
Professional	Effective execution of operational and managerial processes	Maintenance of operational stability
Digital	Application of digital technologies and process automation	Faster adaptation to technological change
Analytical	Information analysis, risk forecasting, and evaluation of alternatives	Improved quality of managerial decision-making
Communication	Work coordination, knowledge sharing, and team collaboration	Enhanced alignment of business processes
Leadership	Change management and employee motivation	Effective implementation of organizational transformation
Innovation	Generation of new ideas and process improvement	Creation of sustainable competitive advantages
Adaptive	Rapid acquisition of new knowledge and technologies	Reduced response time to changes in the external environment

Consequently, contemporary human resource management systems should focus not on the development of isolated professional skills but on establishing a balanced competency framework aligned with the enterprise's strategic priorities and the specific characteristics of its business environment.

In a highly dynamic economic environment, particular importance is attached to the development of competencies that directly enhance an enterprise's ability to respond to change and sustain organizational performance. While professional competencies provide the foundation for the effective execution of job responsibilities, the conditions of digital transformation require competencies that promote organizational agility and strategic flexibility. In particular, digital, managerial, communication, leadership, and innovation competencies constitute the core capabilities supporting organizational adaptability and determining the effectiveness of strategic transformation.

Digital competencies have become one of the most rapidly evolving dimensions of employee professional development. Their significance extends far beyond the ability to use information and communication technologies. Contemporary employees are expected to utilize digital platforms for organizing work processes, analyze information using digital tools, operate automated systems, apply artificial intelligence technologies, ensure information security, and collaborate effectively within digital environments. Digital competency therefore contributes to the acceleration of business processes, the reduction of operating costs, the improvement of managerial decision-making accuracy, and the expansion of enterprises' capacity for innovation. At the same time, the development of digital competencies must be continuous, as technological advances occur at a much faster pace than the renewal of traditional professional knowledge.

Managerial competencies are equally important, as they enable the coordination of organizational units, the efficient allocation of resources, and the achievement of the enterprise's strategic objectives. Contemporary managers are expected not only to

master the fundamental management functions of planning, organizing, motivating, and controlling but also to operate effectively under conditions of high uncertainty, rapidly assess risks, make well-informed decisions, and coordinate the activities of cross-functional teams. Consequently, modern management theories increasingly emphasize the development of strategic thinking, systems analysis, project management, and data literacy as essential components of managerial competence.

Communication competencies also play a critical role in ensuring enterprise resilience. In contemporary organizations, organizational effectiveness increasingly depends on the quality of information exchange among employees, the speed of knowledge sharing, the level of mutual trust, and the ability to collaborate across functional boundaries. Poorly developed communication competencies may result in duplication of tasks, an increased frequency of managerial errors, slower decision-making processes, and inadequate coordination among organizational units. Conversely, strong communication competencies facilitate the rapid exchange of information, the development of a shared understanding of strategic objectives, and the effective implementation of organizational change.

Leadership competencies have become particularly significant in the context of business transformation. Contemporary leadership is increasingly focused not on administrative control but on the ability to unite employees around common goals, foster trust, encourage innovation, and create an environment that supports continuous professional development. Leaders serve as catalysts for organizational change by coordinating activities, managing conflicts effectively, motivating employees, and cultivating an organizational culture oriented toward continuous improvement. Research indicates that enterprises with highly developed leadership competencies among their managers adapt more rapidly to crisis situations and demonstrate superior organizational performance [2].

Change management competencies also play a vital role. These competencies encompass the ability of employees and managers to assess the need for organizational transformation, determine strategic priorities, anticipate potential consequences, coordinate the implementation of change initiatives, and minimize employee resistance. Effective change management requires well-developed capabilities in strategic planning, crisis management, negotiation, teamwork, and communication. Together, these competencies enable enterprises to transition smoothly to new operating models while maintaining productivity and the quality of business processes.

Under contemporary conditions, enterprise competitiveness increasingly depends on its ability to create, accumulate, and effectively utilize knowledge. This necessitates the development of employees' innovation competencies, which are reflected in their ability to generate new ideas, evaluate alternative solutions to complex problems, implement advanced technologies, and improve business processes. Employees' innovative capacity contributes not only to the development of new products and services but also to the optimization of organizational structures, the improvement of management systems, the enhancement of customer service quality, and the more efficient utilization of organizational resources. Consequently, the development of

innovation competencies has a direct impact on the long-term competitiveness of enterprises.

The development of employee competencies produces a multiplier effect. The enhancement of individual competencies not only improves the performance of individual employees but also generates positive outcomes for the organization as a whole. As a result, enterprises develop a comprehensive set of competitive advantages reflected in higher labor productivity, improved product and service quality, reduced operating costs, increased innovation activity, a stronger organizational culture, and a higher level of organizational resilience.

The development of a balanced system of professional, digital, managerial, communication, leadership, and innovation competencies creates the conditions necessary for timely responses to changes in the external environment, enhances the effective utilization of human capital, strengthens competitive positions, and ensures the long-term resilience of the enterprise. Therefore, investment in employee competency development should be regarded as a strategic management priority that enables the creation of an adaptive, innovation-oriented, and competitive organization capable of operating successfully in the context of contemporary economic transformations.

Employee competency development is a systematic process that should be integrated into the overall strategy of enterprise development. The effectiveness of such a system is determined not by the number of training activities conducted but by the organization's ability to ensure the continuous enhancement of employees' professional capabilities in accordance with its strategic objectives, technological developments, and business requirements. Consequently, contemporary enterprises are moving beyond occasional training initiatives toward comprehensive competency development systems that encompass planning, implementation, evaluation of learning outcomes, and their integration into the broader human resource management system.

The development of an effective competency development system is based on the principles of strategic alignment, continuous learning, individualization, adaptability, practical relevance, and performance evaluation. Adherence to these principles ensures the development of competencies that correspond to the enterprise's actual needs and can be effectively applied in professional practice.

Corporate learning remains the primary instrument for competency development, with its content directly aligned with the strategic objectives of the enterprise. Its focus is determined not only by the requirements of specific job positions but also by the organization's future development, digital transformation initiatives, and the need to cultivate new competencies. The competency-based approach has become widely adopted, involving the use of competency profiles to assess employees' qualifications and design individualized professional development programs.

In the contemporary business environment, the processes of upskilling and reskilling have become particularly important. Upskilling focuses on expanding and deepening employees' existing competencies to enable them to perform more complex tasks and work with emerging technologies. Reskilling, in contrast, involves the

acquisition of entirely new competencies required for changes in job responsibilities or career transitions. Both approaches represent organizational responses to rapid technological advancement, production automation, and the digital transformation of the economy.

The effectiveness of competency development depends largely on the application of contemporary approaches to adult learning. Practice-oriented learning methods, including case studies, business simulations, project-based learning, training programs, workshops, role-playing exercises, and the analysis of real business situations, are considered particularly effective. These methods simultaneously support the development of professional, communication, analytical, and managerial competencies.

Workplace learning (on-the-job learning) also occupies an important place within contemporary competency development systems. This approach enables employees to apply newly acquired knowledge immediately in their daily work, adapt more rapidly to technological changes, and receive continuous feedback from supervisors and colleagues. It is complemented by the 70–20–10 learning model, according to which the majority of competencies are developed through practical work experience, a substantial proportion through interaction with mentors and colleagues, while formal education provides the foundational component of professional development.

Overall, contemporary competency development systems combine corporate learning, the competency-based approach, upskilling, reskilling, workplace learning, business simulations, project-based learning, training programs, and other practice-oriented learning methods. Despite differences in their implementation, all of these approaches share the common objective of ensuring the systematic development of employee competencies in alignment with the enterprise's strategic needs. Their greatest effectiveness is achieved through integrated application, which contributes to the development of an adaptive, competitive, and change-ready workforce.

Alongside traditional forms of professional training, contemporary enterprises increasingly implement individual employee development tools that support not only the acquisition of new knowledge but also the development of practical experience, managerial thinking, and the ability to perform effectively in non-routine situations. One such tool is mentoring, which involves the systematic transfer of professional knowledge and experience from a more experienced employee to a less experienced colleague. Unlike conventional job instruction, mentoring is a long-term developmental process aimed not only at facilitating professional adaptation but also at fostering corporate values, organizational culture, and employees' professional identity. Mentoring programs are particularly effective in onboarding new employees, developing talent pools, and preparing future leaders.

Another important instrument for competency development is coaching, which focuses on unlocking employees' potential by helping them establish professional goals, identify effective ways to achieve them, and strengthen their capacity for independent decision-making. Unlike mentoring, coaching does not involve the transfer of predefined solutions or accumulated experience; instead, it is based on a collaborative partnership between the coach and the employee. This approach promotes

responsibility, critical thinking, self-management, and continuous professional self-development. Consequently, coaching is increasingly employed to develop managerial, leadership, and strategic competencies among managers at different organizational levels.

Effective competency development cannot be achieved without a well-established Knowledge Management system that supports the acquisition, organization, dissemination, and utilization of the organization's intellectual resources. In the contemporary business environment, knowledge has become a strategic organizational asset, while its loss due to employee turnover or inadequate knowledge transfer may negatively affect business continuity. For this reason, enterprises implement electronic knowledge repositories, internal professional communities, digital libraries, corporate forums, and systems for documenting best practices. These mechanisms provide employees with continuous access to accumulated organizational knowledge regardless of structural changes or personnel movements, thereby enhancing organizational resilience to both internal and external challenges.

An important direction in the modernization of competency development systems is the adoption of digital learning platforms. The most widely implemented solutions are Learning Management Systems (LMS), which support the planning, delivery, monitoring, and evaluation of employee learning activities. Their implementation enables organizations to automate training processes, design individualized learning programs, monitor course completion, and maintain comprehensive records of employees' competency development. Furthermore, LMS platforms provide employees with access to learning resources regardless of their physical location, making them particularly valuable in remote and hybrid work environments [14].

Alongside LMS platforms, a new generation of learning technologies—Learning Experience Platforms (LXP)—has gained increasing prominence in recent years. Unlike traditional learning management systems, LXP platforms are designed to personalize the learning experience by applying data analytics algorithms to generate individualized recommendations for educational content. These recommendations take into account employees' professional profiles, competency assessment results, career aspirations, and previous learning experiences. As a result, employees are able to design personalized learning pathways, thereby increasing both learning motivation and the overall effectiveness of professional development.

The integration of artificial intelligence technologies into the learning process has also had a substantial impact on employee competency development. Intelligent systems can analyze employee performance, identify competency gaps, forecast future learning needs, and automatically generate personalized development programs. In addition, artificial intelligence is increasingly used to develop interactive simulations, virtual training environments, adaptive assessments, and digital learning assistants that provide immediate feedback and support continuous learning. These technologies enhance the effectiveness of competency development by enabling greater personalization of learning experiences and more efficient utilization of educational resources.

An important trend in contemporary human resource management is the transition from standardized training programs to personalized professional development pathways. This approach takes into account employees' individual competency levels, the specific nature of their professional responsibilities, their career development potential, and the strategic needs of the enterprise. Personalized learning enhances the practical effectiveness of training, reduces the time required to acquire the necessary competencies, and promotes the more efficient utilization of human capital.

Each of the contemporary competency development tools has its own advantages and specific areas of application. The highest level of effectiveness is achieved when these tools are implemented in an integrated manner. The combination of corporate learning, mentoring, coaching, digital learning platforms, knowledge management systems, and artificial intelligence technologies creates an integrated learning ecosystem capable of supporting the continuous development of employee competencies in alignment with the organization's strategic objectives.

A contemporary competency development system should be founded on the principles of continuous learning, flexibility, personalization, and digital integration. Its effectiveness should be evaluated not by the number of individual training activities but by the organization's ability to establish a comprehensive professional development ecosystem in which learning becomes an integral part of everyday work. The implementation of modern competency development tools contributes to the formation of adaptive human capital, enhances employees' readiness for organizational change, strengthens the enterprise's competitive position, and supports its long-term resilience in the context of digital transformation and a highly uncertain external environment.

The analysis of theoretical approaches and contemporary human resource management practices demonstrates that ensuring enterprise resilience requires a transition from isolated professional training initiatives to the establishment of a comprehensive system of strategic competency management. Such a system should be integrated into the overall strategic management framework of the enterprise and ensure the alignment of human resource policies with the organization's long-term objectives. Its primary purpose should extend beyond improving employees' professional qualifications to include the development of the competencies required to implement strategic transformation, enhance organizational adaptability, and strengthen competitive advantage.

The establishment of a strategic competency management system should be viewed as a continuous cycle of interconnected processes encompassing the definition of the enterprise's strategic development objectives, forecasting future competency requirements, assessing the existing human capital base, identifying competency gaps, designing professional development programs, implementing learning initiatives, and evaluating their effectiveness. This approach ensures the systematic management of competencies and enables the timely adaptation of the workforce to changes in the external environment.

An important component of the proposed system is the development of a corporate competency framework. This framework should define the key competencies

required to achieve the enterprise's strategic objectives, establish the expected proficiency levels for different categories of employees, and include clearly defined behavioral indicators for competency assessment. The use of a unified competency framework ensures consistency across recruitment, onboarding, performance evaluation, learning and development, career management, and succession planning processes, thereby improving the transparency of human resource decisions and promoting the more effective utilization of human capital.

Given the rapid evolution of technologies and business models, corporate competency frameworks should be reviewed and updated regularly. The revision of key competencies should reflect changes in the enterprise's strategic priorities, advances in digital technologies, transformations in the labor market, and the emergence of new professional requirements. Such an approach ensures that the competency development system remains relevant and enables organizations to respond proactively to external challenges.

A fundamental prerequisite for effective employee development is the systematic assessment of competency levels. The purpose of such assessment should extend beyond determining employees' current professional qualifications to identifying their potential for further development, forecasting future learning needs, and designing individualized professional development plans. Competency assessment should be conducted using a comprehensive approach that combines both quantitative and qualitative methods.

In contemporary human resource management practice, the most effective approach involves combining several assessment methods, including competency-based interviews, 360-degree feedback, Assessment Centers, performance evaluation, professional and digital competency testing, employee self-assessment, and expert evaluation by supervisors. The integrated use of these methods provides objective information about employees' strengths, identifies areas for further development, and reduces subjectivity in human resource decision-making.

Particular attention should be devoted to competency gap analysis. Comparing employees' actual competency levels with those required to achieve the enterprise's strategic objectives makes it possible to identify priority areas for learning and development and to allocate resources for employee development more efficiently. This approach increases the relevance of learning programs while improving their overall cost-effectiveness.

An important recommendation is the integration of competency development into the enterprise's strategic management process. In practice, employee development often remains the responsibility of the human resource department and is insufficiently connected with strategic planning activities. To enhance management effectiveness, competency development indicators should be incorporated into the enterprise's key performance indicators (KPIs), digital transformation programs, organizational development plans, and investment projects.

Integrating the competency-based approach into strategic management also requires the application of HR analytics to forecast future competency needs, evaluate

the effectiveness of learning initiatives, and analyze the impact of employee development on organizational performance. The use of analytical tools enables evidence-based managerial decision-making, facilitates the early identification of competency shortages, and improves the return on investment in human capital.

To ensure long-term organizational resilience, enterprises should cultivate a culture of continuous professional development that encourages employees to engage in self-directed learning, share knowledge, and participate actively in the improvement of business processes. Achieving this objective requires strong leadership support, the creation of a favorable learning environment, the implementation of modern digital learning platforms, and the establishment of motivation and recognition systems that acknowledge employees' professional achievements.

The findings of this study confirm that employee competency development should be regarded not merely as a functional component of human resource management but as a strategic prerequisite for enterprise resilience to change. Under contemporary conditions, an organization's ability to develop employee competencies proactively, foster a culture of continuous learning, and integrate the competency-based approach into strategic management determines its capacity to adapt to emerging challenges, utilize human capital effectively, maintain competitive advantage, and achieve long-term sustainable development.

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1.9. Change Management in Enterprises: Impact on the Socio-Psychological Climate of the Workforce and Stabilization Mechanisms

In the context of today's economic development, enterprises operate in an environment characterized by continuous change driven by the acceleration of digital transformation, market globalization, economic instability, a shortage of qualified personnel, and the need to adapt to the consequences of military conflict. For Ukrainian enterprises, these challenges are further exacerbated by the destruction of production and logistics infrastructure, business relocation, changes in employment patterns, intensified competition for human capital, and the necessity of ensuring business continuity under conditions of heightened uncertainty. Under such circumstances, traditional management approaches are no longer capable of providing the required level of organizational effectiveness, thereby underscoring the need for a comprehensive approach to organizational change management.

Today, change management is recognized as one of the key instruments for ensuring the sustainable development of an enterprise, enhancing its adaptability, and strengthening its competitiveness. Organizational change encompasses the transformation of business processes, the digitalization of operations, the improvement of human resource management systems, the development of corporate culture, and the implementation of innovations. At the same time, the success of such transformations depends not only on economic or technological factors but also on employees' willingness to embrace change, their level of motivation, trust in management, and ability to adapt to new working conditions. Therefore, effective change management should integrate organizational, economic, and socio-psychological mechanisms that help minimize employee resistance and foster positive attitudes toward organizational transformation processes [4; 8; 10].

Particular importance in the implementation of organizational change is attached to the socio-psychological climate of the workforce, which is one of the key determinants of enterprise performance. A favorable socio-psychological climate fosters an atmosphere of mutual trust, openness, cooperation, and support, enhances employee motivation, improves labor productivity, strengthens teamwork, and reduces the level of workplace conflict. Conversely, an unfavorable psychological climate, which often arises during large-scale organizational transformations, may lead to resistance to

change, professional burnout, reduced employee engagement, and a decline in organizational performance [1; 9; 12].

In the context of war and post-war recovery, maintaining a stable socio-psychological climate has become particularly important. Employees face increased levels of stress, psychological exhaustion, uncertainty about the future, and emotional strain, all of which directly affect their work performance and their perception of organizational change. Therefore, the implementation of modern mechanisms for psychological support, the promotion of effective leadership, the development of a strong corporate culture, the establishment of constructive internal communication, and effective conflict management have become essential prerequisites for stabilizing the socio-psychological climate and ensuring the successful implementation of organizational change [3; 5].

Thus, the relevance of this study lies in the need to further develop the theoretical foundations and practical approaches to organizational change management while taking into account its impact on the socio-psychological climate of the workforce. The development of effective mechanisms for stabilizing this climate will enhance employee adaptability, reduce resistance to change, strengthen corporate culture, and contribute to the sustainable development of enterprises operating under contemporary socio-economic challenges.

In today's dynamic economic environment, effective change management has become an integral component of strategic management, enabling enterprises to adapt to both internal and external challenges, maintain competitiveness, and create favorable conditions for long-term sustainable development.

Contemporary academic literature defines change management as a purposeful and systematic process of planning, organizing, implementing, and controlling organizational transformations aimed at adapting an enterprise to changes in its internal and external environment. It encompasses not only the introduction of new technologies, organizational structures, and business processes but also the management of employee behavior, the development of positive attitudes toward innovation, overcoming resistance to change, and ensuring effective interaction among all participants in the transformation process. Such a comprehensive approach to change management minimizes the risks associated with organizational transformation while improving the overall effectiveness of its implementation [4].

The need for change management stems from the fact that a modern enterprise operates as an open socio-economic system that continuously interacts with its external environment. Changes in legislation, market conditions, technological development, consumer behavior, and workforce availability all require timely and appropriate managerial responses. At the same time, organizational change should not be viewed solely as a response to crises, but rather as a strategic instrument for organizational development, improving operational efficiency, and achieving the enterprise's long-term objectives [8].

Scientific approaches to change management are based on various concepts that explain the patterns of organizational transformation and employee behavior

throughout the change process. Among the most widely recognized are Kurt Lewin's Three-Stage Model, John Kotter's Eight-Step Model, Jeff Hiatt's ADKAR Model, and the Organizational Development (OD) approach, which emphasizes the continuous improvement of organizational performance through employee development and the strengthening of corporate culture. Despite their conceptual differences, these approaches share several common principles, including the need for systematic change planning, effective communication, active employee involvement, and continuous monitoring of implementation outcomes. Contemporary Ukrainian scholars also emphasize that the application of change management models should take into account the specific characteristics of an enterprise, the scale of organizational transformation, and the influence of the external environment [10].

The implementation of organizational change is based on a number of fundamental principles, among which systematicity, comprehensiveness, consistency, adaptability, continuity, transparent communication, and a people-centered approach are of particular importance. Adherence to these principles ensures that managerial decisions are aligned with the enterprise's overall development strategy while promoting the efficient use of available resources. In practice, organizational change typically involves several interconnected stages, including identifying the need for change, defining objectives and expected outcomes, developing a transformation program, implementing planned initiatives, monitoring progress, and evaluating the effectiveness of the measures undertaken.

An essential component of the change management process is the application of appropriate managerial tools that facilitate the successful implementation of organizational transformation. These tools include strategic planning, business process reengineering, the digitalization of management processes, risk management, project management, key performance indicator (KPI) monitoring systems, as well as modern internal communication and employee training solutions. The effective use of these instruments enables organizations to coordinate change initiatives, identify potential deviations from planned objectives in a timely manner, and respond flexibly to emerging challenges [8].

A particularly important role in organizational change management is played by the leadership of the enterprise. Senior management defines the strategic direction of development, formulates a vision for future transformation, allocates the necessary resources, and creates conditions for effective cooperation among organizational units. Leaders' ability to communicate openly, motivate employees, and foster an atmosphere of trust largely determines the success of organizational change initiatives. At the same time, employees should not be viewed merely as recipients of managerial decisions but as active participants in the transformation process. The effectiveness of organizational change depends significantly on their level of engagement, professional competence, willingness to learn, and readiness to embrace innovation [2].

The theoretical foundations of change management indicate that the success of organizational transformation depends not only on the appropriate selection of change management models and implementation tools but also on management's ability to

secure employee support and create favorable conditions for workforce adaptation to new organizational requirements. Therefore, particular attention should be given to the socio-psychological climate of the workforce as one of the key factors influencing both the effectiveness of change management and the overall performance of the enterprise.

A deeper understanding of the theoretical foundations of change management necessitates examining its impact on the socio-psychological climate of the workforce, as the human factor is often the decisive determinant of the success or failure of organizational transformation. Regardless of the scale of change, its implementation is accompanied by modifications to established working conditions, interpersonal relationships, the distribution of authority and responsibilities, and organizational practices. These changes directly affect employees' psychological well-being, motivation, and willingness to support managerial decisions.

The socio-psychological climate is a complex characteristic of a work collective that reflects the quality of interpersonal relationships, the level of trust between employees and management, the moral and psychological atmosphere, the degree of team cohesion, mutual support, and employees' satisfaction with their working conditions. Unlike organizational structure or management systems, the socio-psychological climate develops gradually under the influence of managerial, social, psychological, and cultural factors and serves as an important indicator of the quality of an enterprise's internal environment. Researchers emphasize that a positive socio-psychological climate contributes to higher labor productivity, encourages employee initiative, strengthens corporate culture, and improves overall organizational performance.

The socio-psychological climate is not a static phenomenon, as it continuously evolves under the influence of both internal and external factors. One of the most significant drivers of its transformation is organizational change, which alters established patterns of interaction, professional roles, communication systems, and routine work processes. When organizational changes are accompanied by transparent communication, open leadership, and a fair distribution of responsibilities, they can serve as a foundation for team development and organizational growth. Conversely, inadequate preparation for change, the absence of clearly defined objectives, or a low level of trust between employees and management often leads to a deterioration of the socio-psychological climate, increased tension, and interpersonal conflicts [1].

The implementation of organizational change is almost invariably accompanied by a range of psychological responses from employees, as any change disrupts established work routines and requires adaptation to new conditions. The nature of these responses depends on individual employee characteristics, professional competence, previous experience with organizational change, leadership style, and the effectiveness of internal communication. The most common reactions include uncertainty, anxiety, fear of losing one's job or professional status, emotional strain, reduced self-confidence, and a cautious attitude toward innovation. At the same time, when the change process is effectively managed, employees may demonstrate genuine interest, professional

growth, willingness to acquire new competencies, and active participation in the implementation of managerial initiatives [3].

In the context of martial law, employees' psychological responses acquire distinctive characteristics. High levels of emotional stress, persistent uncertainty, security risks, forced displacement, and disruptions to everyday life intensify occupational stress, anxiety, and emotional exhaustion. Under these circumstances, the success of organizational change increasingly depends on management's ability to maintain employees' psychological resilience, ensure transparent communication, and foster an atmosphere of mutual support within the workforce.

Table 1. Factors Influencing the Socio-Psychological Climate during Organizational Change

Positive factors	*Impact on the workforce*	*Negative factors*	*Consequences for the workforce*
Open and timely communication	Increased trust in management and reduced uncertainty	Insufficient information	Spread of rumors and increased anxiety
Democratic leadership style	Development of partnership-based relationships	Authoritarian leadership style	Distrust and increased conflict
Employee involvement in decision-making	Greater responsibility and stronger support for change	Exclusion of employees from decision-making	Resistance to change
Fair motivation and reward system	Higher job satisfaction	Unequal distribution of workload and rewards	Demotivation and reduced productivity
Psychological support and employee training	Improved adaptation to change	Lack of organizational support	Stress and professional burnout
Supportive corporate culture	Stronger team cohesion	Weak organizational culture	Deterioration of employee interaction

Source: compiled by the author based on [1; 2; 7; 9; 11].

The data presented in Table 1 indicate that the nature of the socio-psychological climate is largely determined by the quality of managerial decisions and the way organizational change is implemented. Transparent communication, effective leadership, fair motivation systems, and continuous employee support contribute to the creation of a positive psychological environment that facilitates workforce adaptation to new organizational conditions. Conversely, deficiencies in management practices, informational uncertainty, and a lack of trust between employees and management create conditions that undermine the moral and psychological atmosphere, thereby complicating the successful implementation of organizational change.

One of the most common manifestations of a negative perception of organizational transformation is resistance to change. In the academic literature, resistance to change is defined as a set of conscious or unconscious behaviors exhibited by employees aimed at preserving established working conditions and avoiding the uncertainty associated with organizational innovations. The underlying causes of resistance may include an insufficient understanding of the need for change, fear of job loss, doubts about one's

professional competence, lack of trust in management, negative previous experiences, insufficient motivation, or reluctance to move beyond familiar job responsibilities [4].

Resistance to change may take various forms, ranging from passive non-compliance with new requirements, reduced productivity, avoidance of responsibility, and the spread of negative attitudes to open conflicts, the sabotage of managerial decisions, or employee turnover. Such behaviors may result in a deterioration of the socio-psychological climate, increased staff turnover, reduced organizational trust, disrupted internal communication, delays in the implementation of strategic initiatives, and a decline in the enterprise's financial and operational performance. Therefore, the timely identification of the causes of resistance and the application of appropriate managerial and psychological interventions to overcome it constitute one of the key challenges of contemporary management [8; 11].

The socio-psychological climate is one of the fundamental determinants of successful organizational change, as it shapes team cohesion, employees' readiness to embrace innovation, and the overall effectiveness of managerial decision-making. Taking into account employees' psychological characteristics, responding promptly to manifestations of resistance, and creating a supportive internal environment make it possible to minimize the negative consequences of organizational transformation and ensure the successful functioning of the enterprise. This, in turn, highlights the need to examine practical mechanisms for stabilizing the socio-psychological climate that can facilitate the effective implementation of organizational change and enhance organizational resilience in the face of contemporary challenges.

The established relationship between organizational change and the socio-psychological climate of the workforce demonstrates that the success of transformation processes depends not only on the appropriateness of the enterprise's development strategy but also on management's ability to maintain the stability of the organization's internal environment. Consequently, particular attention should be paid to the mechanisms for stabilizing the socio-psychological climate, as they create favorable conditions for employee adaptation, reduce resistance to change, strengthen trust between employees and management, and contribute to the effective implementation of managerial decisions.

In contemporary human resource management practice, mechanisms for stabilizing the socio-psychological climate are viewed as a comprehensive set of organizational, psychological, communicative, and motivational measures designed to support constructive interaction within the workforce and ensure employees' psychological readiness for change. The implementation of these mechanisms helps reduce uncertainty, prevent workplace conflicts, increase employee engagement, and create favorable conditions for developing positive attitudes toward organizational transformation.

Effective internal communication is of primary importance in the implementation of organizational change. Open information exchange between management and employees facilitates a timely understanding of the objectives, tasks, and expected outcomes of organizational transformation. Transparency in managerial decision-

making reduces uncertainty, prevents the spread of rumors, and fosters an atmosphere of mutual trust. Particularly important is the establishment of two-way communication, enabling employees to express their opinions, ask questions, receive feedback, and actively participate in discussions regarding forthcoming changes [7].

Another important mechanism for stabilizing the socio-psychological climate is employee involvement in managerial decision-making. Engaging employees in the planning and implementation of organizational change increases their sense of responsibility for the final outcomes, strengthens their commitment to the organization's development, and reduces psychological barriers to innovation. Practical experience demonstrates that employees are considerably more willing to support change when they understand its necessity and have the opportunity to influence certain aspects of its implementation [4].

Leadership also plays a crucial role in maintaining a positive socio-psychological climate during periods of organizational transformation. Contemporary managers are expected not only to organize and coordinate the change process but also to serve as communicators, mentors, and motivators for their teams. Leadership qualities such as openness, consistency, professional competence, and the ability to support employees largely determine the level of organizational trust and the workforce's successful adaptation to new working conditions.

Table 2. Key Mechanisms for Stabilizing the Socio-Psychological Climate during Organizational Change

Mechanism	*Main purpose*	*Expected outcome*
Internal communication	Timely information sharing and feedback	Increased trust and reduced uncertainty
Employee involvement	Participation in managerial decision-making	Greater support for change and stronger sense of responsibility
Leadership	Mentoring, coordination, and employee support	Improved team cohesion
Employee training	Skills development and professional learning	Faster adaptation to organizational change
Motivation	Financial and non-financial incentives	Higher labor productivity
Psychological support	Counseling and stress prevention	Reduced emotional strain
Corporate culture	Development of shared organizational values	Stronger teamwork and collaboration

Source: compiled by the author based on [1; 2; 5; 7; 11].

Continuous employee training and competency development constitute an essential component of successful organizational change. The introduction of new technologies, digital tools, and modern work practices requires employees to continuously update their knowledge and skills. Training not only enhances professional competence but also reduces the anxiety associated with unfamiliar working conditions, strengthens employees' confidence in their own capabilities, and promotes a positive attitude toward organizational change.

Alongside professional development, employee motivation, adaptation, and psychological support remain essential instruments for stabilizing the socio-psychological climate. An effective motivation system should incorporate not only financial incentives but also opportunities for professional development, career advancement, public recognition, and participation in managerial decision-making. Particular attention should be devoted to onboarding programs for new employees, psychological counseling, the development of emotional resilience, and the prevention of occupational burnout, especially under conditions of martial law.

The development of a positive socio-psychological climate is impossible without fostering a corporate culture based on the principles of openness, mutual respect, partnership, and trust. Corporate culture shapes employees' patterns of behavior, regulates interactions among organizational units, influences attitudes toward innovation, and strengthens employees' organizational identity. As such, it creates favorable conditions for supporting organizational change, enhancing teamwork, and promoting shared responsibility for the enterprise's performance.

The stabilization of the socio-psychological climate is a continuous managerial process that requires the integrated application of organizational, communicative, psychological, and motivational mechanisms.

Table 3. Impact of Socio-Psychological Climate Stabilization Mechanisms on Change Management Outcomes

Area of impact	Primary mechanism	Organizational outcome
Reducing resistance to change	Internal communication and employee involvement	Greater support for organizational change
Employee adaptation	Training and mentoring	Shorter adaptation period
Increasing employee motivation	Financial and non-financial incentives	Higher productivity
Maintaining psychological resilience	Psychological support	Reduced stress and workplace conflict
Building trust	Corporate culture and leadership	Stronger team cohesion
Improving change management effectiveness	Integrated application of all mechanisms	Sustainable enterprise development

Source: developed by the author based on [1; 2; 5; 7; 9; 11].

Only their systematic combination can create an atmosphere of trust, enhance employees' readiness for change, reduce resistance, and strengthen teamwork. Under contemporary conditions, a human-centered approach to change management has become one of the key prerequisites for improving enterprise competitiveness, increasing organizational adaptability, and ensuring long-term sustainability.

The analysis of the theoretical foundations of change management, the characteristics of the socio-psychological climate, and the mechanisms for its stabilization demonstrates that the success of organizational transformation largely depends on an enterprise's ability to align its strategic development objectives with effective human resource management. The experience of contemporary organizations confirms that even economically justified and technologically advanced changes may

fail to achieve the expected outcomes if insufficient attention is paid to employees' psychological readiness, the quality of internal communication, and the creation of a supportive socio-psychological climate.

The experience of leading global companies indicates that change management is no longer viewed as an isolated managerial function. Instead, it has become an integral component of strategic management, human resource management, corporate culture, and digital transformation initiatives. Consequently, improving the effectiveness of organizational change requires the integrated application of modern human capital management practices, digital technologies, employee motivation systems, and continuous feedback mechanisms between management and employees. Such a comprehensive approach enables enterprises to strengthen their adaptability to changes in the external environment while maintaining high levels of employee engagement.

One of the key directions for improving change management is the integration of HR policy into the overall enterprise management system. Whereas human resource departments were previously focused primarily on personnel administration, recruitment, and employee training, the contemporary concept of human resource management assigns HR a strategic role in organizational development. HR departments increasingly serve as coordinators of employee adaptation to change, competency development, corporate culture enhancement, internal communication, and the assessment of the socio-psychological climate.

The integration of HR policy into the change management system involves a comprehensive set of interrelated measures. First and foremost, HR policies should be aligned with the enterprise's strategic objectives. Workforce planning should take into account long-term organizational development priorities, the introduction of new technologies, the digitalization of business processes, and changes in organizational structure. Under these conditions, strategic human resource planning becomes particularly important, as it enables organizations to develop talent pipelines, anticipate future competency requirements, and minimize the risks associated with shortages of qualified personnel [10].

At the same time, an effective HR policy should focus not only on providing the enterprise with an adequate workforce but also on unlocking the potential of every employee. Organizational change is frequently accompanied by the need to acquire new professional skills, adopt new working methods, or assume revised job responsibilities. Under such circumstances, it is essential to establish a system of continuous professional development that enables employees to upgrade their qualifications, undergo reskilling, and acquire competencies related to modern digital technologies.

A successful example of such an approach is provided by Microsoft, which, during its large-scale digital transformation, introduced the concept of a "learn-it-all culture" instead of the traditional "know-it-all" mindset. The company emphasized continuous learning, the development of soft skills, openness to new knowledge, and support for internal talent mobility. This approach significantly enhanced employees' innovative capacity, accelerated their adaptation to technological change, and fostered a

culture of continuous learning, ultimately contributing to the company's overall organizational performance.

Another essential component of an integrated HR policy is the development of a talent management system. Modern enterprises are increasingly shifting from traditional personnel management toward human capital management, recognizing employees as the organization's most valuable strategic resource. Consequently, HR policy should encompass not only the attraction of highly qualified professionals but also the creation of favorable conditions for their long-term professional development, career advancement, and retention within the organization. Research indicates that enterprises investing in employee development are more successful in implementing organizational change and experience significantly lower levels of staff turnover [9].

The development of HR policy has become particularly important under conditions of martial law. Ukrainian enterprises are facing large-scale employee relocation, workforce mobilization, changes in employment structures, shortages of highly qualified specialists, and considerable psychological pressure on work teams. Under these circumstances, HR departments increasingly perform functions related to employee psychological support, adaptation programs, the promotion of corporate collaboration, and the strengthening of employees' emotional resilience [3].

Another important direction for improving the effectiveness of change management is the use of modern digital communication tools. Business digitalization has fundamentally transformed approaches to internal communication by enabling the rapid exchange of information regardless of employees' physical location. Digital communication has become especially important since the COVID-19 pandemic and, subsequently, during the full-scale war in Ukraine, when a substantial proportion of employees shifted to remote or hybrid work arrangements.

Modern digital platforms enable organizations to provide employees with timely information regarding organizational change, conduct online meetings, training sessions, and consultations, as well as maintain continuous feedback between management and the workforce. Among the most widely used tools are Microsoft Teams, Slack, Google Workspace, Zoom, corporate intranet portals, customer relationship management (CRM) systems, human resource management (HRM) platforms, and mobile applications designed for internal communication.

However, the effectiveness of digital communication depends not only on the adoption of advanced software solutions. Equally important is the development of a digital organizational culture characterized by common standards for information exchange, transparent communication, managerial accessibility, and the continuous enhancement of employees' digital competencies. Without these conditions, even the most sophisticated information systems are unlikely to deliver the desired outcomes.

Particular attention should be given to the use of digital platforms in supporting change management processes. Through corporate information systems, management can communicate project progress, provide access to learning resources, conduct online surveys, assess employee satisfaction, and obtain real-time feedback from the workforce. These capabilities significantly enhance the transparency of organizational

transformation, strengthen trust in managerial decisions, and facilitate the timely identification of issues arising during the implementation of change initiatives.

A notable example is IBM, which extensively utilized internal digital platforms during its digital transformation to communicate regularly with employees, conduct electronic surveys, and analyze workforce sentiment. The information collected was used by management to adjust managerial decisions promptly, thereby minimizing resistance to change and maintaining a high level of employee engagement throughout the implementation of strategic initiatives.

The integration of HR policy with modern digital communication tools provides a solid foundation for effective change management, as it not only ensures efficient information support throughout the transformation process but also creates favorable conditions for employee development, strengthens trust between management and the workforce, and enhances the organization's capacity to adapt to contemporary challenges.

Another essential prerequisite for the successful implementation of organizational change is the timely availability of reliable information regarding the socio-psychological climate within the workforce. Because organizational transformation is accompanied by changes in organizational structures, the redistribution of responsibilities, the introduction of new technologies, and modifications to established work practices, employees' psychological well-being continuously evolves throughout the change process. Consequently, the assessment of the socio-psychological climate should not be conducted on an occasional basis but should instead become an integral component of the organization's strategic human resource management system.

Regular monitoring of the socio-psychological climate enables management to identify, at an early stage, factors that negatively affect employee motivation, trust in leadership, the quality of internal communication, and the effectiveness of teamwork. Unlike traditional employee satisfaction assessments, contemporary monitoring encompasses a much broader range of indicators. These include employee engagement, psychological safety, readiness to support organizational change, trust in managers, the quality of horizontal and vertical communication, the frequency of workplace conflicts, levels of occupational burnout, and the overall assessment of corporate culture [9].

A comprehensive approach should be adopted when assessing the socio-psychological climate by combining both quantitative and qualitative research methods. The most commonly used instruments include anonymous employee surveys, sociological questionnaires, individual interviews, focus groups, psychological assessments, and the analysis of workforce indicators such as staff turnover, absenteeism, labor productivity, and requests submitted to human resource departments. The integrated use of these methods provides a more objective understanding of the organization's internal environment and facilitates the identification of areas requiring timely managerial intervention.

The monitoring of the socio-psychological climate becomes particularly important during periods of large-scale organizational transformation. At this stage, it is essential not only to assess the final outcomes of change initiatives but also to continuously

evaluate employees' responses throughout each phase of implementation. Such an approach enables management to identify early signs of psychological tension, increasing workplace conflict, or the emergence of negative attitudes toward change before these factors begin to adversely affect organizational performance [5].

Another important direction for improving change management is the assessment of employees' readiness for organizational transformation. Practical experience indicates that most difficulties encountered during the implementation of change arise not from shortcomings in strategic decisions but rather from employees' insufficient readiness to accept and implement them. Therefore, it is advisable to evaluate employees' psychological, professional, and organizational readiness during the planning stage of change initiatives.

Employee readiness for change can be defined as a multidimensional construct encompassing employees' awareness of the necessity for transformation, positive attitudes toward innovation, willingness to engage in professional learning, ability to adapt to new working conditions, and trust in organizational leadership. A high level of readiness facilitates the successful implementation of managerial decisions, whereas insufficient readiness may result in either passive or active resistance to change.

The assessment of employees' readiness should be conducted across several interrelated dimensions. First, it is important to determine employees' level of awareness regarding the reasons for and objectives of the proposed changes. Equally important is the evaluation of their professional competencies, willingness to acquire new technological skills, level of motivation, and psychological resilience. Particular attention should also be paid to assessing employees' trust in management, as this factor significantly influences their perception of managerial decisions and their willingness to support organizational transformation.

The experience of Toyota illustrates that the successful implementation of large-scale production changes relies heavily on thorough employee preparation. Before introducing new production processes, employees participate in specialized training programs, engage in group discussions, contribute suggestions for process improvement, and are given opportunities to evaluate the potential implications of forthcoming changes. This approach helps reduce resistance to change while fostering employees' sense of responsibility and commitment to the successful implementation of managerial initiatives.

One of the most effective instruments for maintaining a positive socio-psychological climate is the establishment of an efficient feedback system. Contemporary approaches to human resource management increasingly reject the traditional one-way communication model, in which information flows exclusively from management to employees. Instead, organizations are adopting two-way communication systems that facilitate the continuous exchange of information across all levels of the organizational hierarchy.

A feedback system should operate on a continuous basis and involve all categories of employees. It may be implemented through regular meetings between managers and staff, digital suggestion platforms, corporate portals, anonymous surveys, internal

discussion forums, individual consultations, and periodic employee interviews. A crucial prerequisite for its effectiveness is the timely response of management to the feedback received. When employees do not observe tangible outcomes resulting from their participation, trust in the feedback system quickly diminishes.

A noteworthy example is the practice adopted by Unilever, which utilizes digital platforms to regularly collect employee feedback regarding working conditions, the effectiveness of managerial decisions, and the organization of work processes. The collected information is analyzed in real time, enabling the company to identify emerging issues promptly and make timely adjustments to various aspects of its human resource management policies.

Alongside the development of communication systems, change risk management has become an increasingly important component of organizational transformation. Contemporary management theory defines change-related risks as potential factors capable of negatively affecting the achievement of transformation objectives. These risks include employee resistance, shortages of professional competencies, insufficient financial resources, ineffective communication, conflicts between organizational units, information barriers, employee psychological exhaustion, and inadequate managerial support [5; 11].

Effective risk management should be implemented throughout every stage of organizational change. Initially, organizations should identify potential risks, assess the likelihood of their occurrence, and evaluate their possible impact on organizational performance. The subsequent stage involves developing a comprehensive set of preventive measures aimed at mitigating adverse consequences. It is equally important to assign responsibility for risk monitoring, establish a system of early warning indicators, and regularly review response plans in accordance with changes in the external and internal environment.

Under martial law, the range of risks associated with organizational change expands considerably. In addition to traditional organizational challenges, enterprises face security threats, business relocation, disruptions in logistics, labor shortages, the psychological consequences of prolonged stress, and the need to adapt rapidly to changing economic conditions. Consequently, integrating psychological considerations into the organizational risk management system has become particularly important. The timely identification of signs of professional burnout, chronic fatigue, or emotional exhaustion enables organizations to prevent the deterioration of the socio-psychological climate and maintain employees' productivity and overall well-being [3; 6].

Particular attention should also be paid to the use of advanced digital analytics for forecasting risks related to organizational change. Large international companies increasingly employ Human Resources Analytics (HR Analytics) to assess employee engagement, labor productivity, professional development, staff turnover, and job satisfaction. Based on these analytical insights, management can identify potential problems at an early stage, anticipate employees' responses to forthcoming changes, and make more informed managerial decisions.

The success of organizational change largely depends on the systematic and integrated nature of managerial actions. Practical experience demonstrates that organizations achieve the best outcomes when change management is viewed as a continuous process embedded within the broader corporate governance system. Within this approach, particular emphasis is placed on human capital development, transparent internal communication, the strengthening of corporate culture, leadership development, and the cultivation of an organizational environment founded on mutual trust.

For Ukrainian enterprises operating under conditions of martial law and during the post-war recovery period, these recommendations have particular practical significance. The integration of contemporary HR management practices, digital technologies, employee psychological support, continuous monitoring of the socio-psychological climate, and systematic risk management can significantly enhance organizational adaptability to external challenges, mitigate the adverse consequences of organizational transformations, and contribute to the sustainable development and long-term resilience of enterprises.

Improving the effectiveness of change management requires a comprehensive approach that integrates strategic human resource management, the digitalization of internal communications, continuous monitoring of the socio-psychological climate, assessment of employees' readiness for change, an effective feedback system, and proactive risk management. The implementation of these recommendations will contribute to creating a supportive organizational environment, increasing employee engagement in the change process, strengthening trust between employees and management, and ensuring the long-term competitiveness of enterprises in the context of dynamic socio-economic transformations.

Conclusions. In today's rapidly changing environment, change management has become a prerequisite for ensuring the effective functioning and sustainable development of enterprises. Increasing uncertainty, digital transformation, economic instability, and wartime challenges require organizations not only to adopt new managerial approaches but also to take into account the socio-psychological aspects of workforce management.

The study has demonstrated that the socio-psychological climate is one of the key determinants of successful organizational change implementation. Employees' readiness to embrace change, their resistance to innovation, and the achievement of intended organizational outcomes largely depend on the level of trust, the effectiveness of internal communication, employee motivation, leadership, and the strength of the corporate culture.

The findings substantiate that enhancing the effectiveness of change management requires the integrated application of modern managerial mechanisms, including the development of HR policies, improvement of internal communication systems, continuous professional development of employees, regular monitoring of the socio-psychological climate, the adoption of digital technologies, and the implementation of effective feedback mechanisms. The integration of these elements strengthens

organizational adaptability, increases employee engagement, and enhances organizational resilience in an environment of continuous change.

Effective change management should be based on the integration of strategic managerial decisions with a human-centered approach that considers employees' needs, motivation, and psychological well-being. Such an approach creates favorable conditions for fostering a positive socio-psychological climate, ensuring the successful implementation of organizational transformations, and supporting the long-term development and sustainability of the enterprise.

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1.10. Conceptualization of the Innovative Development of Agricultural Enterprises Within the Framework of Scientific Approaches

Theoretical understanding of the innovative development of agricultural enterprises requires an examination of the evolution of scientific approaches to interpreting its essence, substantive characteristics, and formation patterns. The contemporary understanding of this category has emerged as a result of the long-term development of economic thought, within which innovation has been regarded as a source of economic change, development as a process of quantitative growth and qualitative transformation of an economic system, and agricultural production as a specific environment for the creation, diffusion, and practical application of innovations. The combination of these scientific perspectives has gradually contributed to the formation of a comprehensive vision of enterprise innovative development as a purposeful process of renewal based on the use of new knowledge, technologies, management methods, organizational solutions, and market opportunities.

The need for an in-depth study of this issue is determined by the fact that the innovative development of an agricultural enterprise cannot be reduced solely to technical modernization or the implementation of individual new technologies. It encompasses systemic changes in the production, organizational, managerial, marketing, personnel, financial, and environmental components of enterprise activity. At the same time, the nature and effectiveness of such changes are largely determined by the specific features of agricultural production, including its dependence on natural and climatic conditions, seasonality, the duration of production cycles, the biological characteristics of agricultural products, the limited availability of land resources, and an increased level of economic risk. Therefore, it is appropriate to consistently examine the scientific propositions within which the concept of innovative development has evolved – from classical theories of innovation to contemporary approaches that take into account the sectoral characteristics of agricultural enterprises.

The concept of «innovation» constitutes the fundamental category for revealing the content of innovative development. In scientific literature, it is characterized by multidimensionality and combines procedural, result-oriented, functional, and instrumental features. Historically, the term originates from the Latin word innovatio, meaning renewal, change, or the introduction of something new. In the course of the development of economic science, its meaning has expanded considerably – from the designation of a specific technical novelty to a comprehensive category reflecting the creation, implementation, diffusion, and commercialization of new solutions in various spheres of economic activity [1].

In its contemporary interpretation, innovation is not limited to the mere emergence of novelty. Its defining features include practical implementation, the ability to generate economic, social, technological, or environmental effects, and its orientation toward strengthening the competitiveness of an economic entity. New ideas, scientific developments, or technical solutions acquire the characteristics of innovation only when they are introduced into production or management practice and produce tangible results. This approach makes it possible to distinguish between an invention or novelty and an innovation: a novelty represents a potentially new solution, whereas an innovation is the result of its practical implementation and utilization.

The first fundamental approach to interpreting innovation in economic science is generally associated with the concept developed by J. Schumpeter, who, in the first half of the twentieth century, substantiated its understanding as a new combination of production factors. The scholar identified five principal forms of innovation: the creation of a new product or the improvement of its properties; the introduction of a new method of production; the development of a new market; the use of a new source of raw materials or semi-finished products; and the implementation of new forms of business organization [1]. Within this approach, innovation is regarded not as an accidental change but as a deliberate combination of resources capable of disrupting the established state of an economic system and ensuring its transition to a qualitatively new level of functioning.

A fundamentally important provision of J. Schumpeter's concept is the recognition of innovation as an internal driver of economic dynamics. New combinations of production factors create the prerequisites for structural shifts, the emergence of new types of economic activity, changes in the competitive positions of enterprises, and the transformation of the market environment. The renewal of the economic system occurs through the mechanism of "creative destruction," whereby new technologies, products, organizational models, and business practices gradually displace obsolete ones. For agricultural enterprises, this process may take the form of a transition to resource-saving technologies, the use of high-yielding crop varieties and animal breeds, the digitalization of production processes, the implementation of precision agriculture, the modernization of logistics, and changes in market interaction mechanisms.

The further development of the process-oriented understanding of innovation is reflected in the works of B. Twiss. The scholar interpreted innovation not as a single event or the final outcome of scientific and technological activity, but as a consistent and manageable process encompassing the path from the emergence of an idea to its practical implementation in the form of a product, technology, or service capable of generating market value [3]. This approach emphasizes the interrelationship between scientific research, the development of a new solution, its adoption in production, commercialization, and diffusion among consumers.

The process-oriented interpretation is particularly important for studying the innovative development of agricultural enterprises, since the implementation of innovations in agriculture usually requires a prolonged period of preparation, testing, and adaptation to specific natural and production conditions. The effectiveness of

innovation depends not only on its technical characteristics but also on the availability of financial, material, informational, and human resources, the readiness of personnel for change, the level of managerial competence, and the enterprise's ability to integrate a new solution into the existing management system. Accordingly, the innovation process in agriculture should be regarded as a set of interrelated stages, each of which influences the final outcome and requires appropriate managerial support.

In the second half of the twentieth century, economic science witnessed a further expansion of the content of the innovation concept, which was associated with its interpretation in the context of entrepreneurship, strategic management, and the formation of competitive advantages. One of the most influential theorists in this field, P. Drucker, defined innovation as a specific instrument of entrepreneurship through which change is transformed into new economic opportunities [4]. Accordingly, innovativeness is associated not only with the creation of fundamentally new technologies or products but also with an entrepreneur's ability to identify changes in the external environment in a timely manner, assess their potential, and use them for business development.

As V. Naidiuk aptly observes, this interpretation reflects the instrumental approach to understanding innovation, according to which its essence is determined not merely by the presence of novelty but primarily by the possibility of transforming change into a practically applicable economic opportunity [5]. From this perspective, innovation acquires significance only when it is incorporated into entrepreneurial activity and contributes to the creation of new value. Such value may be manifested in the establishment of a new business, the development of a new service, the modernization of an existing product, the formation of a new market offer, or the emergence of promising areas of economic activity.

The instrumental approach therefore shifts the emphasis from novelty as an abstract characteristic to the economic and managerial consequences of its practical application. A new idea, scientific achievement, or technological solution does not automatically become an innovation unless it is introduced into business processes and produces a measurable effect. Accordingly, the defining features of innovation include not only originality but also feasibility, practical applicability, economic relevance, and the ability to generate benefits for the enterprise, consumers, and other stakeholders.

In this context, innovation serves as a mechanism for implementing entrepreneurial initiative and converting uncertainty into development opportunities. It enables enterprises to identify unmet consumer needs, create new market segments, improve existing value propositions, and respond more flexibly to changes in demand. Innovation may also facilitate market differentiation by allowing an enterprise to offer products or services with improved characteristics, higher quality, lower costs, greater convenience, or additional consumer value.

The instrumental interpretation is particularly important under conditions of economic instability, rapid technological change, and intensifying competition. In such an environment, enterprises are required not only to react to external changes but also to anticipate them and deliberately shape their strategic responses. Innovation becomes

a means of increasing organizational flexibility, reducing vulnerability to market fluctuations, and strengthening the enterprise's capacity to operate under uncertainty. It also supports the timely adjustment of production, marketing, investment, and management decisions to new technological, institutional, and consumer trends.

The instrumental approach has substantially broadened the conceptual boundaries of innovation. It is increasingly viewed not only as an outcome of scientific and technological progress but also as an instrument of strategic enterprise renewal. This interpretation encompasses transformations that may affect production systems, organizational structures, management models, business processes, communication mechanisms, and relationships with external stakeholders. Consequently, innovation may be technological, product-related, process-related, organizational, managerial, marketing-oriented, social, or institutional in nature.

Within production activity, innovation may involve the implementation of new machinery, automated systems, resource-efficient technologies, advanced materials, or data-driven control methods. In management, it may be expressed through new planning systems, decentralized decision-making, digital monitoring, project-based approaches, or performance management tools. Marketing innovations may include new distribution channels, digital communication platforms, personalized customer interaction, and new methods of product positioning. Organizational innovations may involve changes in the division of responsibilities, internal coordination, personnel motivation, partnership arrangements, and mechanisms of knowledge exchange.

An equally important dimension concerns the interaction of enterprises with suppliers, consumers, investors, research institutions, and public authorities. Innovation may transform traditional business relationships by replacing linear supply chains with more flexible networks of cooperation. It can also support the establishment of long-term partnerships, joint research projects, shared digital platforms, and collaborative forms of value creation. In this sense, innovation contributes not only to the internal modernization of the enterprise but also to the reconfiguration of its position within the broader economic environment.

For agricultural enterprises, the instrumental approach is especially relevant because innovative development in this sector cannot be confined to the acquisition of new machinery or the introduction of individual production technologies. It may include the application of precision agriculture, digital monitoring systems, automated irrigation, remote sensing, decision-support tools, and resource-saving production methods. At the same time, it also encompasses the improvement of planning systems, logistics, financial management, marketing, cooperation, personnel development, and risk management.

Innovative development in agriculture may therefore be supported through the introduction of digital platforms, the use of agricultural data, the modernization of storage and processing systems, the development of direct sales channels, and the integration of producers into value chains. It may also involve production diversification, the introduction of new crop varieties and livestock breeds, the

development of organic production, the implementation of circular-economy principles, and entry into new domestic or international markets.

The strategic significance of innovation for agricultural enterprises is also associated with the specific risks inherent in agricultural production. Dependence on natural and climatic conditions, seasonality, biological production cycles, and fluctuations in market prices increase the need for adaptive and risk-resilient solutions. In this context, innovation becomes a means of improving forecasting, reducing production losses, stabilizing yields, optimizing resource use, and strengthening the enterprise's ability to respond to external disruptions.

Thus, the evolution of scientific approaches to interpreting innovation demonstrates a gradual transition from its narrow understanding as an isolated technical novelty to a comprehensive vision of innovation as a process, a result, an entrepreneurial instrument, and a factor of strategic transformation. The classical approach emphasizes new combinations of production factors and their role in economic dynamics. The process-oriented approach focuses on the sequence of stages through which an idea is transformed into a practically applied solution. The instrumental approach, in turn, highlights the capacity of innovation to create new economic opportunities, strengthen competitiveness, and ensure enterprise renewal.

These approaches should not be viewed as mutually exclusive. On the contrary, they complement one another and make it possible to reveal different aspects of the same phenomenon. The classical interpretation explains the transformative nature of innovation, the process-oriented approach clarifies the mechanisms of its creation and implementation, while the instrumental approach emphasizes its practical and strategic value. Their integration provides a more comprehensive theoretical understanding of innovation and its role in enterprise development.

The synthesis of these provisions forms the conceptual basis for further examination of the innovative development of agricultural enterprises as a systemic, continuous, and purposeful process of qualitative renewal. Such development involves not only the implementation of individual innovations but also the consistent transformation of technologies, resources, management systems, organizational structures, and market behavior. Its effectiveness depends on the enterprise's ability to integrate innovation into long-term strategic priorities and ensure coherence between technological, economic, organizational, and institutional changes.

The subsequent expansion of scientific views on the essence of innovation was associated with the gradual transition from a closed model of innovation activity to an open approach. The closed model assumed that enterprises generated ideas, conducted research, developed technologies, and commercialized new products primarily through their own internal resources. Although this model contributed to the accumulation of internal competencies, it also limited access to external knowledge, increased the cost of innovation, and reduced the speed at which enterprises could respond to technological and market change.

Under the open innovation model, the creation and implementation of innovations are no longer confined to the internal capabilities of a single enterprise.

Instead, they are based on active interaction with other participants in the economic and innovation environment. Enterprises may obtain ideas, technologies, competencies, and research results from external sources while simultaneously sharing or commercializing those developments that cannot be fully utilized internally. Such interaction contributes to a more efficient allocation of knowledge and resources and accelerates the transformation of ideas into marketable solutions.

Studies devoted to the concept of open innovation demonstrate that an enterprise cannot ensure sustainable innovative development by relying exclusively on its own research potential and internal developments. The growing complexity of technologies, the increasing cost of research, the shortening of product life cycles, and the rapid diffusion of knowledge make isolated innovation activity progressively less effective. To strengthen innovation capacity, enterprises should combine internal competencies with external sources of knowledge and technological expertise [6; 7].

External knowledge may be obtained through cooperation with universities, research institutions, technology centres, consulting organizations, suppliers, customers, start-ups, and other enterprises. Such cooperation enables access to specialized competencies, research infrastructure, experimental results, market information, and technological solutions that would be difficult or costly to create independently. It also allows enterprises to reduce uncertainty, share risks, and shorten the period between idea generation and practical implementation.

Partnerships and network cooperation are therefore becoming essential components of contemporary innovation activity. They may take the form of joint research projects, strategic alliances, innovation clusters, public-private partnerships, technology transfer agreements, contractual research, or shared digital platforms. Through these mechanisms, enterprises are able to coordinate resources, exchange knowledge, test new solutions, and jointly create products or services that reflect the needs of different participants in the innovation process.

An important feature of open innovation is the increasing role of customers and users in creating new solutions. Enterprises may involve consumers in identifying problems, testing prototypes, evaluating product characteristics, and generating ideas for improvement. This interaction makes it possible to reduce the gap between technological capabilities and actual market demand. As a result, innovations become more responsive to user needs and have a greater probability of successful commercialization.

For agricultural enterprises, the transition to open innovation is particularly significant because their innovation capacity is often constrained by limited financial resources, insufficient research infrastructure, and unequal access to advanced technologies. Cooperation with research institutions, advisory services, technology providers, processing companies, financial organizations, and public authorities may compensate for these limitations. It also creates opportunities for adapting scientific developments to local production conditions and accelerating their diffusion across the agricultural sector.

Open innovation in agriculture may include the joint development of new crop varieties, the testing of digital technologies, the introduction of resource-efficient production systems, the creation of traceability platforms, and the implementation of environmental solutions. Such cooperation may also facilitate access to investment, specialized knowledge, market information, and international experience. Therefore, the open innovation model expands the sources of enterprise renewal and strengthens the integration of agricultural enterprises into broader innovation ecosystems.

Accordingly, the transition from closed to open innovation represents not merely a change in the sources of knowledge but a transformation of the entire logic of innovation management. The enterprise becomes part of a network in which innovation emerges through the interaction of multiple actors, the combination of diverse competencies, and the joint creation of value. This approach deepens the understanding of innovative development as a collective, interorganizational, and ecosystem-based process rather than an exclusively internal function of a single enterprise [6; 7].

These propositions were further developed in the works of M. Curley, who associates the transformation of the open innovation concept with the emergence of the Open Innovation 2.0 paradigm. Its content is determined by the transition from individual partnerships to systemic and integrated cooperation among businesses, research institutions, public authorities, civil society, and other participants in innovation processes. The principal characteristics of this paradigm include collaborative value creation, the development of innovation ecosystems, the use of emerging technological opportunities, the integration of resources and competencies, and an orientation toward the practical implementation of developed solutions [8]. From this perspective, innovation is viewed not only as the outcome of an individual enterprise's activity but also as the result of multilevel interaction among actors involved in the creation, adaptation, diffusion, and commercialization of new knowledge.

Contemporary international methodological approaches have made an important contribution to specifying the content of the category of innovation. According to the Oslo Manual 2018, an innovation is defined as a new or improved product or process that differs significantly from the enterprise's previous products or processes and has already been made available to potential users or brought into use [9]. Therefore, the mere generation of a new idea or the development of a promising solution is insufficient for it to be recognized as an innovation. A necessary condition is the practical application of such a solution or its introduction to the market.

The distinction made in the Oslo Manual 2018 between innovation and innovation activity is of particular methodological importance. Innovation refers to a specific result that has already been applied in practice, whereas innovation activity encompasses a set of scientific, technological, organizational, financial, and commercial actions aimed at developing, financing, implementing, and disseminating new solutions [9]. This approach makes it possible to distinguish the achieved result from the processes, resources, and activities that ensure its creation, testing, commercialization, and practical use.

In Ukrainian economic research, the category of innovation is predominantly interpreted broadly, combining result-oriented and process-oriented dimensions. It includes not only the outcomes of scientific and technological activity but also purposeful transformations in the production, organizational, managerial, marketing, and other functional areas of an enterprise. A. V. Hryshchenko, for instance, interprets innovation, on the one hand, as the final outcome of the innovation process embodied in a new or substantially improved product, method, or technology that is applied within an enterprise and has market value. On the other hand, innovation is regarded as a sequential process encompassing the stages from the development of a new solution to its practical implementation and aimed at achieving economic, social, and environmental effects [10].

A similar position is advanced by V. S. Naidiuk, who systematizes existing interpretations of innovation according to functional, attributive, and object-based approaches. The functional approach defines innovation as a process of change; the attributive approach emphasizes novelty as its defining feature; and the object-based approach presents innovation as a specific product, technology, process, or organizational solution resulting from the practical implementation of new ideas [5]. The combination of these approaches confirms the multidimensional nature of the category and demonstrates that it cannot be restricted to a single form of manifestation.

An important extension of this perspective is provided by O. H. But-Husaim, who emphasizes that innovation should not be identified exclusively with technological renewal. According to the researcher, innovation is simultaneously a socio-economic phenomenon capable of transforming business models, organizational structures, internal communication patterns, employee interactions, and managerial approaches [11]. Consequently, the effects of innovation implementation may encompass not only the production and technological sphere but also the organizational, human resource, social, and institutional components of enterprise activity.

A broad interpretation of innovation is also incorporated into the Ukrainian legal framework. According to the Law of Ukraine «On Innovation Activity» innovations include newly created or improved competitive technologies, products, or services, as well as organizational and technical solutions of a production, administrative, commercial, or other nature, whose application substantially improves the structure and quality of production and the social sphere [12]. This definition emphasizes the practical application of innovations, their competitiveness, and their ability to generate positive changes in economic and social activities.

The legislative interpretation confirms that innovation may take technological, product-related, process-related, organizational, or managerial forms. The decisive criterion for identifying an innovation is not only the presence of novelty but also the achievement of a practical result manifested in improved product quality, enhanced production processes, more efficient management, stronger competitive positions, or better social conditions.

The synthesis of the scientific and regulatory provisions considered above provides grounds for defining innovations as new or substantially improved products,

technologies, production and management processes, organizational forms, and business solutions that have been practically implemented in enterprise activities and contribute to qualitative renewal. Their application promotes more efficient resource utilization, the creation of competitive advantages, greater adaptability to changes in the external environment, and the formation of prerequisites for long-term development. From this perspective, innovations should be regarded as one of the key drivers of enterprise transformation and the development of its capacity for systemic and continuous growth.

With regard to the essence of the concept of «development» both Ukrainian and international scholarly literature describe it as a multidimensional phenomenon encompassing a set of transformations that enable an object or system to move toward a qualitatively new and more advanced level of organization, functioning, and performance [13]. Early reflections on development can be traced to the works of ancient Greek philosophers, including Aristotle, Plato, and Democritus. However, their interpretations were predominantly philosophical and contemplative and lacked a clearly defined scientific and methodological foundation. Over time, the understanding of development evolved within classical and historical schools of economic thought, Marxism, institutionalism, Keynesianism, and neoclassical theory, gradually acquiring a more structured conceptual and methodological framework [1].

Contemporary economic literature offers a broad range of interpretations of this category. According to the Academic Explanatory Dictionary of the Ukrainian Language, development is understood as a process of transition from one qualitative state to another, accompanied by changes in the internal properties and characteristics of a particular phenomenon or object [14]. This interpretation provides a conceptual basis for economic research, in which development is associated not only with increases in production volumes, income, or other quantitative indicators but also with more profound structural transformations. These may include technological modernization, the renewal of organizational forms, changes in employment patterns, and the redistribution of resources among sectors of the economy.

From this perspective, development is not regarded as an automatic or exclusively externally determined process. It presupposes the active involvement of economic actors in creating competitive advantages, responding to global challenges, adapting their activities to changing conditions, and ensuring sustainable economic progress [15]. Accordingly, the content of development combines quantitative growth with qualitative transformation, while its results are reflected in changes in the structure, capabilities, relationships, and performance of an economic system.

The position advanced by V. O. Zanora deserves particular attention. The scholar interprets enterprise development as a sequence of purposeful transitions to a new organizational level, determined by the combined influence of internal and external factors and accompanied by qualitative and quantitative changes in the functioning of the system [16]. This interpretation makes it possible to examine development simultaneously as an achieved result and as a dynamic state that is continuously

transformed under the influence of numerous economic, technological, organizational, social, and institutional factors.

A similar scientific perspective is presented by O. V. Lopushynska, who defines enterprise development as an integrated set of changes occurring both within the internal environment of an enterprise and in its interaction with the external environment [17]. Internal transformations may affect the organizational structure, personnel, technologies, management mechanisms, corporate culture, information flows, and the allocation of financial and material resources. External changes, in turn, are associated with market conditions, competitive pressures, institutional requirements, technological trends, stakeholder expectations, and other environmental determinants. Such an interpretation emphasizes that enterprise development is formed at the intersection of internal capabilities and external challenges. The author stresses that effective development is possible only when the strategic objectives of the enterprise are aligned with the tendencies and requirements of the external environment and supported by adequate internal resources and managerial competencies.

This approach also highlights the importance of maintaining a balance between internal stability and external adaptability. An enterprise must preserve the integrity of its organizational system while simultaneously introducing changes that enable it to respond to market fluctuations, regulatory shifts, technological progress, and changes in consumer behaviour. Consequently, development should not be regarded solely as internal restructuring. It also involves the establishment of effective mechanisms for interaction with suppliers, customers, investors, public authorities, research institutions, and other stakeholders whose decisions may influence the enterprise's long-term prospects.

In turn, O. M. Vinichenko interprets enterprise development as a combination of interrelated changes that ensure its gradual transition toward new states of functioning, contribute to higher operational efficiency, and strengthen its capacity to adapt to external conditions [18]. Under this approach, development is viewed as a continuous movement rather than a single transformation or isolated managerial action. It is manifested through the accumulation of changes that gradually alter the enterprise's internal configuration, strategic orientation, resource potential, technological capabilities, and ability to respond to emerging challenges.

An important feature of this interpretation is the recognition of development as a cumulative process. Individual changes may initially appear limited in scale, but their interaction can generate significant structural and functional effects over time. For example, the modernization of production technologies may require changes in staff qualifications, management systems, logistics, financing mechanisms, and market positioning. Therefore, the effectiveness of enterprise development depends on the consistency of transformations and the degree to which they are coordinated within a unified strategic framework.

The analysis of the existing scientific approaches provides grounds for defining development as a dynamic, continuous, and purposeful process involving qualitative

and quantitative changes in all areas of enterprise activity and in its relationships with the external environment. Quantitative changes may be reflected in the growth of production volumes, income, market share, labour productivity, or investment resources. Qualitative changes involve deeper transformations in technologies, organizational structures, management systems, competencies, business models, and the enterprise's position within the market environment.

Such changes enable the enterprise to move toward a new state of functioning, improve the efficiency of resource use and managerial decision-making, and enhance its adaptability to changing economic conditions. Development therefore combines the achievement of higher performance indicators with the transformation of the enterprise's internal characteristics and external interaction mechanisms. Its results are manifested not only in economic growth but also in greater flexibility, resilience, innovation capacity, and readiness to respond to emerging risks and opportunities.

This interpretation is particularly relevant in the context of innovative development, where the enterprise's transition to a qualitatively new level is directly associated with its ability to generate, adopt, adapt, diffuse, and commercialize innovations. Innovative development requires not only the availability of new ideas or technologies but also the organizational capacity to transform them into practical solutions. This includes the ability to assess innovation opportunities, mobilize resources, manage implementation risks, train personnel, and integrate innovations into existing production and management systems.

Unlike general development, which may result from a wide variety of internal and external factors, innovative development is distinguished by the fact that innovations serve as the principal source of qualitative transformation. In this case, the process extends beyond the modernization of individual components of enterprise activity and involves systemic changes based on the introduction of new technological, organizational, managerial, marketing, digital, and market-oriented solutions. Innovative development therefore affects not only production methods but also the enterprise's structure, business processes, management system, interaction with partners and consumers, mechanisms for creating value, and approaches to strategic decision-making.

At the same time, innovative development should not be reduced to the mechanical introduction of new technologies. Its essence lies in the ability of an enterprise to ensure the interconnection between innovation and strategic renewal. A technological solution becomes a factor of development only when it contributes to improved productivity, reduced costs, increased product quality, better market responsiveness, or stronger competitive positions. Similarly, organizational or managerial innovations acquire practical importance when they improve coordination, accelerate decision-making, increase employee involvement, or enhance the efficiency of resource allocation.

For this reason, contemporary economic research considers innovative enterprise development an essential prerequisite for maintaining competitiveness, strengthening adaptability, and ensuring long-term resilience under conditions of rapid and often

unpredictable environmental change. The systematic implementation of innovations allows an enterprise to respond more effectively to technological shifts, changing consumer demand, intensified competition, resource constraints, institutional transformations, and growing sustainability requirements. It also creates opportunities for entering new markets, developing new products and services, and forming more flexible business models.

The effectiveness of innovative development, however, depends on the enterprise's ability to integrate innovations into a coherent development strategy rather than apply them as isolated, fragmented, or temporary measures. Strategic integration involves defining innovation priorities, aligning them with long-term objectives, ensuring appropriate financing, developing personnel competencies, creating mechanisms for monitoring results, and adjusting innovation activities in response to external change. Without such coordination, even potentially valuable innovations may fail to produce sustainable economic and organizational effects.

A more comprehensive examination of the category of "innovative enterprise development" requires consideration of the interpretations presented in contemporary scientific literature (Table 1.1). The synthesis of the existing definitions demonstrates that scholars approach this concept from different methodological perspectives and emphasize various substantive aspects. Some researchers focus on the realization of innovation potential, others on the continuity of innovation processes, structural renewal, strategic change, competitiveness, or the achievement of economic and social effects.

Nevertheless, most interpretations share the understanding of innovative development as a process of qualitative enterprise transformation driven by the creation and implementation of innovations. The common feature of these approaches is the recognition that innovative development involves purposeful changes in the internal state of an enterprise and in the way it interacts with the external environment. It is therefore appropriate to interpret this category as a complex process that combines innovation activity, strategic renewal, resource transformation, and the formation of new competitive capabilities.

Table 1.1

Interpretations of the Essence of the Concept of «Innovative Enterprise Development»

Author(s)	Definition
O. H. But-Husaim	Innovative development of business structures is regarded as a comprehensive process of continuous renewal of business processes through the implementation of new technologies, products, and services aimed at improving operational quality and adapting to changes in the market environment.
A. V. Hryshchenko	Innovative enterprise development is the result of the coordinated functioning of financial, managerial, technological, marketing, and innovation-related components that ensure strategic performance and determine the level of innovation activity.
Ye. O. Didenko, Yu. S. Motorna	Innovative enterprise development is interpreted as a process of systemic renewal based on the utilization of innovation potential and aimed at increasing

	competitiveness, achieving strategic objectives, and ensuring innovation security.
L. O. Voloshchuk	Innovative enterprise development refers to achieving positive qualitative changes in the enterprise's condition through the formation and effective utilization of its innovation potential in the course of its activities.
L. I. Fedulova	Innovative enterprise development is defined as a dynamic process of qualitative changes in the innovation-related condition of an enterprise resulting from the intensification of its innovation activity.
O. A. Adamenko	Innovative enterprise development consists in a consistent transition to a new qualitative state through the implementation of innovations in products, processes, and all areas of economic activity.
O. Yu. Yemelianov, D. R. Havras	Innovative enterprise development is associated with changes in the characteristics of resources and managerial competencies that contribute to the growth of innovation potential and ensure a stable improvement in financial and economic performance.
V. S. Naidiuk	Innovative enterprise development is a process of purposeful change in the enterprise's condition based on its innovation potential, which creates new opportunities for further development and market activity.
N. Kashchena, Ye. Chmil	Innovative enterprise development is viewed as the capacity for comprehensive transformation and multidirectional growth through the implementation of innovations aimed at strengthening competitive positions, resilience, and operational security.
K. V. Kovtunenko, A. O. Kotsaha	Innovative development of a business structure is defined as innovation-oriented development of its areas of activity aimed at improving efficiency and profitability and expanding sales markets.
O. B. Vatchenko, B. S. Vatchenko, O. L. Cherevko	Innovative development is a continuous process of qualitative change based on the creation and implementation of innovations with the aim of increasing competitiveness and efficiency in a changing environment.
M. M. Koshlata	Innovative enterprise development is characterized by the use of various forms of innovation in production and commercial activities to increase profitability and strengthen competitive advantages.
N. M. Sulima, M. V. Savytskyi	Innovative enterprise development is a systemic transformation of its organizational, production, managerial, and marketing activities through the implementation of innovations aimed at ensuring long-term competitiveness in a dynamic external environment.

Source: compiled based on data from [5; 10; 11; 19; 20; 21; 22; 23; 24; 25; 26; 27; 28].

The principal differences between the existing approaches concern the specific components and outcomes emphasized by individual researchers. Some definitions focus on the continuity and systematic nature of innovative change, while others highlight the realization of innovation potential, the renewal of internal elements of enterprise activity, or the transformation of business processes and organizational structures. A considerable number of scholars also associate innovative development with improved efficiency, stronger competitive positions, increased resilience, and the ability of an enterprise to operate effectively in a dynamic external environment.

Thus, the common conceptual basis of the analyzed approaches lies in the recognition that innovative development is not limited to the introduction of individual new products, technologies, or managerial methods. It constitutes a comprehensive and continuous process that transforms the enterprise as an integrated economic system,

strengthens its innovation capacity, and creates the conditions necessary for sustainable functioning and long-term advancement.

At the same time, the generalization of scientific approaches to interpreting innovative enterprise development provides only a broad theoretical basis for further analysis and does not fully reflect the sector-specific characteristics of agricultural production. Unlike enterprises operating in many other areas of the economy, agricultural enterprises are exposed to pronounced seasonality, dependence on natural and climatic conditions, lengthy biological cycles, the specific role of land as the principal means of production, and an elevated level of production and market risks. Under such circumstances, innovative development in agriculture cannot be reduced to the introduction of isolated innovations. It requires a comprehensive consideration of the technological and biological features of production, the availability and structure of resources, environmental constraints, and the need to ensure food security.

The economic literature presents a considerable variety of approaches to defining the essence of innovative development in agricultural enterprises, which reflects the complexity and multidimensional nature of this category. In particular, O. V. Bolshaia and O. S. Bilichenko emphasize that such development should not be interpreted merely as partial technological modernization. Instead, it should be regarded as a systemic process that combines scientific knowledge, advanced technologies, institutional transformations, and managerial innovations [29]. A similar position is expressed by A. M. Brychko, who associates innovative development in agricultural enterprises with the improvement of organizational management structures, the application of resource-saving technologies, the enhancement of personnel qualifications, and the selection of innovations appropriate for production and economic activities [30].

Particular attention should also be given to the approach according to which innovation processes in agricultural enterprises are closely connected with biological transformations in crop and livestock production. Such processes are generally long-term in nature and are manifested through the modernization of products and services, as well as through the introduction of new methods, technologies, and approaches to operational activity [31]. A related position is advanced by O. B. Slyvinska, who explains innovative development in the agricultural sector through the specific features of innovation activity and the mechanisms by which innovations are incorporated into production. The researcher also emphasizes the importance of combining internal and external sources of investment to intensify innovation processes and ensure their continuity [32].

Recent studies increasingly focus on the technological and digital dimensions of innovative development in agricultural enterprises. B. Huang notes that the implementation of innovations contributes to higher labour and land productivity, improved product quality, reduced operating costs, and increased profitability. At the same time, it strengthens the resilience and competitiveness of agricultural enterprises and promotes a higher level of environmental safety [33]. Thus, innovation is viewed not only as a means of improving economic performance but also as a factor in

achieving greater sustainability and reducing the negative environmental impact of agricultural production.

The digital dimension of innovative development is examined by M. I. Burdiak and I. V. Tomashuk, who argue that contemporary technologies contribute to the formation of an integrated digital model of an agricultural enterprise. Such a model combines management systems, machinery and technical equipment, software tools, data flows, and organizational and economic relationships within a unified information environment [34]. This integration improves the coordination of production and management processes, increases the accuracy and timeliness of managerial decisions, and creates opportunities for continuous monitoring of resource use and operational performance.

Other researchers likewise substantiate the importance of digital technologies as an essential component of the innovative development of agricultural enterprises. Their application supports the improvement of management systems, the automation of production operations, the optimization of resource use, and the strengthening of the competitive position of agribusiness entities [35; 36; 37].

Particularly illustrative in this context is the study in which the innovative development of agricultural enterprises is examined through the lens of readiness for Agribusiness 4.0, digital transformation, and innovation activity [38]. This approach provides grounds for asserting that the contemporary interpretation of innovative development in agricultural enterprises is increasingly shifting toward the integration of conventional technological modernization with digital solutions, data-driven technologies, automation, and new management formats.

The institutional dimension is equally important, since the effectiveness of innovative development in agricultural enterprises largely depends on the external environment. N. M. Vdovenko substantiates this process from the perspective of institutionalization, emphasizing the role of innovation infrastructure, the institutional ecosystem, and coordination mechanisms [39]. At the same time, another approach views innovative development in agricultural enterprises as closely related to the management of processes involving the creation, identification, and implementation of innovations in production and supporting business processes in order to strengthen competitiveness [40]. A conceptually similar position is reflected in OECD provisions, where agricultural innovation systems are interpreted as mechanisms for improving the economic, social, and environmental performance of the agri-food sector through coordinated interaction among its participants and public support for innovation [41].

Alongside this, contemporary studies increasingly examine the innovative development of agricultural enterprises through ecosystem-based and sustainability-oriented approaches. In this context, a number of researchers substantiate an integrated model for supporting such development, combining systemic, ecosystem, mechanism-based, and model-oriented approaches and encompassing technological, organizational, economic, social, and environmental components [42]. At the same time, V. A. Mamchur and H. Ya. Studinska emphasize the necessity of combining increased

efficiency in agricultural production with improved socio-economic conditions in rural areas [43].

The position according to which innovative development in agricultural enterprises should be examined in relation to competitiveness and an innovation-driven model of economic activity is also well founded. In particular, V. V. Skrypnyk associates the category under study with the intensification of innovation processes in the agro-industrial sector under the conditions of globalization and integration [44], whereas T. M. Stukan links it to the modernization of the material and technical base, the implementation of resource-saving technologies, and the improvement of organizational arrangements [45]. From this perspective, innovative development serves as a prerequisite for strengthening market resilience, adaptability, and the competitive position of agricultural enterprises.

The synthesis of the scientific approaches considered above makes it possible to identify the principal features of the innovative development of agricultural enterprises arising from the specific characteristics of agricultural production (Table 1.2).

Table 1.2

Features of the Innovative Development of Agricultural Enterprises

Feature	Manifestation in the Agricultural Sector	Impact on Innovative Development
Dependence on natural and climatic conditions	The activities of agricultural enterprises are influenced by weather conditions, soil quality, and water availability.	Creates a need for adaptive, resource-efficient, and risk-resilient innovations.
Biological nature and seasonality of production	Innovative changes are linked to biological cycles in crop and livestock production and to the temporal unevenness of production processes.	Determines a longer innovation cycle and requires careful planning of innovation implementation.
Land as the principal means of production	Land resources constitute the foundation of production activity and are directly affected by technological interventions.	Increases the importance of precision agriculture, monitoring technologies, and the restoration of resource potential.
High resource intensity and risk exposure	Innovation activity requires substantial financial, technical, human, and information resources under conditions of considerable uncertainty.	Strengthens the role of innovation potential, investment support, and institutional support mechanisms.
Technological and digital transformation	Innovative development is increasingly associated with digitalization, automation, Big Data, precision agriculture, and smart farming.	Enhances productivity, the quality of managerial decision-making, resource-use efficiency, and competitiveness.
Institutional, social, and environmental determinants	Innovation processes depend on innovation infrastructure, technology transfer, and government support and generate social and environmental consequences.	Shapes the external conditions for innovation implementation and directs development toward the long-term sustainability of the agricultural sector.

Source: summarized by the author based on [29-45].

The findings of the study provide grounds for concluding that the contemporary interpretation of the innovative development of agricultural enterprises has emerged through the gradual complication and integration of scientific views on innovation, development, and the mechanisms of their practical implementation in economic activity. The evolution of this category reflects a transition from a narrow understanding of innovation as the introduction of individual technological solutions to its interpretation as a systemic driver of qualitative transformation, structural renewal, and long-term enterprise development.

Within the agricultural sector, innovative development acquires an independent and sector-specific meaning, since it combines general economic patterns of innovation-driven change with the distinctive conditions under which agricultural enterprises operate. These conditions include dependence on natural and climatic factors, the biological nature and seasonality of production, the specific role of land and other natural resources, the duration of production cycles, the high level of operational and market uncertainty, and the need to ensure efficient resource use. Consequently, the innovative development of agricultural enterprises cannot be reduced to isolated modernization measures or the introduction of individual technologies. It should be regarded as a comprehensive process that encompasses technological, organizational, managerial, economic, digital, social, and environmental transformations.

The specific nature of agricultural production also determines the objectives and expected outcomes of innovative development. In addition to increasing productivity and profitability, it is aimed at strengthening the adaptability of enterprises to environmental change, reducing production and market risks, improving the quality and safety of agricultural products, rationalizing the use of land, water, energy, and other resources, and enhancing the long-term resilience of agricultural production. In this context, innovation becomes a means of reconciling economic efficiency with environmental responsibility, social development, and food security.

The generalization of the examined scientific approaches also demonstrates that innovative development should be understood as a continuous and purposeful process based on the realization of an enterprise's innovation potential. This process involves the generation, selection, adaptation, implementation, dissemination, and commercialization of innovations, as well as the creation of appropriate organizational, financial, technological, and institutional conditions for their effective application. Its success depends not only on the availability of innovative solutions but also on the enterprise's managerial capacity, personnel competencies, investment resources, digital readiness, access to knowledge, and interaction with research institutions, public authorities, business partners, and other participants in the agricultural innovation ecosystem.

Thus, the innovative development of an agricultural enterprise may be interpreted as a dynamic process of systemic qualitative transformation driven by the implementation of innovations and adapted to the specific characteristics of agricultural production. Its purpose is to improve economic performance, strengthen resilience and

competitiveness, enhance resource efficiency, and ensure the enterprise's ability to respond effectively to technological, market, institutional, and environmental changes.

Such an interpretation provides a theoretical basis for further substantiating the conceptual foundations of innovation management in agricultural enterprises. It also creates the necessary prerequisites for identifying the principles, objectives, functions, methods, and organizational mechanisms of managing innovation processes, as well as for developing practical approaches to forming and implementing innovation-oriented development strategies in the agricultural sector.

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1.11. Predictive Analytics and Machine Learning in Digital Marketing Effectiveness Assessment

The digital transformation of business processes and the rapid expansion of digital communication channels have significantly influenced approaches to promoting products and services, interacting with consumers, and organizing the marketing activities of enterprises. The use of digital marketing tools enables organizations to reach target audiences rapidly, personalize advertising messages, automate individual marketing operations, and analyze user behavior within the digital environment. At the same time, the growing number of digital platforms and advertising channels, together with the continuous accumulation of large volumes of marketing data, complicates the assessment of digital marketing performance and creates a need to apply modern analytical methods [1].

Traditional approaches to evaluating marketing performance are primarily based on analyzing the outcomes of completed advertising campaigns and do not always provide sufficient opportunities for responding promptly to changes in consumer behavior and the dynamics of the digital environment. Under such conditions, predictive analytics and machine learning technologies become particularly important. Their application enables forecasting conversion rates, estimating the probability of customer churn, identifying typical behavioral patterns, and improving the validity of managerial decision-making in digital marketing [2]. The relevance of this study is driven by the need to develop a comprehensive system for evaluating digital marketing tools that integrates behavioral, conversion, financial, and predictive indicators into a unified analytical environment.

Issues related to the application of predictive analytics, machine learning, and digital marketing analytics have occupied an important place in academic research in recent years. In particular, D. Herhausen et al. demonstrated that the application of machine learning in marketing improves the quality of marketing decisions, enhances the accuracy of consumer behavior forecasting, and increases the effectiveness of personalized offers. At the same time, the authors emphasized the emergence of new challenges associated with integrating algorithmic models into marketing management systems [3].

H. Alserhan et al. found that the application of predictive analytics in marketing strategies and e-commerce personalization positively affects customer engagement and improves the effectiveness of marketing decisions. However, the practical implementation of such technologies is complicated by insufficient data quality and challenges in integrating digital systems [4]. A. Kaponis et al. demonstrated that machine learning in digital marketing automates content personalization, improves

recommendation systems, and enhances customer retention through behavioral analysis [5].

In their study, N. Laila et al. systematized contemporary trends in digital marketing development among small and medium-sized enterprises. The authors emphasized the increasing importance of digital transformation, e-commerce, and marketing analytics in strengthening business competitiveness [6]. The importance of data analytics and machine learning for the personalization of marketing communications was also substantiated by Z. Zare et al. The researchers concluded that the application of predictive models and customer segmentation improves consumer interactions and strengthens long-term customer relationships [7].

H. Kennedy et al. confirmed the feasibility of applying predictive analytics to evaluate user engagement on social media platforms. Their findings demonstrated that machine learning models can provide higher forecasting accuracy than traditional regression methods [8]. M. Al Khaldy et al. found that combining artificial intelligence and predictive analytics in digital marketing contributes to higher audience engagement, increased conversion rates, and improved return on marketing investments [9].

R. Basu et al. summarized the current directions of applying artificial intelligence, machine learning, and data analytics in digital marketing. Among the principal areas of digital transformation in marketing activities, the authors identified AI-driven personalization, branding automation, e-commerce optimization, and enhanced marketing interactions through social media [10].

O. Leha and A. Makarchuk substantiated the effectiveness of ensemble machine learning models in improving the accuracy of analytical evaluation of digital systems. Their findings confirm the appropriateness of applying intelligent algorithms in forecasting processes and maintaining the performance of digital platforms [11]. Yu. Bezruchenkov and H. Shchuka established that the use of digital tools, analytical platforms, and artificial intelligence algorithms contributes to improving managerial processes, enhancing user interaction, and increasing the adaptability of digital systems to changes in the external environment [12].

Therefore, the analysis of previous studies indicates the active implementation of predictive analytics, machine learning, and artificial intelligence technologies in digital marketing. Their application enhances the accuracy of marketing performance evaluation, enables the personalization of consumer communications, and optimizes managerial decision-making in the digital environment.

Despite the considerable number of studies conducted in this field, most focus on individual digital marketing tools or specific machine learning applications. At the same time, the development of an integrated system to evaluate the effectiveness of digital marketing processes remains underexplored. Further research is required to combine behavioral, conversion, financial, and predictive indicators within a unified analytical framework.

A separate scientific challenge concerns integrating predictive analytics and machine learning models into the system to evaluate the effectiveness of marketing

campaigns. Most existing methodological approaches are primarily oriented toward the retrospective analysis of actual digital marketing outcomes and pay insufficient attention to forecasting future user behavior and the expected results of marketing activities.

The scientific novelty of this study lies in the development of an integrated approach to the analytical evaluation of digital marketing that combines behavioral, conversion, financial, and predictive indicators within a unified framework. The proposed approach leverages predictive analytics and machine learning models, enabling more accurate evaluation of the effectiveness of digital marketing campaigns and expanding the use of comprehensive analytical tools in marketing decision-making.

The effectiveness of digital marketing requires a systematic evaluation approach because each marketing instrument performs a distinct function within the process of communicating with potential customers [13, p. 231]. Some tools contribute to raising awareness of products or services; others facilitate users' transition to interacting with the enterprise; while still others influence customer retention and repeat purchases [14, p. 67]. Therefore, a comprehensive assessment of digital marketing effectiveness should rely not on a single aggregated indicator but on a system of complementary indicators that evaluate both the behavioral and financial outcomes of marketing activities (Table 1).

The proposed system of indicators demonstrates the comprehensive nature of evaluating digital marketing effectiveness, since the performance of marketing instruments is determined not only by the scale of audience reach but also by user engagement, conversion activity, economic efficiency, and the enterprise's ability to retain customers over the long term. At the same time, different groups of indicators perform distinct analytical functions. Web analytics and behavioral indicators characterize audience activity and conversion, advertising indicators assess the effectiveness of marketing campaigns, and financial and retention indicators evaluate the economic efficiency of digital marketing and the stability of the customer base.

Table 1

System of Indicators for Evaluating the Effectiveness of Digital Marketing Tools

Indicator Group	Indicators	Description
Web Analytics Indicators	Total users, active users, new users, returning users, average session duration	Characterize audience size, user activity, and the intensity of interaction with the website.
Engagement Indicators	Engagement rate, bounce rate, engagement duration	Reflect the level of user interaction with content and the effectiveness of maintaining user attention.
Search Analytics Indicators	Organic traffic, keyword rankings, backlinks, domain authority	Determine a website's visibility in search engines and its overall authority.
Conversion Indicators	Conversion rate, click-through rate (CTR), primary conversions	Characterize the effectiveness of converting visitors into desired actions.

Indicator Group	Indicators	Description
Advertising Indicators	Cost per click (CPC), cost per action (CPA), cost per lead (CPL), customer acquisition cost (CAC)	Measure the costs associated with attracting users, leads, and customers.
Financial Indicators	Return on investment (ROI), return on advertising spend (ROAS), marginal return on advertising spend (mROAS), average revenue per user (ARPU), monthly recurring revenue (MRR)	Reflect on the profitability of digital marketing activities.
Retention Indicators	Customer retention rate, customer churn rate, customer lifetime value (CLV)	Characterize customer loyalty and the long-term value of the customer base.
Social Media Indicators	Likes, shares, comments, engagement metrics	Reflect audience activity on social media platforms.

Source: Developed by the author based on [15–18].

Importance should be attached to combining quantitative indicators with analytical approaches to their interpretation, because individual indicators alone cannot provide a comprehensive understanding of digital marketing effectiveness. Consequently, there is a need to employ various methodological approaches to evaluate the performance of digital marketing tools, enabling a comprehensive analysis of an enterprise's marketing activities (Table 2).

The methodological approaches presented above demonstrate the gradual evolution of digital marketing evaluation from the simple recording of statistical indicators toward comprehensive analytical modeling of user behavior and marketing communication effectiveness. Whereas traditional web analytics primarily focuses on assessing website traffic and audience activity, predictive analytics and machine learning techniques enable forecasting future user behavior, estimating conversion probabilities, and predicting the effectiveness of marketing campaigns.

At the same time, attribution analysis, behavioral modeling, and marketing funnel analysis provide opportunities to identify the most effective communication channels, detect problematic stages in the customer interaction process, and determine the factors influencing customers' purchasing decisions.

Table 2

Methodological Approaches to Evaluating the Effectiveness of Digital Marketing Tools

Evaluation Method	Essence of the Method	Analytical Tools	Practical Significance
Web Analytics	Analysis of user behavior on a website	Google Analytics 4, BigQuery, Google Tag Manager	Evaluation of website traffic, user interactions, and behavioral characteristics
Behavioral Analytics	Analysis of user behavioral patterns	Heatmaps, interaction analysis, session tracking	Identification of engagement drivers and reasons for user abandonment
Conversion	Analysis of the	Conversion tracking,	Assessment of marketing

Evaluation Method	Essence of the Method	Analytical Tools	Practical Significance
Analytics	effectiveness of target actions	attribution models	funnel performance
Predictive Analytics	Forecasting future user behavior	Artificial intelligence algorithms, predictive models	Prediction of conversion rates and user behavior
Machine Learning Analytics	Automated modeling of marketing processes	Machine learning algorithms, clustering techniques, and behavioral modeling	Optimization of marketing strategies and advertising campaigns
Attribution Analysis	Allocation of conversion value across marketing channels	Data-driven attribution, multi-channel analytics	Determination of the contribution of individual channels to conversion outcomes
Marketing Funnel Analysis	Evaluation of the effectiveness of different funnel stages	Upper-, middle-, and lower-funnel performance metrics	Identification of problematic stages in customer interaction
Financial Marketing Analysis	Assessment of the economic effectiveness of digital marketing	ROI analysis and advertising expenditure analysis	Evaluation of the profitability of marketing investments

Source: Developed by the author based on [15–18].

The integration of analytical, behavioral, and financial approaches forms the foundation for a comprehensive evaluation of digital marketing effectiveness and enhances the validity of managerial decision-making in digital communications.

For the practical application of these methodological approaches, a well-designed system of marketing indicators is critical, as it provides the analytical basis for evaluating digital marketing performance by enabling quantitative assessment of advertising campaign effectiveness, user engagement, and the economic efficiency of marketing expenditures (Table 3).

Some indicators assess audience behavioral activity, particularly user engagement and interaction with content, whereas others characterize the effectiveness of users' transitions to target actions and the return on marketing investments.

Indicators such as return on advertising spend, customer acquisition cost, and customer lifetime value are of particular importance within the system of digital marketing analytics, as they enable assessment not only of the short-term effectiveness of marketing campaigns but also of their impact on the enterprise's long-term profitability.

Some indicators assess audience behavioral activity, particularly user engagement and interaction with content, whereas others characterize the effectiveness of users' transitions to target actions and the return on marketing investments.

Table 3

Key Digital Marketing Indicators and Their Economic and Analytical Interpretation

Indicator	Calculation Formula	Economic Meaning	Managerial Significance
Click-through rate	Number of clicks / Number of impressions × 100%	Level of advertisement clickability	Assessment of the attractiveness of advertising content
Conversion rate	Number of conversions / Number of visitors × 100%	Share of users who completed a target action	Analysis of the effectiveness of marketing campaigns
Cost per click	Advertising expenditure / Number of clicks	Cost of one click	Control of digital advertising expenditure
Cost per action	Advertising expenditure / Number of target actions	Cost of achieving a target action	Assessment of advertising campaign effectiveness
Customer acquisition cost	Marketing expenditure / Number of new customers	Cost of acquiring a new customer	Analysis of customer acquisition efficiency
Return on advertising spend	Revenue generated from advertising / Advertising expenditure	Return on advertising expenditure	Assessment of the effectiveness of advertising investments
Incremental return on advertising spend	Incremental revenue / Advertising expenditure	Incremental revenue generated through advertising	Analysis of improvements in the effectiveness of marketing campaigns
Customer lifetime value	Average order value × Purchase frequency × Duration of interaction	Long-term customer value	Assessment of the profitability of the customer base
Engagement rate	Number of engaged sessions / Total number of sessions × 100%	Level of user engagement	Analysis of audience engagement
Bounce rate	Number of sessions without engagement / Total number of sessions × 100%	Share of sessions without engagement	Identification of content and navigation problems

Source: Developed by the author based on [17].

Indicators such as return on advertising spend, customer acquisition cost, and customer lifetime value are of particular importance within the system of digital marketing analytics, as they enable assessment not only of the short-term effectiveness of marketing campaigns but also of their impact on the enterprise's long-term profitability.

At the same time, the analysis of click-through, conversion, and engagement indicators creates opportunities to promptly adjust advertising messages, content structure, and digital communication channels.

The further development of digital marketing analytics is associated with the use of predictive models, artificial intelligence algorithms, and machine learning tools, which enable not only the assessment of the actual results of marketing activities but

also the forecasting of future user behavior, conversion probabilities, and the risk of customer loss.

Under such conditions, digital marketing is gradually shifting from descriptive analysis to prediction-oriented management of marketing processes. The use of predictive analytics in digital marketing relies on processing large volumes of behavioral data, automating pattern identification, and developing consumer behavior forecasting models.

Artificial intelligence algorithms enable the analysis of users' interaction paths across digital platforms, the assessment of purchase probability, the forecasting of conversion rates, and the determination of customer churn risk.

Audience segmentation based on behavioral characteristics is becoming increasingly important, as it enables the personalization of marketing communications and improves the effectiveness of advertising campaigns.

One area of predictive analytics application is the automated optimization of advertising campaigns, in which machine learning algorithms adjust advertising parameters based on audience responses and predicted outcomes.

Such approaches are used in digital analytical systems, including Google Analytics 4, where predictive analytics enables the forecasting of users' future actions, purchase probability, and expected customer value.

The principal areas of applying predictive analytics and machine learning within the digital marketing evaluation system are summarized in Table 4.

Table 4

Application of Predictive Analytics and Machine Learning in the Digital Marketing Evaluation System

Application Area	Technologies and Methods	Analytical Outcome	Practical Application
Conversion Forecasting	Predictive analytics, regression models	Estimation of the probability of completing a target action	Identification of users with a high likelihood of making a purchase
Behavioral Modeling	Machine learning models	Analysis of user behavioral patterns	Development of personalized marketing communications
Audience Segmentation	Clustering algorithms	Formation of customer segments	Grouping users according to behavioral and consumption characteristics
Customer Churn Prediction	Churn prediction models	Identification of customer attrition risk	Detection of customers with a high probability of terminating their relationship with the company
Attribution Analysis	Data-driven attribution	Evaluation of the contribution of marketing channels	Identification of the most effective digital marketing channels
Recommendation Systems	Artificial intelligence-based recommendation systems	Generation of personalized recommendations	Automated selection of products and content according to user preferences
Audience	Engagement forecasting	Prediction of user activity	Identification of content

Engagement Analysis	models		generating the highest level of engagement
Automated Optimization	Automated advertising optimization systems	Automated management of advertising campaigns	Automatic adjustment of advertising parameters according to audience behavior

Source: Developed by the author based on [11; 13; 19; 20].

As demonstrated in Table 4, contemporary digital technologies enable forecasting of user behavior, estimation of conversion probabilities, and timely identification of customer churn risks [21, p. 26]. The application of machine learning models to behavioral modeling and audience segmentation is particularly important, as it enables the development of personalized marketing communications and enhances the relevance of advertising content.

At the same time, automated advertising optimization systems and data-driven attribution analysis contribute to more efficient allocation of advertising budgets and improved return on marketing investments. The integration of behavioral, conversion, financial, and predictive analytics establishes the foundation for a comprehensive evaluation of digital marketing effectiveness. Consequently, it is appropriate to develop an integrated evaluation system that combines actual marketing performance with predictive assessments generated by analytical methods and machine learning.

The proposed predictive and analytical framework for evaluating digital marketing effectiveness integrates several interrelated evaluation components. Its principal concept is to assess digital marketing comprehensively, considering not only the current outcomes of advertising campaigns but also audience behavioral characteristics, financial performance, and the projected future results of customer interactions.

The principal components of the proposed predictive and analytical digital marketing evaluation system are presented in Table 5.

Table 5

Indicators of the Predictive and Analytical System for Evaluating Digital Marketing Effectiveness

Evaluation Block	Indicator	Formula / Evaluation Method	Analytical Significance
Behavioral Effectiveness	Engagement rate	Engaged sessions / Total sessions × 100%	Measures the level of audience engagement
Behavioral Effectiveness	Bounce rate	Non-engaged sessions / Total sessions × 100%	Indicates the proportion of low-quality or irrelevant traffic
Conversion Effectiveness	Conversion rate	Number of conversions / Number of visitors × 100%	Measures the effectiveness of converting users into target actions
Conversion Effectiveness	Click-through rate	Number of clicks / Number of impressions × 100%	Reflects the attractiveness of advertising messages
Financial Effectiveness	Return on advertising spend (ROAS)	Advertising revenue / Advertising expenditure	Measures the profitability of advertising campaigns

Financial Effectiveness	Customer acquisition cost (CAC)	Marketing expenditure / Number of new customers	Measures the cost of acquiring one new customer
Predictive Effectiveness	Predicted conversion rate	Machine learning model prediction	Expected proportion of future conversions
Predictive Effectiveness	Customer churn probability	Predictive estimate of customer attrition risk	Measures the risk of losing customers
Predictive Effectiveness	Predicted customer lifetime value	Forecast of future customer revenue	Measures potential long-term customer value

Source: Developed by the author.

The proposed system of indicators enables a comprehensive evaluation of digital marketing effectiveness across several interrelated dimensions. Behavioral indicators characterize the level of audience engagement and the quality of user interaction with digital content. Conversion indicators measure the effectiveness of users' transition toward target actions. Financial indicators evaluate the economic efficiency of marketing expenditures, whereas predictive indicators assess the expected future outcomes of marketing activities.

The integration of these evaluation blocks enables assessment of digital marketing not only from the perspective of current performance but also from the perspective of the prospective effectiveness of marketing communications.

The proposed system of indicators enables a comprehensive evaluation of digital marketing effectiveness across several interrelated dimensions. Behavioral indicators characterize the level of audience engagement and the quality of users' interaction with digital content; conversion indicators measure the effectiveness of users' transition to target actions; financial indicators assess the economic efficiency of marketing expenditures, whereas predictive indicators reflect the expected future outcomes of marketing activities. The integration of these components enables the assessment of digital marketing not only from the perspective of current performance but also from the perspective of the prospective effectiveness of marketing communications.

To ensure a comprehensive evaluation of digital marketing performance, it is advisable to employ an integrated effectiveness indicator that combines behavioral, conversion, financial, and predictive components within a single analytical framework.

The weighting coefficients of the integrated indicator were determined by considering the analytical significance of each evaluation block within the digital marketing system. Behavioral effectiveness and conversion effectiveness were assigned equal weights of 0.25 each, as they characterize the level of audience engagement and the effectiveness of users' transition to target actions. These components form the foundation for evaluating the effectiveness of digital marketing communications and reflect the quality of user interactions with digital platforms.

The highest weight (0.30) was assigned to financial effectiveness because of the decisive role of economic performance in the digital marketing evaluation system. Financial indicators enable assessment of the return on advertising expenditures, the profitability of marketing investments, and the overall economic impact of digital marketing tools.

Predictive effectiveness was assigned a weight of 0.20 because predictive analytics and machine learning techniques primarily perform analytical and forecasting functions to assess future trends in user behavior, conversion probabilities, and customer churn risk. Nevertheless, incorporating the predictive component into the integrated indicator enhances the evaluation system's adaptability and promotes a forward-looking orientation in digital marketing management.

Accordingly, the proposed weighting structure provides a balanced integration of behavioral, conversion, financial, and predictive dimensions within the integrated evaluation framework for digital marketing effectiveness:

$$[IDME = 0.25 \times BE + 0.25 \times CE + 0.30 \times FE + 0.20 \times PE]$$

where:

IDME – Integrated Digital Marketing Effectiveness indicator;

BE – Behavioral Effectiveness;

CE – Conversion Effectiveness;

FE – Financial Effectiveness;

PE – Predictive Effectiveness.

For the practical application of the integrated effectiveness indicator, it is advisable to employ an interpretation scale that enables the assessment of digital marketing performance and supports the identification of priorities for further optimization of marketing activities.

An IDME value ranging from 0.00 to 0.25 indicates low digital marketing effectiveness, reflecting poor marketing performance, insufficient user engagement, and inefficient use of the marketing budget.

A value between 0.26 and 0.50 indicates a moderate level of effectiveness, with certain positive marketing outcomes observed; however, advertising campaigns, content strategy, and communication channels still require further optimization.

Values within the range of 0.51 to 0.75 indicate a satisfactory level of effectiveness, demonstrating efficient marketing performance, stable conversion rates, and positive returns on marketing investments.

Finally, values between 0.76 and 1.00 represent a high level of digital marketing effectiveness, characterized by substantial returns on marketing investments, highly effective digital communications, and favorable forecasts regarding the future development of marketing campaigns.

Conclusions

The application of the proposed integrated framework for evaluating digital marketing effectiveness combines actual marketing performance indicators with predictive assessments generated through predictive analytics and machine learning techniques. The practical value of this approach lies not only in determining the current effectiveness of an enterprise's marketing activities but also in forecasting user behavior, conversion probabilities, customer churn risks, and the expected customer lifetime value.

The findings of this study demonstrate that digital marketing performance is inherently multidimensional. Consequently, its objective evaluation cannot be achieved

using isolated or unrelated indicators. Developing a comprehensive understanding of marketing effectiveness requires the systematic integration of relevant indicators within a unified analytical framework.

Traditional web analytics and conversion analysis methods primarily provide descriptive and retrospective assessments of marketing performance. In contrast, predictive analytics and machine learning substantially expand analytical capabilities by incorporating forecasts of future user behavior, conversion probabilities, and customer churn risks. This creates the foundation for a transition from the analysis of historical performance toward prediction-oriented management of digital marketing processes.

The proposed integrated effectiveness indicator ensures a balanced consideration of different indicator groups and enhances the objectivity of digital marketing performance evaluation. The developed weighting structure reflects the priority of financial outcomes while simultaneously incorporating behavioral, conversion, and predictive characteristics of marketing activities.

Future research should focus on improving machine learning models to increase forecasting accuracy and on integrating artificial intelligence technologies into automated digital marketing campaign management systems.

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1.12. Innovative Approaches to Risk Management in International Industrial Logistics Under Uncertainty

ІННОВАЦІЙНІ ПІДХОДИ ДО РИЗИК-МЕНЕДЖМЕНТУ В МІЖНАРОДНІЙ ПРОМИСЛОВІЙ ЛОГІСТИЦІ В УМОВАХ НЕВИЗНАЧЕНОСТІ

ВСТУП ТА ПОСТАНОВКА ПРОБЛЕМИ В ЗАГАЛЬНОМУ ВИГЛЯДІ

У сучасних умовах функціонування глобальних та національних ринків категорія «ризик» набуває статусу фундаментального чинника, що визначає стратегію розвитку будь-якої логістичної системи [6]. Соціально-економічний зміст ризику в логістиці полягає у виникненні ситуації невизначеності, за якої існує ймовірність настання подій, що призводять до відхилення від запланованих показників ефективності ланцюга постачання [2]. Актуальність теми зумовлена докорінною трансформацією глобальних логістичних систем під впливом геополітичної нестабільності, постпандемічних викликів та стрімкого розвитку цифрових технологій [2].

У сегменті міжнародних перевезень промислового обладнання та технічних засобів рівень невизначеності є критично високим, оскільки будь-яка затримка або пошкодження вантажу призводить до зупинки виробничих циклів і значних фінансових втрат [2]. Традиційні підходи до управління ризиками, що базуються на реактивній моделі — тобто реагуванні на інциденти після їх настання через механізми страхування або претензійної роботи — вже не забезпечують

конкурентоспроможності [2]. Сучасний ринок вимагає від логістичних операторів переходу до предиктивного управління, яке дозволяє ідентифікувати загрози ще до їхнього фізичного прояву [2]. Попри те, що провідні компанії активно впроваджують елементи концепції 4PL та використовують окремі інструменти моніторингу, у галузі спостерігається суттєвий методичний розрив [2]. Проблема полягає в тому, що накопичені масиви даних часто залишаються «сирими» і не інтегруються в єдину аналітичну систему, яка могла б видавати готові сценарії рішень [2]. Це створює ситуацію, за якої компанія володіє інформацією про проблему в реальному часі, але не має алгоритмів для її завчасного прогнозування [2]. Отже, розробка інтелектуальних моделей, що поєднують технічний моніторинг із прогнозуючою аналітикою, є критично необхідною для логістичної галузі України [2].

Динаміка розвитку міжнародної торгівлі та промислової кооперації вимагає переосмислення класичних канонів надійності ланцюгів постачання. Промислове обладнання, що є об'єктом інвестування та основою капітальних активів підприємств, характеризується високим ступенем унікальності та практичною неможливістю швидкої заміни на ринку в разі настання форс-мажорних обставин [2]. Якщо в логістиці споживчих товарів (FMCG) збій у постачанні окремої партії компенсується за рахунок страхових запасів на розподільчих центрах, то в індустріальному секторі затримка унікального гідравлічного преса або турбогенератора автоматично консервує будівництво чи модернізацію заводу на невизначений термін. Така специфіка переносить акцент з простого розрахунку ймовірностей втрат на побудову стійких та гнучких екосистем, здатних адаптуватися до турбулентного зовнішнього середовища.

ТЕОРЕТИКО-МЕТОДОЛОГІЧНІ ОСНОВІ ДОСЛІДЖЕННЯ ЕКОНОМІЧНОЇ СУТНОСТІ ЛОГІСТИЧНОГО РИЗИКУ

Логістичний ризик не слід розглядати лише як імовірність збитку; це складна багаторівнева категорія, яка відображає готовність суб’єкта господарювання до прийняття рішень в умовах альтернативності та дефіциту інформації [2]. Як зазначається у науковій праці Р. О. Побережного, економічна природа ризику проявляється у загрозі зниження капіталізації підприємства, зростанні операційних витрат та неефективному використанні ресурсів через непередбачувані коливання ринкової кон’юнктури [10]. Важливо розуміти, що ризик у логістиці виконує низку специфічних функцій [2]. Зокрема, інноваційна функція стимулює менеджмент до пошуку нетрадиційних шляхів вирішення проблем та впровадження предиктивних технологій [2]. Регулятивна функція проявляється у створені резервних фондів та розробці планів ліквідації наслідків негативних подій [2]. Соціальний аспект ризику має не менше значення, оскільки він безпосередньо стосується стабільності забезпечення населення товарами, безпеки праці персоналу на складах та під час транспортування [2]. У аналітичних матеріалах рекрутингових порталів підкреслюється, що сучасні виклики, зокрема воєнні дії та міграційні процеси, створюють нові соціальні ризики, пов’язані з дефіцитом кваліфікованих кадрів та необхідністю адаптації корпоративної культури до кризових умов [1].

З погляду системного підходу, логістичний ризик є деструктивною властивістю логістичної системи, що виникає внаслідок взаємодії системи з її зовнішнім середовищем та через недосконаліть внутрішніх зв’язків між елементами. Економічна сутність цієї категорії також тісно пов'язана із трансакційними витратами. Невизначеність поведінки контрагентів, загроза опортуністичного виконання зобов'язань перевізниками, асиметрія інформації на ринку фрахту — все це підвищує приховані витрати підприємства. Відтак, ризик-менеджмент у промисловій логістиці виступає не як ізольована функція технічного контролю, а як стратегічний інструмент оптимізації загальних логістичних витрат (Total Logistics Costs) та захисту інвестиційного капіталу суб’єктів ЗЕД.

Розглядаючи методологічні засади оцінки ризиків, необхідно звернутися до концепції прийнятного ризику (tolerable risk). В умовах глобальної макроекономічної нестабільності досягнення нульового рівня ризику є економічно недоцільним і технічно неможливим, оскільки витрати на створення абсолютної системи захисту перевищать потенційні збитки від інцидентів. Отже, завданням менеджменту є визначення оптимального балансу між витратами на превентивні заходи та рівнем залишкові ризику, який компанія здатна самостійно абсорбувати без загрози для своєї фінансової стабільності [2].

КОМПЛЕКСНА КЛАСИФІКАЦІЯ ЕКЗОГЕННИХ ТА ЕНДОГЕННИХ ЛОГІСТИЧНИХ ЗАГРОЗ В СУЧАСНИХ УМОВАХ

Для розробки ефективного механізму управління необхідно застосовувати науково обґрунтовану класифікацію ризиків, яка дозволяє ідентифікувати джерела небезпеки [6]. Традиційно ризики поділяють на зовнішні (екзогенні) та внутрішні (ендогенні) [6]. Зовнішні ризики формуються під впливом факторів макросередовища, на які логістична система практично не може впливати, але зобов’язана враховувати при плануванні [6]. До цієї групи належать політичні та воєнні загрози, які в контексті України стали визначальними [2]. Бойові дії спричиняють руйнування інфраструктури, блокування морських портів та зміну звичних наземних маршрутів [2]. Крім того, критичними є нормативно-правові ризики, що включають зміни у митному законодавстві, податковому регулюванні та правилах перетину кордону суміжними державами [2]. Як стверджується у навчальних посібниках з логістики, зовнішні ризики часто мають кумулятивний характер, де одна подія тягне за собою ланцюгову реакцію подорожчання палива, запчастин та послуг субпідрядників [5].

Деталізуємо структуру екзогенних ризиків у сучасній практиці:

- Геополітичні та мілітарні загрози: пряме пошкодження активів внаслідок бойових дій, закриття повітряного простору, мінування морських шляхів, конфіскація або експропріація майна [2].

- Макроекономічні ризики: різкі коливання валютних курсів, що впливають на розрахунки з іноземними контрагентами, інфляційне зростання вартості енергоносіїв, зміна відсоткових ставок за кредитами для фінансування оборотних коштів [10].

- Форс-мажорні природно-кліматичні чинники: аномальні погодні умови, що блокують ключові транспортні артерії (наприклад, обміління судноплавних каналів чи критичні паводки) [2].

Внутрішні ризики безпосередньо пов'язані з внутрішньою структурою логістичного ланцюга та якістю операційного менеджменту [6]. Вони включають техніко-технологічні аспекти, організаційні прорахунки та кадрові ризики [6]. Відповідно до профільних методичних джерел, внутрішні ризики є більш контрольованими, оскільки їхня мінімізація залежить від впровадження систем моніторингу, регулярного технічного обслуговування обладнання та підвищення кваліфікації персоналу [5]. У ланцюгах постачання промислового обладнання внутрішні ризики часто пов'язані з порушенням технологічних умов транспортування надважких або великогабаритних вантажів, що вимагає специфічного інженерного супроводу [2].

Особливу увагу слід приділяти інформаційним ризикам, адже в умовах цифровізації втрата доступу до даних про вантаж може паралізувати роботу всієї компанії [2]. Також вагоме місце посідають комерційні ризики, що виникають у процесі взаємодії з контрагентами [2]. Це можуть бути ризики невиконання зобов'язань постачальниками, зриви термінів відвантаження або невідповідність якості обладнання заявленим характеристикам [2].

Додатково в межах ендогенних загроз виділяють:

- Управлінські прорахунки: помилки при виборі субпідрядників (перевізників, експедиторів), некоректне планування графіків доставки без урахування технологічних вікон, відсутність дублюючих каналів зв'язку та альтернативних маршрутів [2].

- Технологічні ризики: відмова вантажопідйомної техніки під час перевалки на мультимодальних терміналах, збої в роботі корпоративних ERP та TMS систем, фізичне старіння парку спеціалізованих транспортних засобів [2].

СПЕЦИФІКА ФОРМУВАННЯ ЛАНЦЮГІВ ПОСТАЧАННЯ ТА ПРОЄКТНОЇ ЛОГІСТИКИ У СЕГМЕНТІ ПРОМИСЛОВОГО ОБЛАДНАННЯ

Формування ланцюгів постачання у сегменті промислового обладнання та складних технічних засобів суттєво відрізняється від логістики товарів масового споживання (FMCG) через унікальні фізико-хімічні характеристики вантажів, надвисоку капіталомісткість та технологічну складність процесів перевалки [2]. Якщо логістика товарів широкого вжитку орієнтована на швидкість оборотності запасів та максимальну стандартизацію операцій, то постачання верстатів, автоматизованих ліній, енергетичних агрегатів та важкої спецтехніки потребує індивідуального проєктного підходу, відомого у міжнародній практиці як «Project Cargo Management» [2]. Специфіка промислової логістики зумовлена насамперед одиничним або дрібносерійним характером виробництва, що виключає можливість використання шаблонних логістичних схем і вимагає розробки унікального плану транспортування для кожної одиниці товару [5].

Першочерговим фактором складності є екстремальні вагогабаритні параметри промислових об'єктів [2]. Більшість агрегатів належать до категорії негабаритних або великовагових вантажів (Out of Gauge), що вимагає залучення

спеціалізованого рухомого складу: низькорамних тралів з гідравлічною підвіскою, посилених залізничних платформ-транспортерів або суден типу «Ro-Ro» та «Heavy Lift» [2]. Процес транспортування такого обладнання потребує проведення попереднього інженерного обстеження всього маршруту для оцінки несучої здатності мостів, радіусів повороту доріг та висоти ліній електропередач [2]. Висока вартість одиниці обладнання, яка часто становить основу активів підприємства, зумовлює критичну потребу у комплексному страхуванні за принципом «All Risks» [10]. Будь-яке мікропошкодження прецизійних вузлів або електронних плат управління під час вібрацій чи навантаження може призвести до повної втрати функціональності верстата, що означатиме для замовника не лише фінансові збитки, а й зрив термінів запуску всього інвестиційного проєкту [2].

Окрему увагу в контексті формування ланцюгів постачання промислової техніки слід приділити складним процедурам митного регулювання та документального супроводу [2]. На відміну від споживчих товарів, промислові верстати та лінії часто мають складні коди згідно з Українською класифікацією товарів зовнішньоекономічної діяльності (УКТ ЗЕД), що регулярно призводить до класифікаційних суперечок із митними органами [2]. Специфічною проблемою є постачання обладнання у розібраному стані декількома транспортними засобами протягом певного часу, що вимагає оформлення так званих «комплектних об'єктів» [2]. Як підкреслюється в дослідженнях О. Г. Костюка, найменша помилка у технічному описі специфікації або некоректне трактування термінів Інкотермс тягне за собою тривалі простої на кордоні, нарахування штрафних санкцій та значне подорожчання логістичної складової [9].

Економічна специфіка також проявляється у надзвичайно тривалому логістичному циклі [2]. Від моменту підписання контракту на виготовлення верстата до його фінальної інсталяції на фундамент замовника можуть пройти місяці або навіть роки [2]. Це створює високу вразливість ланцюга постачання до макроекономічних ризиків: коливань валютних курсів, зміни вартості енергоносіїв та фрахтових ставок [10]. Предикативний аналіз у таких умовах має охоплювати не лише безпосередній транспорт, а й моніторинг стадій виробництва на самому заводі-виготовлювачі [2]. Дефіцит одного критичного компонента або затримка у відвантаженні окремого вузла може зупинити монтаж всієї технологічної лінії, генеруючи колосальні непрямі збитки через простої персоналу та неможливість виконання виробничих планів [2].

Проєктна логістика у цьому контексті вимагає синхронізації дій багатьох учасників: виробника, кількох перевізників різних видів транспорту, митних брокерів, страхових компаній, державних органів, що видають дозволи на перевезення негабариту, та монтажних бригад на майданчику замовника. Кожна ланка цього ланцюга є потенційним джерелом ризику. Тому управління такими проєктами базується на створенні детальної дорожньої карти — критичного шляху проєкту (Critical Path Method), де будь-яке відхилення від графіка на початкових етапах має кумулятивний ефект затримок на фініші.

КРИТИЧНИЙ АНАЛІЗ НАУКОВИХ ПОГЛЯДІВ НА ПРОБЛЕМУ УПРАВЛІННЯ ЛОГІСТИЧНИМИ РИЗИКАМИ

Системний аналіз сучасного наукового дискурсу та практичного досвіду логістичного менеджменту свідчить про те, що теоретична база управління ризиками пройшла складну еволюцію — від стихійного реагування на збитки до формування комплексних стратегій ризик-менеджменту [2]. Проте ретельний огляд праць вітчизняних та зарубіжних вчених дозволяє виявити низку фундаментальних розбіжностей між теоретичними моделями та вимогами реального бізнес-середовища [2]. Перш за все, критичного переосмислення потребує домінуючий у науковій літературі підхід до класифікації та нейтралізації ризиків [2]. У фундаментальних роботах, зокрема у посібнику О. М. Гіржевої, приділяється значна увага оптимізації витрат та ефективності логістичних каналів, проте механізми адаптації цих каналів до раптових деструктивних впливів часто розглядаються через призму статичних моделей, які не враховують миттєву зміну зовнішніх чинників [5].

Основна проблема більшості вітчизняних джерел полягає у їхньому вираженому реактивному характері, де ризик-менеджмент сприймається переважно як набір інструментів для ліквідації наслідків подій, що вже сталися, як-от страхування вантажів, формування фінансових резервів на покриття збитків або складне юридичне опрацювання претензій після факту псування майна [6]. Хоча ці заходи є методично обґрунтованими та необхідними для фінансової стійкості, вони фактично не вирішують головного завдання сучасного логістичного оператора, що прагне до моделі 4PL — а саме запобігання збоям ще до їх фізичного прояву в ланцюгу постачання [2]. Зарубіжний досвід та актуальні тенденції розвитку технологічних стартапів акцентують увагу на глобальній цифровізації як ключовому факторі стійкості бізнесу [4]. Впровадження концепцій IoT, Big Data та блокчейн-технологій дозволило значно підвищити прозорість операцій, проте аналіз діяльності багатьох операторів показує наявність «інформаційного парадоксу», коли компанії накопичують величезні масиви даних про рух вантажів, стан обладнання та зовнішні умови, але при цьому не мають адекватних алгоритмів для їхньої інтелектуальної інтерпретації в режимі реального часу [2].

Наявність сучасних датчиків вібрації, нахилу чи температури часто залишається лише інструментом пасивного моніторингу, через що інформація про критичне пошкодження дороговартісного промислового обладнання надходить оператору лише в момент інциденту або вже після прибуття вантажу до отримувача, що робить оперативне втручання та зміну маршруту фактично неможливими [2]. Особливого значення критичний аналіз наукових поглядів набуває у контексті управління ризиками при транспортуванні технічно складних засобів, оскільки специфіка таких об’єктів вимагає не просто відстеження географічних координат, а й глибокого розуміння фізико-технічних параметрів збереженості [2]. Вони часто ігноруються в економічно орієнтованих джерелах, де ризик розглядається як суто фінансова категорія збитків [10], тоді як для промислового сектору ризик — це насамперед загроза порушення цілісності

інженерної системи, де економічні втрати є лише вторинним наслідком технічного збою [2].

Вітчизняна наукова думка останніми роками почала активно досліджувати вплив інноваційних бізнес-моделей та стартап-екосистем на трансформацію логістики, що дозволяє вносити в галузь методи гнучкого управління та валідації гіпотез [11]. Проте критичний погляд на ці джерела виявляє, що вони переважно зосереджені на комерційній стороні запуску нових сервісів, залишаючи поза увагою питання надійності та математичної точності алгоритмів, що лежать в основі предиктивної аналітики [4]. Через це виникає суттєва методична прогалина між візуально привабливою бізнес-моделлю та реальною математичною моделлю прогнозування ризику в умовах високої невизначеності [7]. Переважна більшість існуючих методик оцінки ризиків базуються на статистичному аналізі минулих періодів або на суб'єктивних експертних оцінках [6]. В умовах геополітичної нестабільності, в яких функціонує українська логістика, вони перестають бути надійними прогнозами майбутнього, що вимагає рішучої відмови від застарілих підходів на користь інтелектуальних самонавчальних систем [2].

КОНЦЕПЦІЯ СТРАТЕГІЇ «SAFE-SUPPLY» ЯК ІННОВАЦІЙНОЇ СТАРТАП-ІНІЦІАТИВИ В СЕГМЕНТІ RMaaS

Для розв'язання цієї проблеми пропонується впровадження інтелектуальної стратегії «Safe-Supply», яка базується на переході до моделі «управління ризиками як сервісу» (RMaaS) [2]. Концепція стартапу в межах стратегії «Safe-Supply» розглядається не просто як бізнес-ініціатива, а як тимчасова організація, що перебуває в активному пошуку повторюваної та прибуткової бізнес-моделі проєкту ланцюга постачання в умовах екстремальної невизначеності [8]. Головною ціннісною пропозицією стратегії є гарантування безпеки та фізичної цілісності промислових активів замовника через створення «інформаційного щита» за рахунок новітніх технологій [2].

Фундаментальним елементом стратегії «Safe-Supply» є використання інструментарію OSINT-розвідки (Open Source Intelligence) для формування предиктивної моделі поведінки в ланцюгах постачання [2]. На відміну від стандартних методів моніторингу, OSINT дозволяє агрегувати дані з тисяч відкритих джерел — від цифрових медіа транзитних країн до супутникових знімків черг на митних постах та аналізу соціальних мереж для виявлення потенційних страйків працівників транспортної інфраструктури [2]. Це дозволяє логістичному оператору виявляти «вузли вразливості» ще на етапі планування [2].

Стратегія передбачає, що надійність поставки більше не є випадковим фактором, а стає керованим результатом інтелектуального аналізу середовища [2]. Другий стратегічний вектор зосереджений на прогнозуючому нівелюванні затримок [2]. Використовуючи алгоритми штучного інтелекту, система дозволяє моделювати тисячі сценаріїв проходження маршруту, обираючи той, що має найменший коефіцієнт ризику при заданих параметрах швидкості [2]. Третім компонентом є технологічний контроль цілісності (IoT-Shield), де кожна одиниця дороговартісного промислового обладнання інтегрується в єдину цифрову

мережу за допомогою активних IoT-датчиків для моніторингу фізичного стану вантажу в реальному часі (удари, нахили, вологість) [2]. Клієнт отримує доступ до «цифрового двійника» поставки, що усуває інформаційну асиметрію [2].

АЛГОРИТМІЗАЦІЯ ПРЕДИКТИВНОГО УПРАВЛІННЯ ТА МАТЕМАТИЧНЕ МОДЕЛЮВАННЯ РИЗИКІВ

В основі аналітичного ядра стратегії «Safe-Supply» покладено математичний апарат розрахунку комплексного індексу логістичного ризику (*Rtotal*) в реальному часі. На відміну від статичних матриць «імовірність–наслідки», запропонована динамічна модель враховує часову залежність та взаємозв'язок між різними факторами загроз.

Загальний інтегральний показник ризику для конкретного маршруту та типу промислового обладнання визначається за формулою:

$$Rtotal\ (t)=i=1\sum nwi\cdot Pi(t)\cdot Ii,$$

де:

- wi — ваговий коефіцієнт i-го фактора ризику (визначається методом аналізу ієрархій на основі історичних даних Big Data), причому $\sum i=1nwi=1$;

- $Pi(t)$ — динамічна ймовірність настання інциденту i-го типу в момент часу t, яка безперервно коригується на основі поточного потоку даних OSINT та телеметрії IoT;

- Ii — показник впливу (тяжкості наслідків) інциденту на фінансовий та операційний стан ланцюга постачання (виражається у відносних одиницях від 0 до 1).

Динамічна ймовірність $Pi(t)$ для ризиків затримок на кордонах або транзитних вузлах розраховується за допомогою модифікованої моделі Марковських процесів:

$$dtdPi(t)=-\lambda i\cdot Pi(t)+\mu i\cdot(1-Pi(t)),$$

де λi — інтенсивність виникнення деструктивних факторів (наприклад, частота утворення заторів за даними супутникового моніторингу), а μi — інтенсивність відновлення нормального пропускного режиму транспортного вузла.

Для оцінки ризику фізичного пошкодження прецизійного обладнання внаслідок механічних коливань під час транспортування використовується функція надійності, що базується на розподілі Вейбулла:

$$Pdamage(G)=1-\exp(-(\eta G)\beta),$$

де:

- G — амплітуда вібраційного навантаження або удару (G-force), що фіксується IoT-датчиком;

- η — масштабний параметр, що відповідає гранично допустимому технічному навантаженню для даного класу обладнання згідно з паспортом заводу-виробника;

- β — параметр форми, що відображає накопичення мікропошкоджень (утому матеріалу конструкції верстата) протягом усього часу транспортування.

Застосування цих алгоритмів дозволяє системі автоматично генерувати попереджувальний сигнал (Alert) для 4PL-оператора, коли інтегральний показник

Rtotal(*t*) перевищує критичний поріг безпеки *Rcrit*=0,65, що є тригером для негайного запуску альтернативного сценарію доставки.

ОПЕРАЦІЙНИЙ ПЛАН ПРОЄКТУ ТА АРХІТЕКТУРА ІНТЕЛЕКТУАЛЬНОЇ СИСТЕМИ МОНІТОРИНГУ

Операційний план проєкту вибудовується як безперервний цикл, що бере свій початок із фази глибокого превентивного ризик-аудиту логістичної екосистеми клієнта [2]. Наступним етапом є фаза динамічного проєктування індивідуального безпечного логістичного коридору [2]. Далі слідує стадія технологічного налаштування (Setup), яка передбачає фізичну інсталяцію IoT-контролерів безпосередньо на корпус або всередину пакування промислового обладнання для вимірювання вібраційних навантажень (G-force), показників вологості та температури, з інтеграцією даних у хмарну платформу [2]. Основна фаза полягає у предиктивному моніторингу та активній диспетчеризації в режимі 24/7 [2]. Завершується операційний цикл стадією повного аналітичного комплаєнсу, коли замовник отримує «цифровий паспорт» поставки з повною історією телеметрії [2]. Така декомпозиція дозволяє ефективно перевіряти інноваційні гіпотези на кожному етапі життєвого циклу послуги [11].

Архітектурно інтелектуальна система «Safe-Supply» складається з трьох взаємопов'язаних рівнів (модулів):

Модуль збору даних (Data Acquisition Layer)

Включає апаратну частину (IoT-трекери з автономним живленням до 90 днів, оснащені акселерометрами, гіроскопами, датчиками розкриття та геопозиціонування за технологіями GPS/GLONASS/Galileo) та програмні парсери для OSINT (автоматичний збір новинних стрічок, повідомлень митниці, метеорологічних зведень) [2].

Модуль інтелектуальної обробки та аналізу (Data Processing & AI Layer)

Розміщений у хмарній інфраструктурі, де за допомогою нейромережевих моделей відбувається фільтрація шумів телеметрії, розпізнавання аномалій у поведінці транспортних засобів та розрахунок динамічних марковських моделей і вейбуллівських функцій пошкоджень.

Інтерфейсний модуль (User Experience Layer)

Представлений інтерактивною картою (Dashboard) для диспетчера 4PL-провайдера та мобільним додатком для замовника [2]. На карті відображається «цифровий двійник» вантажу, поточний вектор руху, а також колірна індикація рівня ризику кожної ділянки маршруту (зелений – безпечно, жовтий – підвищена увага, червоний – критична загроза).

ФІНАНСОВО-ЕКОНОМІЧНЕ ОБҐРУНТУВАННЯ ТА МОДЕЛЬ МОНЕТИЗАЦІЇ СИСТЕМИ ДЛЯ 4PL-ОПЕРАТОРІВ

Фінансова життєздатність проєкту забезпечується впровадженням унікальної гібридної трирівневої моделі монетизації, яка орієнтована на створення інтелектуальної цінності та поділ ризиків із клієнтом [7]. Перший рівень — Setup Fee — виступає як разовий платіж за підключення, що покриває витрати на проведення первинного аудиту, індивідуальну кастомізацію програмних шлюзів та підготовку IoT-обладнання [2]. Другий рівень — Success Fee (Комісія за успіх) —

розраховується як преміальна винагорода, яку клієнт сплачує лише за умови ідеального дотримання всіх цільових KPI безпеки (точний час прибуття ETA, відсутність механічних впливів) [2]. Третій рівень представлений моделлю SaaS-передплати, що відкриває замовнику щомісячний доступ до кабінету аналітики ризиків, де він може самостійно моделювати свої майбутні міжнародні контракти на основі Big Data [2]. Впровадження такої структури доходів є критичним фактором для формування сучасних адаптивних бізнес-моделей інноваційних підприємств, які здатні забезпечувати сталий розвиток через пропозицію високотехнологічних рішень замість стандартних посередницьких послуг [9].

Економічне обґрунтування впровадження системи базується на використанні моделі «asset-light», яка передбачає мінімізацію власних фізичних активів на користь цифрових компетенцій та використання існуючої операційної інфраструктури як полігону для масштабування [9]. Це дозволяє зосередити стратегічне управління фінансовими ресурсами на розробці інтелектуального ядра, мінімізувати суб'єктивний вплив людського фактора та успішно подолати точку беззбитковості [3]. Фінансовий план проєкту включає розгорнуті сценарії хеджування ризиків, що забезпечує стабільну прогнозовану рентабельність інвестицій (ROI) на рівні 38-42% річних [3]. Загальний термін окупності проєкту, враховуючи преміальну націнку за інтелектуальну складову, прогнозується в межах 14 місяців, що підтверджує високу інвестиційну привабливість обраної стратегії та гарантує компанії позицію беззаперечного технологічного лідера у ніші предиктивного управління логістичними ризиками промислового сектору [2].

Для наочності представимо структуру капітальних (CAPEX) та операційних (OPEX) витрат інноваційного проєкту у формі порівняльної таблиці:

Таблиця 1

Структура капітальних (CAPEX) та операційних (OPEX) витрат інноваційного проєкту

Стаття витрат	Тип витрат	Питома вага в бюджеті, %	Спрямування фінансових ресурсів
R&D та розробка ПЗ	CAPEX	45	Створення предиктивних ШІ-алгоритмів, архітектури баз даних Big Data та клієнтських інтерфейсів Dashboard.
Закупівля IoT-обладнання	CAPEX	20	Формування оборотного фонду активних датчиків, контролерів телеметрії та акселерометрів високої точності.
Хмарна інфраструктура	OPEX	15	Оренда серверних потужностей (AWS/Azure) для обробки потокових даних у режимі реального часу.
Маркетинг та продажі	OPEX	12	Просування концепції RMaaS на промисловому ринку, B2B-хакатони, залучення якісних 4PL-партнерів.
Операційне управління	OPEX	8	Оплата праці аналітиків, OSINT-інженерів та підтримка безперервної служби диспетчеризації 24/7.

ПРАКТИЧНА РЕАЛІЗАЦІЯ, АНТИРИЗИКОВІ ЗАХОДИ ТА ОЦІНКА ЕФЕКТИВНОСТІ ВПРОВАДЖЕННЯ

Встановлено, що прямий економічний ефект від впровадження інтелектуальної системи формується на перетині зниження операційних збитків та запобігання простоям виробничих ліній замовника на 30–35% [2]. Окрім прямого фінансового ефекту, розроблено комплекс антиризикових заходів, що включає створення фонду оперативного реагування та багаторівневого «Плану Б» [2]. Цей план дозволяє системі в автоматичному режимі перераховувати маршрути та змінювати модальність транспортування у разі виявлення через OSINT-канали ознак наближення кризи (страйки, закриття кордонів, негода) [2].

Важливим додатковим аспектом є інтеграція з інноваційними страховими продуктами: надання страховикам об'єктивних даних телеметрії в реальному часі дозволяє знизити страхові тарифи для замовника на 15–20% через радикальне зменшення інформаційної асиметрії та ризику шахрайства [10]. Таким чином, інноваційна бізнес-модель, побудована на гнучкому аналізі даних та проактивному управлінні загрозами, є життєздатною та високорентабельною навіть у періоди глобальних криз, забезпечуючи високу якість сервісу та довгострокову конкурентоспроможність логістичного оператора [9].

Практичне впровадження системи RMaaS у діяльність вітчизняних 4PL-операторів дозволяє трансформувати логістичний ланцюг постачання із джерела постійного стресу та невизначеності на стабільний інженерно-економічний конвеєр. Зниження рівня ризиків позитивно позначається на довгострокових партнерських відносинах між суб'єктами господарювання, підвищує інвестиційну привабливість українських виробничих підприємств та забезпечує їхню інтеграцію до європейської промислової мережі на правах надійних та передбачуваних партнерів [2].

ВИСНОВКИ

1. Обґрунтовано, що в умовах сучасної геополітичної та економічної турбулентності управління ризиками в міжнародній промисловій логістиці потребує радикального переходу від традиційних реактивних моделей до проактивного предиктивного ризик-менеджменту на основі цифрових технологій [2].
2. Розкрито специфіку логістики промислового обладнання (Project Cargo Management), яка характеризується високою вартістю активів, одиничним характером виробництва, складними митними процедурами та екстремальними вагогабаритними параметрами, що вимагає індивідуального проєктування логістичних коридорів [2, 9].
3. Запропоновано інноваційну стратегію «Safe-Supply» у межах концепції «управління ризиками як сервісу» (RMaaS), що поєднує інструменти штучного інтелекту, OSINT-розвідки відкритих джерел та IoT-моніторингу фізичного стану вантажу в реальному часі [2].
4. Розроблено математичний апарат динамічного розрахунку інтегрального індексу ризику з використанням Марковських процесів та

розподілу Вейбулла, що дозволяє автоматизувати процес прийняття рішень та мінімізувати вплив людського фактора [2].

5. Доведено високу економічну ефективність запропонованої моделі «asset-light» для 4PL-операторів, яка забезпечує зниження операційних втрат та простоїв замовників на 30-35%, зменшення страхових тарифів на 15-20% та гарантує рентабельність інвестицій (ROI) на рівні 38-42% при терміні окупності проєкту до 14 місяців [2, 3, 10].

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1.13. Public Debt of Ukraine and Financial Instruments for its Management Under Wartime Conditions

Effective public debt management is one of the key prerequisites for a country's financial stability, the balance of the state budget, and the sustainability of macroeconomic development. For Ukraine, particularly amid prolonged external challenges and military hostilities after 2022, the issue of debt burden has become especially urgent.

Russia's full-scale invasion of Ukraine continues to deliver a devastating blow to the national economy, causing large-scale destruction of infrastructure, significant losses in industry and agriculture, and a deterioration of conditions for business and investment. The war has triggered a rapid increase in expenditures on defence and social programmes, which has led to a substantial budget deficit. The existence of a state budget deficit requires the search for sources of financing that will help balance the budget and reduce the level of deficit in the country. According to the Budget Code of Ukraine, the main sources of budget financing are defined as follows: funds from domestic and external borrowings, proceeds from the privatization of state property, the return of budget funds from deposits, proceeds from the sale of securities, and the free balance of budget funds. Under current conditions, the main source of deficit financing is borrowing both within the country and abroad.

The current economic situation in Ukraine is characterized not only by the threat of a growing debt burden, but also by its potential impact on long-term stability. Debt growth may limit opportunities for investment in key sectors, slow the pace of economic recovery, and adversely affect the country's international creditworthiness. In the context of armed conflict, these challenges are of particular importance, since economic resilience is one of the foundations for successfully overcoming the consequences of war.

The growth of debt obligations places significant pressure on the government's capacity for financial manoeuvre. A continuous increase in public debt may lead to a downgrade of the country's credit rating, which, in turn, will complicate access to international financial markets. It will also increase the cost of new borrowing, as investors will require higher interest rates to compensate for the risks associated with the debt burden. Such changes may negatively affect the country's financial stability and economic development, as well as create additional problems for the state budget, especially in circumstances that require the financing of social programmes and critical infrastructure [1].

To assess the state of Ukraine's finances in the context of public debt, it is appropriate to analyse the dynamics of external and domestic public debt and the debt-to-GDP ratio for 2015–2025 (Fig. 1). Over the 11 periods analysed, total public debt increased 5.7 times; comparing the amount of public debt in 2025 with the pre-war year of 2021, the growth rate of total debt was 3,4 times. Ukraine's public debt demonstrates constant dynamics with an upward trend, which is associated both with current expenditures on defence and humanitarian needs and with the need to fulfil obligations to external donors. At the same time, the increase in public debt is accompanied by a

rise in the budget deficit, which creates additional risks for the country's fiscal sustainability: the budget deficit in 2025 increased 36,3 times compared with 2015 and 8,3 times compared with the pre-war year of 2021.

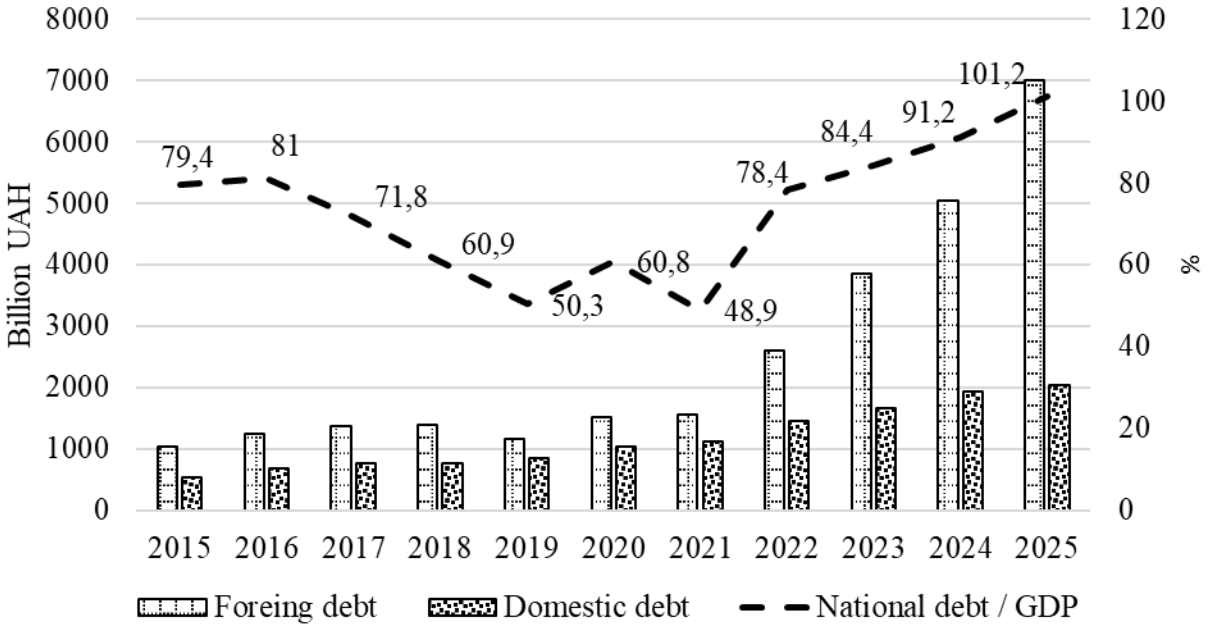

Figure 1 – Public debt indicators of Ukraine during 2015–2025 [2, 3]

It is known that Ukraine's public debt is divided into domestic and external debt. Domestic debt is formed through the placement of domestic government bonds (OVDPs) within the country, whereas external debt is formed through loans from international financial organizations, the issuance of Eurobonds, and loans from foreign governments and commercial banks. During the period under analysis, external borrowings dominate the debt structure. Their predominance became a necessary condition for maintaining the country's solvency, covering the state budget deficit, implementing socially significant programmes, and restoring economic infrastructure. The share of external borrowings was the lowest in 2019 (58,01%) and the highest in 2025 (77,5%). Beginning in 2022, the share of domestic borrowings began to decline steadily, which gives grounds to state that, despite the nominal increase in OVDP volumes, their role in covering the overall needs of the state decreased significantly against the background of large-scale external inflows.

This increase in the share of external debt illustrates the transition to a financing model based on extensive macro-financial support from international institutions and partner countries. In fact, by the end of the period under analysis, three quarters of the country's entire debt portfolio consisted of direct foreign borrowings. Although this to some extent reduces pressure on the domestic financial market, such a structure greatly increases the vulnerability of the national economy to exchange-rate fluctuations and shifts in the international political environment. External borrowings are mostly

earmarked and provide for the use of funds for investment projects that have a long-term socio-economic effect. However, the effectiveness of the use of borrowed resources largely depends on a rational approach to public debt management, which must be systematic, balanced, and transparent [4].

An analysis of the dynamics of Ukraine's public debt and GDP as part of the macroeconomic environment for 2015–2025 demonstrates a pronounced non-linearity of development. The peak of the debt burden during 2015–2016 was a consequence of the deep crisis of 2014–2015. The main reasons were:

- a deep devaluation of the hryvnia, since a significant share of Ukraine's public debt was denominated in foreign currency, namely US dollars and euros. The sharp fall in the hryvnia exchange rate, from approximately UAH 8 per USD in 2013 to more than UAH 25 per USD in 2015, caused the hryvnia equivalent of foreign-currency debt to surge, while nominal GDP in hryvnias simply did not keep pace with this rate of devaluation;
- a decline in real GDP, as the beginning of the war, the loss of territories that generated a significant share of industrial production and exports, and the disruption of economic ties led to a substantial contraction of Ukraine's real GDP;
- the nationalization of PrivatBank and support for the banking sector, as the state was forced to issue a significant volume of domestic government bonds (OVDPs) to recapitalize PrivatBank and other institutions in order to rescue the financial system, which immediately increased domestic debt.

The decline in debt to 50,3% in 2019 was the result of macroeconomic stabilization, strict control over the budget deficit, the effect of restructuring, and, above all, the rapid growth of nominal GDP against the background of a temporary strengthening of the hryvnia. By the end of 2019, Ukraine had reached a very safe and healthy level of debt burden by international standards.

The year 2020 was characterized by the consequences of the pandemic crisis, when GDP amounted to 4194,10 billion UAH and public debt amounted to 2551,88 billion UAH. The debt-to-GDP ratio of 60,8% corresponded to the generally accepted safety criteria for Ukraine under legislation, in particular Article 18 of the Budget Code of Ukraine. A significant improvement in the macroeconomic situation was observed in 2021. Owing to a rapid increase in nominal GDP to 5459,57 billion UAH, with growth exceeding 30%, and a restrained borrowing policy of 2672,06 billion UAH, the level of the debt burden declined to a local minimum of 48,9%. This period can be identified as the phase of the highest fiscal sustainability within the period under study.

However, the events of 2022 radically changed this trajectory. The beginning of the full-scale invasion led to a decline in nominal GDP. It amounted to 5191,03 billion UAH, while public debt increased by 52,5%, reaching 4075,57 billion UAH. This gap was caused by the need to cover a colossal budget deficit in order to finance the security sector and social obligations. The period of 2023–2024 became a time of adaptation to the "wartime economy". The culmination of the entire process was the 2025 indicator of a debt burden equal to 101,2% of GDP, which signals that the indicators exceeded the limits of sustainability defined by the Maastricht criteria and classical macroeconomic

standards. In other words, this effectively means the transition of the economy into a zone of high default risk and indicates the need to revise the debt sustainability strategy through mechanisms of international restructuring and the conversion of credit lines into grant-based formats [5].

The analysis of the currency structure of public debt is also of interest (Fig. 2). This aspect is quite significant, since it is precisely the denomination of obligations that determines the degree of vulnerability of the financial system to exchange-rate fluctuations and the specific features of managing external payments.

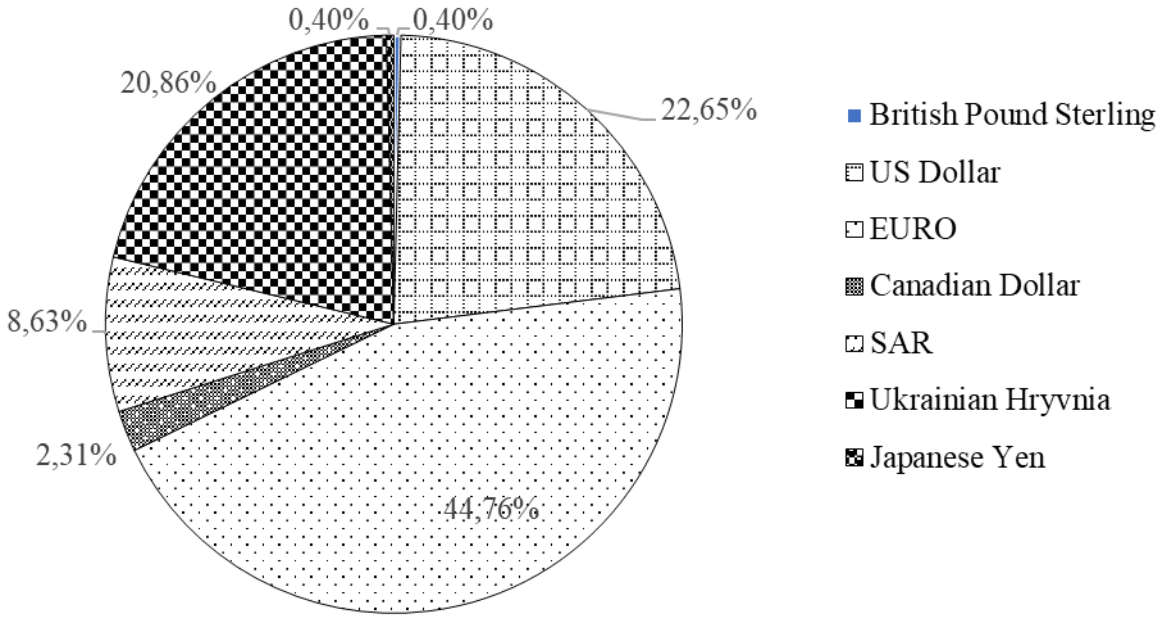

Figure 2 – Structure of Ukraine's public debt by borrowing currency as of the end of 2025 [6]

The current distribution of debt by currency type indicates Ukraine's deep integration into the European financial space and substantial support from international institutions. The analysis of the architecture of the debt portfolio demonstrates the dominant role of the euro, with obligations denominated in this currency amounting to 95,49 billion USD, or 44,76% of all currencies. This not only confirms the status of the European Union as a key strategic creditor, but also reflects a shift in the focus of external borrowings toward European financing instruments, which is a logical consequence of European integration processes. The US dollar ranks second in terms of volume, with 48,31 billion USD, which traditionally underscores the weight of the American currency in the structure of external financing and market borrowings (22,65%).

Special attention should be paid to the share of obligations denominated in the national currency, which amounts to 44,5 billion USD, or 20,86%. Maintaining a significant segment of debt in hryvnias is a positive indicator, as it minimizes currency risks for the budget under conditions of devaluation pressure. Special Drawing Rights

(SDRs) also occupy an important place in the structure, amounting to 18,41 billion USD (8,63%), which directly correlates with financial support programmes from the International Monetary Fund.

The dominance of the euro and the significant shares of the dollar and SDRs indicate that the main body of borrowings has been formed through institutional support from Western partners, which ensures long maturities and low interest rates. However, the high concentration of debt in foreign currency, exceeding 70% of the total portfolio, creates substantial budget vulnerability to exchange-rate fluctuations, since any devaluation of the hryvnia automatically leads to an expansion of the deficit through the recalculation of the principal debt amount into the national equivalent.

Borrowings in Canadian dollars play a less significant but diversifying role, amounting to 4,93 billion USD (2,31%), as do minor shares in Japanese yen, 0,86 billion USD, and British pounds sterling, 0,85 billion USD, at 0,4% each. Such differentiation and the multi-vector nature of the currency basket demonstrate the broad geography of resource mobilization and the use of specific credit lines from partner countries. Thus, the predominance of the euro and the US dollar creates a certain dependence on the monetary policies of the European Central Bank and the Federal Reserve System; however, the high share of hryvnia-denominated obligations and the concessional nature of external loans make it possible to balance the overall risk of public debt servicing [5].

An important component of an effective debt policy is ensuring the state's ability to service and repay its obligations without creating excessive fiscal pressure in the future. The attraction of funds should be based on clear criteria of expediency, efficiency, maturity, and economic benefit, with a focus on achieving long-term financial stability. Thus, public borrowings should not be viewed solely as an instrument for covering temporary budget shortfalls, but should become a lever for stimulating economic growth, developing national production, increasing investment activity, and modernizing infrastructure.

Debt management in Ukraine is carried out in accordance with the Public Debt Management Strategy, which is updated at least once every three years. The document defines objectives, areas of work, approaches to attracting financing, and mechanisms for risk control. The main objectives are to meet the financing needs of the state budget, minimize debt servicing costs, diversify borrowing sources, extend the weighted average maturity of the debt portfolio, and reduce currency risks [7, p. 125].

Considering the specific features of Ukraine's public debt structure, in which the share of external borrowings financed from the budget predominates, the development of a comprehensive system of indicators is highly important. Such a system should include not only indicators of general solvency and liquidity, but also indicators of the maximum permissible debt burden on the state budget. This necessity is due to the fact that the level of public debt significantly affects the state's fiscal policy and limits its capacity to manage budget expenditures, which is important for achieving macroeconomic stabilization in the future. The assessment of the state's debt security is carried out according to the methodology approved by Order № 1277 of the Ministry of

Economy of Ukraine dated 29 October 2013. This methodology has been applied from 2013 to the present.

In general, the following main instruments of public debt management can be identified for Ukraine in the context of ensuring financial security under wartime conditions:

1. Synchronization of fiscal policy, adherence to fiscal discipline, achievement of budgetary balance, and deficit monitoring, which requires more careful planning and forecasting of budget indicators and the search for additional tax revenues.

A difficult decision is the increase of the tax burden, which would allow the government to attract additional revenues to finance defence needs and maintain economic stability under martial law; this was proposed in Draft Law of Ukraine № 11416-d of 30 August 2024 on increasing taxes to finance the army. However, an excessive increase in the tax burden may deepen the shadow economy. Instead, international partners and analytical centres propose alternative solutions. For example, a slight increase in the VAT rate by only 2% could provide almost 80 billion UAH in additional revenues to the state budget without causing significant shadowing of the economy. Other measures, such as increasing taxes on assets or excise duties on selected goods, could also become effective alternatives without leading to significant negative consequences for the economy.

2. An important area for improving public debt management is the improvement of monetary policy. This includes regular assessment and management of risks associated with public debt, in particular interest-rate risks, liquidity risks, and currency risks. Continuous monitoring and effective management of these risks make it possible to minimize the negative impact on public debt servicing.

3. Stimulating economic development by creating favourable conditions for investment and business development. This may be implemented through the introduction of tax incentives and deregulation. At the same time, programmes for the structural transformation of the economy, oriented toward exports and high-tech production, particularly in the western regions of the country, need to be developed. Such measures will contribute to the expansion of economic potential and the improvement of the state's fiscal capacity.

4. Ensuring transparency and accountability in the field of public debt management. A key task is to improve methods for auditing and monitoring public debt through the use of advanced international standards. This will increase the efficiency and reliability of processes for managing the state's debt obligations. An important step in this direction is the involvement of independent international experts to conduct audits and objectively assess public debt management measures. Such an approach will contribute to increased confidence in the state debt policy on the part of investors, creditors, and the public. The introduction of transparent mechanisms for reporting, auditing, and evaluating the effectiveness of debt management according to international rules will become a key step toward ensuring long-term financial stability and strengthening Ukraine's authority in the international arena.

5. Debt refinancing. The government may review and refinance previously issued debt instruments with high interest rates, replacing them with new instruments with lower yields. This will reduce current debt servicing costs. Strengthening the domestic market for government borrowings is strategically important. It will reduce the country's external dependence and financial vulnerability. Attracting long-term loans on concessional terms may help ease the overall debt burden on the state budget. Diversification of financing sources through the domestic public debt market increases the resilience of the state's debt position by reducing risks associated with fluctuations in foreign exchange rates and changes in external lending conditions. Thus, the development of the domestic government borrowing market is a key element of effective public debt management.

6. Optimizing the structure and diversifying sources of public debt financing. The state should consider a wide range of sources: domestic and external, public and private, short-term and long-term. This will make it possible to form an optimal debt structure that takes into account the ratio of costs and risks. Such diversification of financial instruments increases the resilience of the state's debt position.

With the beginning of the full-scale war, Ukraine faced unprecedented conditions for attracting public debt. Leading democratic countries and international financial institutions expressed their willingness to support Ukraine, which had suffered unprovoked aggression, by providing credit resources on exceptionally favourable terms: for long periods and at concessional interest rates. In parallel, agreements were reached to suspend public debt payments to the Group of Seven countries and members of the Paris Club of creditors until the end of 2023. In addition, Ukraine received 480,6 billion UAH in international grants, which were directed toward financing critical social programmes in the areas of education, healthcare, and social protection, thereby making it possible to avoid default. Overall, these exceptional support measures from foreign partners became a key factor that allowed Ukraine to cope with financial and economic challenges during wartime [8, p. 128].

The government's main priority should be to restrain the growth of public debt through non-repayable international financial assistance. At the same time, taking into account the attention and sympathy of the global community toward Ukraine as a country that has suffered unprovoked aggression, it is important to implement a policy of restructuring existing debts and improving the conditions of their servicing. Such a comprehensive approach, combining the attraction of non-repayable assistance and the easing of the debt burden, will allow Ukraine to manage public debt effectively under martial law and ensure financial stability.

7. Implementation of programmes for restructuring existing debt obligations. This provides for the possibility of revising repayment terms and interest rates on debt in order to reduce current servicing costs. Ukraine has already achieved certain results in the field of public debt restructuring. In September 2024, the Government of Ukraine announced the successful completion of a debt restructuring operation that provided for settlements on thirteen series of sovereign Eurobonds and state-guaranteed Eurobonds issued by Ukravtodor. This transaction was aimed at restoring debt

sustainability, supporting macro-financial stability, and increasing state budget resources amid ongoing Russian military aggression. This restructuring became one of the largest debt write-offs in recent comparable sovereign debt operations.

Therefore, the priority task for ensuring the country's financial security is the development and implementation of strategies for debt optimization, refinancing, and restructuring in order to improve the debt portfolio and reduce debt servicing costs. Ensuring transparency and openness in the field of public debt management should become a priority. This will make it possible to guarantee not only sustainable fiscal discipline, but also to gain the trust of investors and civil society. A key aspect of effective long-term public debt management is the ability to respond to global economic trends and adapt to changing market conditions. Only through continuous monitoring of external factors and flexible adjustment of debt policy can the sustainability of the state's financial system be ensured.

Management of external public debt requires improving the effectiveness of the implementation of international agreements and treaties. A necessary condition is ensuring control over the use of credit resources in accordance with the target areas defined within the framework of international cooperation. Cooperation with international financial organizations — the IMF, the World Bank, and the EBRD — is of particular importance, as it not only contributes to financial support but also shapes Ukraine's image as a reliable partner in the field of international finance.

In 2026, Ukraine continues to implement its public debt management policy in accordance with the medium-term strategy for 2024–2026. This strategy was developed taking into account the complex military and economic circumstances caused by the large-scale aggression of the Russian Federation. The priority of debt policy remains unchanged: to ensure budget financing at the best possible cost while simultaneously minimizing risks associated with public debt. Particular attention is paid to the development of the domestic capital market and the attraction of long-term concessional financing [9].

The war in Ukraine has significantly aggravated the problem of public debt, which is growing at a record pace due to the need to finance critically important expenditures. The constant increase in the state budget deficit encourages the government to actively use domestic and external borrowings, which increases the country's overall debt burden.

The key tasks in the field of debt policy should be the optimization of the debt structure, the expansion of the domestic borrowing market, the stimulation of economic growth, and the reduction of the budget deficit. Only by combining these factors will Ukraine be able to ensure debt sustainability and financial security in the medium term.

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CHAPTER 2. INNOVATIVE AND MODERN FOUNDATIONS OF PEDAGOGY AND PSYCHOLOGY

2.1. Development of the Economic Justification of Decisions in the Process of Completing Course Projects by Future Technology Teachers

РОЗВИТОК ЕКОНОМІЧНОГО ОБҐРУНТУВАННЯ РІШЕНЬ ПІД ЧАС ВИКОНАННЯ КУРСОВИХ РОБІТ МАЙБУТНІМИ УЧИТЕЛЯМИ ТЕХНОЛОГІЙ

У сучасних умовах розвитку суспільства, що характеризуються швидкими економічними, технологічними та соціальними трансформаціями, особливого значення набуває підготовка конкурентоспроможних фахівців, здатних не лише володіти професійними знаннями та вміннями, але й ефективно приймати обґрунтовані рішення в умовах обмежених ресурсів. У цьому контексті зростає роль економічної підготовки майбутніх учителів технологій, адже їхня професійна діяльність безпосередньо пов’язана з організацією технологічних процесів, плануванням виробничої діяльності, вибором матеріалів, інструментів, технологій виготовлення виробів та оцінюванням доцільності прийнятих рішень [1].

Сучасна технологічна освіта спрямована на формування у здобувачів освіти не лише технічних і технологічних компетентностей, а й економічного мислення, здатності аналізувати витрати, визначати ефективність виробничих процесів, здійснювати економічні розрахунки та обґрунтовувати прийняті технологічні рішення. У зв’язку з цим майбутній учитель технологій повинен володіти навичками економічного аналізу, що дозволяють інтегрувати економічну складову у процес навчання та формувати в учнів практичне розуміння економічних аспектів виробничої діяльності.

Важливим елементом професійної підготовки майбутніх учителів технологій є виконання курсових робіт, які виступають ефективним засобом поєднання теоретичних знань і практичних умінь. Під час виконання таких робіт студенти не лише опановують методи проєктування виробів, аналізу технологічних процесів та організації виробництва, але й набувають досвіду економічного обґрунтування власних рішень. Саме курсова робота створює умови для комплексного застосування знань з технологій, економіки, організації виробництва та педагогіки, що сприяє формуванню системного професійного мислення [4].

Особливу роль у структурі курсових робіт відіграє економічне обґрунтування прийнятих технологічних рішень. Воно передбачає визначення витрат на матеріали, інструменти, енергію, робочий час, а також аналіз собівартості виробу, можливостей оптимізації технологічного процесу та оцінювання економічної ефективності виготовлення продукції. Уміння проводити такі розрахунки сприяє формуванню раціонального підходу до

організації виробничої діяльності та розвитку економічної культури майбутніх педагогів.

Разом з тим аналіз науково-педагогічної літератури та практики підготовки майбутніх учителів технологій свідчить про те, що питання розвитку умінь економічного обґрунтування рішень під час виконання курсових робіт ще недостатньо розкриті. У багатьох випадках економічна складова розглядається лише як допоміжний елемент технологічного проєктування, що знижує її освітній потенціал та обмежує можливості формування економічної компетентності студентів.

У зв'язку з цим виникає потреба у більш ґрунтовному дослідженні педагогічних умов, методичних підходів та організаційних засобів, які сприяють розвитку здатності майбутніх учителів технологій здійснювати економічне обґрунтування технологічних рішень у процесі виконання курсових робіт. Формування таких умінь є важливим складником професійної підготовки педагогів, оскільки дозволяє поєднати технологічні знання з економічним аналізом та підвищити практичну спрямованість навчання.

Теоретичні засади професійної підготовки педагогічних кадрів та формування компетентнісного підходу в освіті висвітлено у працях вітчизняних учених. У дослідженнях, присвячених проблемам педагогічної освіти, обґрунтовується необхідність розвитку у майбутніх педагогів здатності до аналізу соціально-економічних процесів, планування професійної діяльності та прийняття обґрунтованих рішень. У працях О. Безпалько, І. Звєрєвої, Т. Коленіченко, Н. Ничкало, С. Гончаренка, Л. Ващенко, В. Радкевич розглядаються питання професійної підготовки педагогів, формування ключових і фахових компетентностей, а також інтеграції економічних знань у зміст освіти. Дослідники наголошують, що сучасний педагог має володіти не лише предметними знаннями, але й розуміти економічні аспекти професійної діяльності, зокрема раціональне використання ресурсів, планування витрат та оцінювання ефективності діяльності [2].

Важливе місце у наукових дослідженнях займають питання розвитку економічного мислення у процесі професійної підготовки фахівців. У працях О. Падалки, В. Манька, І. Савченка, Л. Лук'янової розглядаються підходи до формування економічної компетентності здобувачів освіти, розвитку їхньої здатності аналізувати економічні процеси та застосовувати економічні знання у практичній діяльності. Науковці підкреслюють, що економічна компетентність формується не лише через вивчення теоретичних дисциплін, а й у процесі виконання практичних завдань, навчальних проєктів, дослідницької діяльності та аналізу реальних виробничих ситуацій.

Окремий напрям досліджень пов'язаний із методикою навчання технологій та організацією проєктно-технологічної діяльності у процесі підготовки майбутніх учителів. Значний внесок у розвиток цієї проблематики зробили М. Корець, І. Кучерук, С. Ящук, Л. Оршанський, В. Титаренко, О. Бобровник, які досліджували особливості технологічної освіти, методику організації проєктної

діяльності студентів та формування практичних професійних умінь. У їхніх працях підкреслюється, що виконання навчальних проєктів, курсових робіт і технологічних розробок створює сприятливі умови для формування у студентів здатності аналізувати виробничі процеси, визначати витрати матеріалів, оцінювати економічну доцільність технологічних рішень та прогнозувати результати виробничої діяльності [1; 3; 5].

Проблематика формування економічної складової професійної компетентності також розглядається у дослідженнях, присвячених розвитку підприємницьких умінь та економічної культури майбутніх фахівців. У працях В. Мадзігона, Н. Ничкало, Л. Лук'янової, В. Радкевич обґрунтовується необхідність інтеграції економічних знань у зміст технологічної освіти та застосування практико-орієнтованих методів навчання. Дослідники зазначають, що економічні розрахунки, аналіз собівартості виробів, оцінювання ефективності використання матеріалів і ресурсів повинні бути органічною складовою професійної підготовки майбутніх учителів технологій.

Водночас у зарубіжній педагогічній науці значна увага приділяється використанню активних методів навчання для розвитку професійних компетентностей. У працях J. R. Anderson, D. Jonassen, R. Felder, M. Prince, A. Kolmos, P. Blikstein обґрунтовується ефективність проблемно-орієнтованого та проєктно-орієнтованого навчання. Дослідники доводять, що залучення студентів до розв'язання практичних виробничих і економічних завдань сприяє розвитку аналітичного мислення, формуванню здатності до прийняття обґрунтованих рішень, а також розвитку навичок оцінювання економічних наслідків технологічної діяльності.

Таким чином, аналіз наукових джерел свідчить про значний інтерес дослідників до проблеми формування економічної компетентності майбутніх педагогів та інтеграції економічних знань у систему технологічної освіти. Разом з тим потребують подальшого дослідження методичні підходи до розвитку умінь економічного обґрунтування технологічних рішень у процесі виконання курсових робіт майбутніми учителями технологій, що визначає актуальність даного дослідження.

Водночас аналіз наукових праць свідчить, що питання розвитку умінь економічного обґрунтування рішень саме під час виконання курсових робіт майбутніми учителями технологій потребує подальшого наукового осмислення та методичного обґрунтування.

Нормативно-правову основу підготовки майбутніх учителів технологій та формування їхніх професійних, зокрема економічних, компетентностей становлять державні законодавчі та нормативні документи у сфері освіти. Провідне значення у цьому контексті мають Закон України 'Про освіту', Закон України 'Про вищу освіту', а також Закон України 'Про повну загальну середню освіту', у яких визначено основні засади функціонування освітньої системи, принципи підготовки фахівців та вимоги до формування компетентностей здобувачів освіти. У цих документах наголошується на необхідності розвитку

ключових і професійних компетентностей, зокрема здатності до раціонального використання ресурсів, прийняття обґрунтованих рішень та застосування знань у практичній діяльності.

Важливим орієнтиром для організації підготовки майбутніх учителів технологій є Державний стандарт базової середньої освіти, затверджений CMU Cabinet of Ministers of Ukraine, у якому визначено компетентнісний підхід як основу сучасного освітнього процесу. У межах технологічної освітньої галузі стандарт передбачає формування у здобувачів освіти здатності планувати технологічну діяльність, оцінювати ефективність використання матеріалів і ресурсів, здійснювати елементарні економічні розрахунки та приймати обґрунтовані рішення під час виконання практичних і проєктних завдань [6].

Організація професійної підготовки майбутніх учителів технологій у закладах вищої освіти також регламентується стандартами вищої освіти за спеціальністю 014 «Середня освіта (Технології)», які визначають перелік загальних і фахових компетентностей, програмні результати навчання та вимоги до освітньо-професійних програм. У цих документах підкреслюється важливість формування у майбутніх педагогів здатності здійснювати технологічне проєктування, аналізувати економічні аспекти виготовлення виробів, обґрунтовувати вибір матеріалів і технологій, а також організовувати освітній процес із урахуванням практичної та економічної доцільності виробничої діяльності.

Крім того, важливу роль у визначенні змісту професійної підготовки майбутніх учителів технологій відіграють типові освітні програми та навчальні плани, розроблені відповідно до вимог Ministry of Education and Science of Ukraine. Ці документи визначають структуру освітнього процесу, перелік обов’язкових і вибіркових навчальних дисциплін, форми організації навчальної діяльності та результати навчання, яких мають досягти здобувачі вищої освіти. У межах таких програм значна увага приділяється виконанню курсових робіт, індивідуальних проєктів, технологічних розробок і практичних досліджень, що спрямовані на інтеграцію технологічних, організаційних та економічних знань [2].

Виконання курсових робіт і проєктних завдань розглядається як важливий елемент професійної підготовки, оскільки саме в процесі такої діяльності студенти мають можливість застосовувати теоретичні знання на практиці. Під час виконання цих робіт майбутні учителі технологій здійснюють аналіз технологічних процесів, визначають витрати матеріалів, оцінюють трудомісткість виготовлення виробів, розраховують собівартість продукції та обґрунтовують економічну доцільність запропонованих технологічних рішень. Такий підхід сприяє формуванню у студентів здатності комплексно оцінювати виробничі процеси, поєднувати технологічні та економічні аспекти діяльності, а також приймати обґрунтовані професійні рішення.

Водночас зміст підготовки майбутніх учителів технологій формується з урахуванням міжнародних тенденцій розвитку технологічної та інженерної освіти. У багатьох країнах Європейського Союзу та Організації економічного

співробітництва та розвитку (OECD) значна увага приділяється інтеграції технологічної, економічної та підприємницької підготовки студентів. Зокрема, у рекомендаціях Organisation for Economic Co-operation and Development та European Commission наголошується на необхідності розвитку у здобувачів освіти підприємницьких компетентностей, фінансової грамотності та здатності до прийняття економічно обґрунтованих рішень у професійній діяльності. У міжнародних освітніх практиках курсові проєкти та проєктно-орієнтоване навчання широко використовуються як ефективний інструмент формування таких компетентностей.

У зарубіжних дослідженнях підкреслюється, що виконання проєктних і дослідницьких завдань сприяє розвитку у студентів навичок аналізу виробничих ситуацій, планування використання ресурсів, оцінювання економічної ефективності технологічних рішень і прогнозування результатів діяльності. Таким чином, поєднання вимог національних освітніх стандартів із міжнародними підходами до підготовки фахівців дозволяє створити ефективну систему формування економічної компетентності майбутніх учителів технологій, у межах якої курсові роботи виступають важливим інструментом інтеграції технологічних, економічних та організаційних знань [3; 5: 6].

Таким чином, аналіз нормативно-правових документів свідчить, що сучасна освітня політика України орієнтована на підготовку фахівців, здатних поєднувати технологічні знання з економічним мисленням та практичними навичками прийняття обґрунтованих рішень. Це створює необхідні передумови для дослідження особливостей розвитку умінь економічного обґрунтування рішень у процесі виконання курсових робіт майбутніми учителями технологій.

У процесі підготовки майбутніх учителів технологій важливого значення набуває формування здатності здійснювати обґрунтований вибір технологічних рішень з урахуванням економічних факторів. Сучасна технологічна освіта передбачає не лише оволодіння студентами технологіями обробки матеріалів, конструювання виробів і організації технологічних процесів, але й формування економічного мислення, уміння оцінювати витрати ресурсів та визначати ефективність виробничої діяльності. У цьому контексті виконання курсових робіт виступає важливим засобом інтеграції технологічних, організаційних і економічних знань.

Курсова робота у підготовці майбутніх учителів технологій має комплексний і міждисциплінарний характер та виступає важливою формою організації навчально-дослідницької діяльності студентів. Вона спрямована на інтеграцію теоретичних знань і практичних умінь, отриманих у процесі вивчення фахових дисциплін, зокрема технологій обробки матеріалів, матеріалознавства, основ проєктування, організації виробництва, економіки та педагогіки. Завдяки виконанню курсових робіт студенти мають можливість застосувати отримані знання у практичній діяльності, що сприяє формуванню цілісного професійного мислення та здатності вирішувати реальні технологічні завдання [4].

Курсова робота також виконує важливу дидактичну функцію, оскільки створює умови для розвитку дослідницьких умінь, самостійності та відповідальності студентів за результати власної діяльності. У процесі її виконання студенти навчаються працювати з науковими та технічними джерелами інформації, аналізувати існуючі технологічні рішення, здійснювати порівняльний аналіз різних варіантів проєктування виробів та обґрунтовувати вибір оптимального варіанту. Таким чином, курсова робота сприяє формуванню у майбутніх учителів технологій умінь самостійного пошуку інформації, її критичного аналізу та практичного застосування у процесі технологічної діяльності.

Важливою особливістю курсової роботи є її практична спрямованість. Студенти не лише теоретично аналізують проблему, але й виконують реальне проєктування виробу або технологічного процесу, розробляють конструкторську документацію, визначають технологічну послідовність виготовлення виробу та здійснюють економічне обґрунтування прийнятих рішень. Така діяльність дозволяє майбутнім учителям технологій набути практичного досвіду організації технологічного процесу, що є важливим для їх подальшої педагогічної діяльності.

Виконання курсової роботи передбачає проходження низки взаємопов’язаних етапів, кожен з яких має важливе значення для формування професійної компетентності майбутнього вчителя технологій. До таких етапів належать аналіз проблеми та обґрунтування актуальності теми дослідження, проєктування виробу або технологічного процесу, розроблення конструкторської та технологічної документації, вибір матеріалів і технологій виготовлення виробу, а також економічне обґрунтування запропонованих технологічних рішень. Кожен із цих етапів сприяє розвитку певних професійних умінь, зокрема уміння аналізувати технічну інформацію, планувати технологічний процес, оцінювати ефективність використання ресурсів і приймати обґрунтовані рішення.

Крім того, виконання курсових робіт сприяє формуванню у студентів системного підходу до розв’язання технологічних завдань. Майбутні вчителі технологій вчаться розглядати процес виготовлення виробу не лише з технічної точки зору, але й з позиції економічної доцільності, раціонального використання матеріалів і ресурсів, а також можливості практичного застосування розробленого виробу у навчальному процесі. Такий підхід дозволяє сформувати у студентів цілісне уявлення про технологічну діяльність та її роль у сучасному суспільстві.

Отже, курсова робота є важливим елементом професійної підготовки майбутніх учителів технологій, оскільки поєднує теоретичну підготовку з практичною діяльністю та сприяє формуванню ключових професійних компетентностей. Її виконання забезпечує розвиток технологічного, економічного та дослідницького мислення студентів, що є необхідною передумовою для ефективної педагогічної діяльності у сфері технологічної освіти.

Першим етапом виконання курсової роботи є аналіз проблеми та обґрунтування актуальності теми дослідження. На цьому етапі студент здійснює ґрунтовне вивчення наукової, навчально-методичної, технічної та довідкової

літератури, що стосується обраної теми. Зокрема, аналізуються сучасні публікації, методичні рекомендації, підручники, каталоги виробів, технічна документація та інші джерела інформації. Особлива увага приділяється вивченню існуючих аналогів виробів або технологічних рішень, що дозволяє визначити їхні конструктивні особливості, функціональні можливості, переваги та недоліки.

Такий аналіз допомагає студенту сформувати уявлення про сучасні тенденції розвитку технологічної діяльності, рівень технічних рішень у певній галузі та можливі напрями вдосконалення існуючих виробів. У результаті проведеного аналізу студент обґрунтовує актуальність обраної теми курсової роботи, визначає проблему, яку необхідно вирішити, та формулює мету дослідження. Крім того, на цьому етапі визначаються основні завдання роботи, окреслюється структура дослідження, плануються етапи виконання курсового проєкту та визначаються очікувані результати. Такий підхід сприяє формуванню у студентів умінь систематизувати інформацію, здійснювати аналітичну діяльність та аргументовано обґрунтовувати власні рішення.

Другим етапом є проєктування виробу або технологічного процесу, що передбачає розроблення конструктивного рішення майбутнього виробу та визначення його функціонального призначення. На цьому етапі студент формує загальну концепцію виробу, визначає його основні параметри, габаритні розміри, конструктивні елементи та принцип роботи. Важливим завданням є також визначення основних характеристик виробу, таких як міцність, надійність, зручність використання та естетичний вигляд.

У процесі проєктування студент створює ескізи виробу, які відображають його загальну форму, конструкцію та взаємне розташування елементів. На основі цих ескізів аналізуються різні варіанти конструктивного виконання виробу, що дозволяє визначити найбільш раціональне рішення. Важливим аспектом проєктування є врахування ергономічних, естетичних та експлуатаційних вимог. Ергономічні вимоги передбачають забезпечення зручності використання виробу, відповідність його розмірів антропометричним характеристикам користувача. Естетичні вимоги пов’язані з гармонійністю форми, пропорційністю конструкції та відповідністю виробу сучасним дизайнерським тенденціям. Експлуатаційні вимоги стосуються міцності, довговічності, безпечності та надійності виробу у процесі використання.

Наступним етапом є розроблення конструкторської документації, що включає створення технічних креслень, схем, специфікацій матеріалів і деталей виробу. На цьому етапі студент деталізує конструкцію виробу, визначає точні розміри кожної деталі, форму елементів, способи їх з’єднання та взаємодії. Виконуються креслення загального вигляду виробу, а також креслення окремих деталей і вузлів. Такі креслення повинні відповідати вимогам технічної документації та містити всі необхідні позначення, розміри та пояснення.

У сучасних умовах під час виконання курсових робіт дедалі частіше використовуються системи автоматизованого проєктування (CAD), які дозволяють створювати точні графічні моделі виробів, виконувати креслення та візуалізувати

конструкцію майбутнього виробу. Використання таких програмних засобів сприяє формуванню цифрових компетентностей майбутніх педагогів та підвищує якість проєктної документації.

Важливим етапом виконання курсової роботи є вибір матеріалів і технологій виготовлення виробу. На цьому етапі студент аналізує властивості різних матеріалів, які можуть бути використані для виготовлення виробу, зокрема їхню міцність, довговічність, технологічність обробки, доступність та вартість. Порівняння різних матеріалів дозволяє визначити найбільш доцільний варіант, який забезпечує необхідні експлуатаційні характеристики виробу при оптимальних витратах ресурсів.

Паралельно з вибором матеріалів студент розробляє технологічну послідовність виконання операцій, що включає розмічання заготовок, різання або розпилювання матеріалу, механічну обробку, складання деталей, оздоблення поверхні та контроль якості готового виробу. Для кожної операції визначаються необхідні інструменти, обладнання та приблизна тривалість виконання. Розроблення технологічного процесу дозволяє студенту систематизувати знання про методи обробки матеріалів, організацію виробничої діяльності та послідовність виконання технологічних операцій.

Завершальним і водночас одним із найбільш важливих етапів виконання курсової роботи є економічне обґрунтування запропонованих технологічних рішень. На цьому етапі студент здійснює комплексний економічний аналіз реалізації проєкту. Він визначає витрати на основні та допоміжні матеріали, інструменти й обладнання, оцінює витрати електроенергії, а також розраховує витрати часу на виконання технологічних операцій.

На основі отриманих даних студент розраховує собівартість виготовлення виробу, аналізує структуру витрат та визначає можливі способи їх зниження. Наприклад, може розглядатися можливість використання альтернативних матеріалів, оптимізація розміщення деталей на заготовці, скорочення витрат часу на окремі операції або застосування більш ефективних інструментів. У результаті такого аналізу студент робить висновок про економічну доцільність реалізації запропонованого технологічного рішення.

Таким чином, у процесі виконання курсової роботи майбутні учителі технологій набувають практичного досвіду економічного аналізу виробничої діяльності, навчаються оцінювати витрати ресурсів, планувати технологічні процеси та обґрунтовувати прийняті рішення. Це сприяє формуванню у студентів системного підходу до технологічної діяльності та підготовці їх до подальшої педагогічної практики.

Саме економічне обґрунтування дозволяє студентам не лише оцінити доцільність реалізації розробленого проєкту, але й сформувати навички раціонального використання матеріальних, енергетичних та трудових ресурсів. Крім того, воно сприяє розвитку аналітичного мислення, здатності порівнювати альтернативні технологічні рішення та прогнозувати можливі економічні результати виробничої діяльності. Такий підхід має важливе значення для

майбутньої професійної діяльності вчителя технологій, оскільки дозволяє формувати у здобувачів освіти практичне розуміння економічних аспектів технологічної діяльності та сприяє розвитку їхньої підприємницької й економічної компетентності.

Економічне обґрунтування у структурі курсової роботи передбачає виконання комплексу взаємопов'язаних економічних розрахунків, спрямованих на визначення доцільності реалізації технологічного проєкту та оцінювання ефективності використання ресурсів. Цей етап має важливе значення для формування у майбутніх учителів технологій навичок економічного аналізу, раціонального планування виробничої діяльності та прийняття обґрунтованих технологічних рішень. У процесі виконання економічного обґрунтування студенти визначають витрати на основні й допоміжні матеріали, інструменти та обладнання, розраховують витрати часу на виконання технологічних операцій, оцінюють витрати електроенергії та інших ресурсів, а також визначають загальну собівартість виготовлення виробу.

Крім того, важливим елементом економічного обґрунтування є аналіз можливостей оптимізації виробничого процесу. Це може передбачати раціональний вибір матеріалів, удосконалення конструкції виробу, зменшення технологічних втрат матеріалу, оптимізацію послідовності технологічних операцій або використання більш ефективних інструментів. У процесі виконання таких розрахунків студенти навчаються застосовувати елементи економічного аналізу, оцінювати витрати та результати виробничої діяльності, порівнювати різні варіанти виконання проєкту й обирати найбільш економічно доцільний. Така діяльність сприяє розвитку аналітичного мислення та формуванню здатності приймати обґрунтовані рішення у сфері технологічної діяльності.

Одним із практичних прикладів використання економічного обґрунтування під час виконання курсових робіт є проєктування виробів з деревини, що широко застосовується у технологічній освіті. Наприклад, під час виконання курсової роботи на тему «Проєктування та виготовлення настінної декоративної полички» студент повинен не лише розробити конструкцію виробу, створити креслення та визначити технологічну послідовність його виготовлення, але й здійснити економічний аналіз витрат, пов'язаних із реалізацією проєкту.

На першому етапі економічного обґрунтування визначаються матеріали, необхідні для виготовлення виробу. Для виготовлення настінної полички можуть використовуватися соснова дошка, кріпильні елементи (шурупи або саморізи), столярний клей, шліфувальний папір різної зернистості, а також лакофарбові матеріали для декоративного оздоблення поверхні. Після визначення переліку матеріалів студент проводить розрахунок їхньої кількості та вартості з урахуванням розмірів виробу, товщини матеріалу та можливих втрат під час обробки.

Для умовного розрахунку вартості праці може використовуватися середня погодинна ставка. Наприклад, якщо прийняти, що одна година роботи оцінюється у 80 грн, витрати на оплату праці становитимуть приблизно 320 грн.

До цих витрат додаються витрати на електроенергію, що визначаються на основі потужності використовуваних електроінструментів та тривалості їх використання. Наприклад, під час виготовлення виробу можуть використовуватися електролобзик і шліфувальна машина. Якщо сумарне споживання електроенергії становить приблизно 1,5 кВт·год, а вартість одного кіловат-години становить 4 грн, витрати на електроенергію складуть приблизно 6 грн.

Після виконання необхідних розрахунків студент визначає орієнтовну собівартість виготовлення виробу, яка є одним із ключових показників економічної доцільності проєкту. Собівартість формується шляхом підсумовування всіх витрат, пов'язаних із виготовленням виробу, зокрема витрат на матеріали, оплату праці, використання обладнання та енергетичних ресурсів. Такий підхід дозволяє студентам зрозуміти структуру виробничих витрат і сформувати практичні навички економічного аналізу технологічної діяльності.

У наведеному прикладі виготовлення декоративної полички студент спочатку визначає матеріальні витрати. До них належать витрати на основний матеріал (наприклад, деревину або фанеру), допоміжні матеріали (клей, лак, кріпильні елементи, шліфувальний папір тощо). Припустимо, що загальна вартість матеріалів становить 200 грн. Наступним етапом є визначення витрат на оплату праці. Студент розраховує тривалість виконання основних технологічних операцій: розмічання, різання матеріалу, обробку поверхні, складання конструкції, оздоблення виробу. Якщо на виготовлення полички витрачається приблизно 4 години роботи, а умовна вартість однієї години праці становить 80 грн, витрати на оплату праці становитимуть 320 грн.

Окремо враховуються витрати на енергетичні ресурси, які виникають під час використання електроінструментів або обладнання. Наприклад, при використанні електролобзика, шліфувальної машини чи електродрилі визначається їхня потужність, тривалість роботи та вартість електроенергії. У даному випадку витрати на електроенергію можуть становити приблизно 6 грн. Таким чином, загальна орієнтовна собівартість виготовлення декоративної полички становитиме приблизно 526 грн (200 грн матеріальні витрати + 320 грн витрати на оплату праці + 6 грн витрати на електроенергію).

На завершальному етапі економічного обґрунтування студент проводить порівняльний аналіз ринкових цін на аналогічні вироби. Для цього можуть використовуватися дані торговельних мереж, інтернет-магазинів, спеціалізованих платформ електронної комерції або маркетплейсів. Студент аналізує асортимент подібних виробів, їхні конструктивні особливості, матеріали виготовлення, рівень якості та ціновий діапазон. Наприклад, якщо середня ринкова ціна декоративної настінної полички аналогічного розміру і конструкції становить приблизно 650–700 грн, можна зробити висновок, що виготовлення такого виробу є економічно доцільним.

На основі отриманих даних студент також може визначити орієнтовний рівень прибутку у разі реалізації виробу. Якщо умовна ціна продажу становитиме

680 грн, а собівартість – 526 грн, потенційний прибуток може складати близько 150 грн з одного виробу. Крім того, студент може врахувати можливі способи зниження собівартості, наприклад оптимізацію використання матеріалів, скорочення часу обробки або використання більш доступних матеріалів без погіршення якості виробу. Такий аналіз дозволяє майбутнім учителям технологій не лише оцінювати економічну ефективність виготовлення виробів, але й формує у них практичне розуміння принципів організації виробництва, планування витрат та прийняття економічно обґрунтованих рішень у технологічній діяльності.

Таким чином, виконання економічного обґрунтування під час підготовки курсових робіт дозволяє студентам усвідомити взаємозв'язок між технологічними та економічними аспектами виробничої діяльності. Воно сприяє формуванню умінь планувати витрати ресурсів, оцінювати ефективність технологічних рішень, аналізувати ринкову ситуацію та прогнозувати результати виробничої діяльності. У подальшій педагогічній практиці ці знання та вміння можуть бути використані майбутніми учителями технологій для формування у здобувачів освіти основ економічної грамотності та підприємницького мислення у процесі вивчення технологічних дисциплін.

Іншим прикладом економічного обґрунтування у процесі виконання курсових робіт може бути проєкт на тему «Розроблення настільного органайзера для канцелярського приладдя». У межах такого проєкту студент має не лише розробити конструкцію виробу, створити ескізи та креслення, а й здійснити комплексний економічний аналіз можливих варіантів його виготовлення. Одним із ключових завдань у цьому випадку є порівняння різних матеріалів, які можуть бути використані для виготовлення органайзера, зокрема фанери, МДФ або пластику. Для кожного з варіантів студент визначає витрати матеріалів, складність їх обробки, тривалість виконання технологічних операцій, необхідність використання певних інструментів і обладнання, а також орієнтовну собівартість виготовлення виробу.

На першому етапі аналізу студент визначає конструкцію органайзера та кількість необхідних деталей. Наприклад, органайзер може складатися з основи, кількох перегородок, бокових стінок та елементів для розміщення ручок, олівців і дрібних канцелярських предметів. Після визначення конструкції студент розраховує площу матеріалу, необхідного для виготовлення всіх деталей виробу.

Наприклад, виготовлення органайзера з фанери може потребувати приблизно 0,4 м² матеріалу. Якщо вартість фанери становить 250 грн за квадратний метр, витрати на основний матеріал складуть приблизно 100 грн. До цього додаються витрати на допоміжні матеріали, такі як столярний клей (близько 15 грн), шліфувальний папір (10 грн) та лак або фарба для декоративного оздоблення поверхні (близько 30 грн). Таким чином, загальні витрати на матеріали у випадку використання фанери можуть становити приблизно 155 грн.

Якщо ж для виготовлення органайзера використовувати МДФ, вартість матеріалу може бути дещо вищою. Наприклад, при ціні 300 грн за квадратний метр витрати на матеріал становитимуть приблизно 120 грн. Крім того, обробка МДФ часто потребує більш ретельного шліфування та нанесення декоративного покриття, що може збільшити витрати часу на виготовлення виробу. У результаті загальні витрати на матеріали та допоміжні ресурси можуть становити близько 180–190 грн.

Ще одним варіантом є виготовлення органайзера з пластикових листів. У цьому випадку вартість матеріалу може бути значно вищою, наприклад 350–400 грн за квадратний метр, що збільшує загальні витрати на матеріал. Крім того, обробка пластику потребує використання спеціальних інструментів і більш точного виконання технологічних операцій. Це може впливати на витрати часу та енергії, а також ускладнювати процес виготовлення виробу.

Після визначення витрат на матеріали студент переходить до розрахунку витрат часу на виконання технологічних операцій. Наприклад, виготовлення органайзера з фанери може включати такі операції, як розмічання деталей (10–15 хвилин), розпилювання матеріалу (25–30 хвилин), шліфування поверхні (30–40 хвилин), складання конструкції (40–50 хвилин) та оздоблення виробу (30–40 хвилин). У результаті загальний час виготовлення виробу може становити приблизно 2,5–3 години.

Якщо умовно прийняти погодинну оплату праці на рівні 80 грн за годину, витрати на оплату праці становитимуть приблизно 200–240 грн. До цього можуть додаватися незначні витрати на електроенергію, пов’язані з використанням електроінструментів (електролобзик, шліфувальна машина), які можуть становити приблизно 5–7 грн.

На основі отриманих даних студент може визначити орієнтовну собівартість виготовлення органайзера з різних матеріалів. Наприклад, собівартість виробу з фанери може становити приблизно 360–400 грн, тоді як виготовлення такого ж виробу з МДФ або пластику може бути дорожчим. Після цього студент здійснює порівняльний аналіз отриманих результатів та визначає найбільш економічно вигідний варіант виготовлення виробу.

Таким чином, проведення порівняльного економічного аналізу різних матеріалів і технологічних рішень дозволяє студентам обґрунтовано визначати оптимальний варіант виготовлення виробу. Такий підхід сприяє формуванню у майбутніх учителів технологій здатності приймати раціональні рішення на основі економічних розрахунків, аналізувати витрати ресурсів і прогнозувати ефективність технологічної діяльності. У подальшій педагогічній практиці ці уміння можуть бути використані для формування у здобувачів освіти основ економічної грамотності та підприємницького мислення у процесі виконання технологічних проєктів.

Важливим елементом економічного обґрунтування у процесі виконання курсових робіт є аналіз ефективності використання матеріалів. Раціональне використання матеріальних ресурсів має значний вплив на собівартість виробу,

економічність технологічного процесу та загальну ефективність виробничої діяльності. Тому під час виконання курсових робіт студенти навчаються не лише визначати необхідну кількість матеріалів для виготовлення виробу, але й аналізувати можливості їх максимально ефективного використання.

Одним із важливих показників раціонального використання матеріальних ресурсів у процесі виготовлення виробів є коефіцієнт використання матеріалу. Цей показник характеризує ступінь ефективності використання вихідної сировини та визначається як відношення корисної площі або об'єму матеріалу, що безпосередньо використовується для виготовлення деталей виробу, до загальної кількості матеріалу, витраченого у процесі виробництва. Іншими словами, коефіцієнт використання матеріалу відображає, яка частина вихідного матеріалу перетворюється на готові деталі, а яка переходить у відходи або залишки.

У процесі виконання курсових робіт визначення цього показника дозволяє студентам здійснювати аналіз ефективності використання матеріалів та оцінювати рівень технологічних втрат, що виникають під час розмічання, різання та обробки заготовок. Для розрахунку коефіцієнта використання матеріалу студенти визначають загальну площу або об'єм використаного матеріалу, а також сумарну площу або об'єм деталей, які входять до складу готового виробу. Після цього обчислюється відповідне співвідношення, що дає змогу кількісно оцінити ефективність використання матеріальних ресурсів.

Наприклад, якщо для виготовлення виробу використовується лист фанери площею 1 м², а сумарна площа всіх деталей становить 0,8 м², коефіцієнт використання матеріалу дорівнюватиме 0,8 або 80 %. Це означає, що 80 % матеріалу використано безпосередньо для виготовлення виробу, тоді як решта 20 % становить відходи або залишки. Такий розрахунок дає змогу студентам оцінити рівень раціональності технологічного процесу та визначити можливості його вдосконалення.

Аналіз цього показника також сприяє розвитку у майбутніх учителів технологій умінь оптимізувати розміщення деталей на заготовках, планувати процес різання матеріалу та пропонувати способи зменшення втрат. Зокрема, студенти можуть застосовувати методи раціонального розкрою матеріалів, змінювати конфігурацію деталей або використовувати стандартні розміри заготовок, що дозволяє зменшити кількість відходів.

Таким чином, визначення коефіцієнта використання матеріалу є важливим елементом економічного обґрунтування технологічних рішень. Чим вищим є значення цього показника, тим ефективніше використовуються матеріальні ресурси і тим економічно доцільнішим є процес виготовлення виробу. У процесі виконання курсових робіт такі розрахунки сприяють формуванню у студентів навичок економічного аналізу виробничої діяльності, раціонального використання ресурсів та прийняття обґрунтованих технологічних рішень.

У процесі виконання курсових робіт студенти аналізують різні варіанти розміщення деталей на заготовці, що дозволяє визначити найбільш раціональний

спосіб використання матеріалу. Наприклад, під час виготовлення виробів з фанери або дерев'яної дошки важливим є правильне розташування деталей на поверхні матеріалу з урахуванням їхніх розмірів і форми. Оптимальне розміщення деталей дозволяє зменшити кількість відходів і забезпечити більш ефективне використання матеріалу.

Для ілюстрації можна розглянути приклад виготовлення настільного органайзера з фанери. Якщо розміщувати деталі виробу без урахування їх оптимального розташування, значна частина матеріалу може залишитися невикористаною у вигляді відходів. Натомість правильне компонування деталей на листі фанери дозволяє зменшити кількість залишків матеріалу та підвищити коефіцієнт його використання. Наприклад, при нераціональному розташуванні деталей коефіцієнт використання матеріалу може становити приблизно 0,65–0,70, тоді як оптимальне розміщення дозволяє підвищити цей показник до 0,80–0,85.

Крім того, під час аналізу ефективності використання матеріалів студенти враховують технологічні особливості їх обробки. Наприклад, під час розпилювання деревини необхідно враховувати ширину пропилу, яка може становити 2–3 мм. Якщо ці втрати не враховуються під час розрахунків, це може призвести до перевитрати матеріалу. Тому під час планування розкрою матеріалу студент повинен передбачати технологічні припуски та враховувати можливі втрати під час обробки.

Ще одним важливим напрямом підвищення ефективності використання матеріалів у процесі виконання курсових робіт є раціональне використання залишків матеріалу, що утворюються під час виготовлення виробів. У процесі технологічної обробки матеріалів, зокрема деревини, фанери, МДФ або пластику, неминуче виникають залишки різного розміру. У традиційному виробництві такі залишки часто розглядаються як відходи, однак у сучасному технологічному проєктуванні важливим є пошук способів їх ефективного використання.

У межах курсових робіт студенти можуть аналізувати можливості вторинного використання залишків матеріалу та пропонувати різні варіанти їх практичного застосування. Такий підхід сприяє формуванню навичок раціонального використання ресурсів, розвитку технологічного мислення та підвищенню економічної ефективності виробничої діяльності. Зокрема, під час проєктування виробу студент може заздалегідь передбачити оптимальне розташування деталей на заготовці, щоб мінімізувати кількість відходів і забезпечити можливість використання залишків для виготовлення додаткових виробів.

Наприклад, під час виготовлення виробів із фанери або деревини після розкрою основних деталей нерідко залишаються фрагменти матеріалу різної форми та розміру. Такі залишки можуть утворюватися під час вирізання конструктивних елементів виробу, формування отворів, обробки контурів або під час підгонки деталей за розмірами. У традиційному виробництві подібні фрагменти часто розглядаються як відходи, однак у процесі навчально-проєктної діяльності їх доцільно розглядати як додатковий ресурс, що може бути

використаний для виготовлення інших виробів. Такий підхід сприяє раціональному використанню матеріалів, зменшенню кількості відходів і підвищенню економічної ефективності технологічної діяльності.

Іншим прикладом є використання вузьких або видовжених залишків деревини для виготовлення декоративних накладок, рамок для фотографій або елементів інтер'єрного декору. З таких фрагментів можна створювати невеликі декоративні панелі, настінні композиції або елементи оздоблення меблів. У процесі виконання таких виробів студенти можуть застосовувати різні способи обробки поверхні: шліфування, випалювання по дереву, лакування або фарбування, що дозволяє підвищити естетичну цінність готового виробу.

Крім того, залишки матеріалу можуть використовуватися для виготовлення дрібних сувенірних виробів, наприклад брелоків, магнітів або декоративних елементів для оздоблення інтер'єру. Такі вироби можуть мати різну форму: геометричну, рослинну або символічну. Їх виготовлення дозволяє студентам відпрацьовувати навички точного різання, шліфування та декоративного оздоблення матеріалу. У деяких випадках подібні вироби можуть використовуватися як навчальні зразки або демонстраційні матеріали під час проведення уроків технологій.

Залишки більшого розміру можуть бути використані для виготовлення невеликих функціональних предметів, зокрема підставок для книг, настільних органайзерів для зберігання дрібних предметів, тримачів для смартфонів або елементів модульних конструкцій. Наприклад, із декількох залишків фанери можна створити компактний настільний органайзер, який складатиметься з відділень для ручок, олівців, блокнотів або інших канцелярських предметів. У такому випадку студенти мають можливість не лише повторно використати матеріал, але й удосконалити конструкцію виробу, враховуючи функціональні та естетичні вимоги.

Застосування такого підходу під час виконання курсових робіт сприяє формуванню у майбутніх учителів технологій навичок раціонального використання матеріальних ресурсів та розвитку екологічного мислення. Студенти навчаються оцінювати можливості повторного використання матеріалів, планувати розкрій заготовок таким чином, щоб мінімізувати кількість відходів, а також пропонувати альтернативні варіанти використання залишків матеріалу. Це дозволяє не лише підвищити економічну ефективність виробничої діяльності, але й формує відповідальне ставлення до ресурсів та принципів сталого використання матеріалів у технологічній діяльності.

Крім того, залишки матеріалу можуть використовуватися для створення декоративних композицій або дизайнерських елементів, які доповнюють основний виріб. Наприклад, з невеликих фрагментів деревини можна виготовити декоративні вставки, оздоблювальні елементи або аплікації, що надають виробу більш естетичного вигляду. У деяких випадках такі елементи можуть стати складовою частиною нового виробу або окремим декоративним об'єктом.

Використання залишків матеріалу також може бути пов’язане з створенням комплектів виробів. Наприклад, під час виготовлення настільного органайзера студент може використати залишки фанери для створення додаткових підставок під телефон, тримачів для олівців або невеликих коробок для зберігання канцелярських предметів. Такий підхід дозволяє розширити функціональні можливості виробу та підвищити його практичну цінність.

З економічної точки зору використання залишків матеріалу дозволяє зменшити загальні витрати на виробництво, оскільки частина продукції виготовляється з матеріалів, які вже були придбані для виконання основного проєкту. У результаті підвищується коефіцієнт використання матеріалу та знижується собівартість виготовлення виробів. Крім того, виготовлені з залишків додаткові вироби можуть мати самостійну цінність і використовуватися як окремі предмети або навчальні зразки.

Важливим аспектом такого підходу є також екологічний компонент. Раціональне використання матеріалів сприяє зменшенню кількості відходів виробництва та формує у студентів відповідальне ставлення до використання природних ресурсів. У цьому контексті економічне обґрунтування технологічних проєктів поєднується з принципами екологічної доцільності та сталого розвитку.

Таким чином, використання залишків матеріалу у процесі виконання курсових робіт сприяє підвищенню ефективності використання ресурсів, розвитку творчого підходу до технологічної діяльності та формуванню у майбутніх учителів технологій навичок раціонального виробництва. Такий підхід дозволяє не лише зменшити кількість відходів, але й підвищити економічну ефективність технологічного процесу, що є важливим елементом сучасної технологічної освіти.

Крім економічного аспекту, раціональне використання матеріалів має також важливе екологічне значення. Зменшення кількості відходів сприяє більш відповідальному ставленню до використання природних ресурсів та формує у студентів екологічну культуру. У цьому контексті економічне обґрунтування технологічних проєктів поєднується з принципами сталого розвитку та раціонального природокористування.

Таким чином, аналіз ефективності використання матеріалів у процесі виконання курсових робіт сприяє формуванню у майбутніх учителів технологій важливих професійних умінь: планування використання ресурсів, оптимізації технологічних процесів, зменшення виробничих витрат і раціонального використання матеріалів. Ці навички мають важливе значення для їхньої подальшої педагогічної діяльності, оскільки дозволяють формувати у здобувачів освіти практичні навички економічно та екологічно відповідального ставлення до технологічної діяльності.

Крім того, під час виконання курсових робіт доцільно використовувати метод порівняння альтернативних технологічних рішень, який дозволяє оцінити ефективність різних способів виготовлення виробу та визначити найбільш раціональний варіант з економічної і технологічної точки зору. Застосування

такого методу сприяє формуванню у студентів навичок аналітичного мислення, уміння оцінювати різні виробничі ситуації та приймати обґрунтовані рішення на основі комплексного аналізу витрат і результатів.

У межах курсової роботи студент може порівнювати різні варіанти виконання технологічних операцій, що відрізняються за способом обробки матеріалу, використаними інструментами, витратами часу, енергії та рівнем технологічної складності. Одним із найбільш поширених прикладів такого порівняння є аналіз використання ручних інструментів та електроінструментів під час виготовлення виробу.

Наприклад, під час виготовлення деталей з деревини студент може виконувати операцію розпилювання за допомогою ручної ножівки або електролобзика. У разі використання ручного інструменту витрати часу на виконання операції можуть становити приблизно 25–30 хвилин, залежно від товщини матеріалу та складності розпилу. Використання електролобзика дозволяє скоротити тривалість цієї операції до 5–7 хвилин, що значно підвищує продуктивність праці. Однак застосування електроінструменту передбачає додаткові витрати електроенергії, а також необхідність використання відповідного обладнання та дотримання правил техніки безпеки.

Під час проведення економічного аналізу студент враховує всі ці фактори. Зокрема, він визначає витрати часу на виконання операції в кожному випадку та переводить їх у грошовий еквівалент, використовуючи умовну погодинну оплату праці. Наприклад, якщо погодинна ставка становить 80 грн, виконання операції розпилювання ручним інструментом протягом 30 хвилин становитиме приблизно 40 грн, тоді як використання електролобзика протягом 7 хвилин – приблизно 9–10 грн.

Разом із тим студент повинен врахувати витрати на електроенергію. Наприклад, якщо потужність електролобзика становить 600 Вт, а тривалість роботи – 7 хвилин, споживання електроенергії становитиме приблизно 0,07 кВт·год. При вартості електроенергії 4 грн за кВт·год витрати складуть лише близько 0,3 грн, що є незначним порівняно з економією часу. У результаті такого аналізу студент може зробити висновок, що використання електроінструменту є більш ефективним з економічної точки зору.

Аналогічний підхід може застосовуватися і для інших технологічних операцій, зокрема шліфування, свердління або фрезерування матеріалів. Наприклад, шліфування поверхні виробу за допомогою ручного шліфувального бруска може тривати 40–50 хвилин, тоді як використання електричної шліфувальної машини дозволяє виконати цю операцію за 10–15 хвилин. У цьому випадку студент також оцінює витрати часу, електроенергії та можливі переваги використання сучасних технологічних засобів.

Крім інструментів, метод порівняння альтернативних технологічних рішень може застосовуватися і під час вибору матеріалів, конструкцій або способів з'єднання деталей. Наприклад, студент може порівняти використання клеєвого з'єднання та механічного кріплення (шурупів або саморізів) і визначити, який

варіант є більш доцільним з точки зору витрат матеріалів, часу виконання операції та міцності конструкції.

Застосування методу порівняння альтернативних технологічних рішень сприяє більш глибокому розумінню студентами взаємозв'язку між технологічними та економічними аспектами виробничої діяльності. Вони навчаються оцінювати не лише технічну можливість виконання певної операції, але й її економічну ефективність, продуктивність праці та доцільність використання ресурсів. У результаті формується комплексний підхід до вирішення технологічних завдань, що поєднує технічні, економічні та організаційні аспекти виробництва.

Таким чином, застосування методу порівняння альтернативних технологічних рішень у процесі виконання курсових робіт виступає важливим педагогічним інструментом формування професійних компетентностей майбутніх учителів технологій. Використання цього методу сприяє розвитку у студентів аналітичного підходу до організації технологічної діяльності та формує здатність здійснювати обґрунтований вибір найбільш ефективних способів виконання виробничих операцій.

У процесі виконання курсових робіт студенти мають можливість порівнювати різні варіанти технологічних рішень, що можуть застосовуватися під час виготовлення певного виробу. Такий аналіз може охоплювати вибір матеріалів, способів обробки, використання різних інструментів і обладнання, а також визначення оптимальної послідовності технологічних операцій. Порівняння альтернативних варіантів дозволяє оцінити їхні переваги та недоліки, визначити рівень трудомісткості виробничих процесів, витрати часу, матеріалів і енергетичних ресурсів.

Застосування цього методу також сприяє формуванню у студентів умінь здійснювати комплексний аналіз виробничих процесів. Майбутні учителі технологій навчаються оцінювати ефективність різних способів обробки матеріалів, визначати доцільність використання ручних або електричних інструментів, аналізувати вплив технологічних рішень на якість готового виробу та рівень витрат ресурсів. У процесі такого аналізу студенти розглядають не лише технічні характеристики обладнання та технологічних операцій, але й економічні аспекти виробництва, зокрема собівартість виготовлення виробу, витрати енергії, раціональність використання матеріалів і трудових ресурсів.

Крім технічних і економічних чинників, під час порівняння альтернативних технологічних рішень враховуються також організаційні аспекти технологічної діяльності. Зокрема, студенти аналізують складність виконання окремих операцій, безпечність використання обладнання, тривалість виробничого процесу та можливість оптимізації послідовності технологічних етапів. Такий підхід дозволяє сформувати у майбутніх педагогів комплексне бачення виробничої діяльності як системи взаємопов'язаних технологічних, економічних і організаційних процесів.

Порівняльний аналіз альтернативних технологічних рішень сприяє розвитку у студентів умінь системного мислення та здатності оцінювати виробничі процеси з різних позицій. Зокрема, майбутні вчителі технологій навчаються визначати переваги та недоліки різних технологічних підходів, аналізувати витрати часу, матеріалів і енергії, а також прогнозувати результати реалізації того чи іншого технологічного рішення. Такий підхід дозволяє формувати навички раціонального планування технологічної діяльності та прийняття обґрунтованих рішень у процесі виготовлення виробів.

Крім того, використання методу порівняння альтернативних технологічних рішень сприяє розвитку аналітичних, дослідницьких та прогностичних умінь студентів. Вони навчаються працювати з технічною інформацією, здійснювати порівняльний аналіз різних варіантів виконання технологічних операцій, оцінювати економічну ефективність використання ресурсів та визначати найбільш доцільний спосіб реалізації технологічного проєкту. У результаті формується здатність обґрунтовувати власні рішення на основі логічного аналізу та економічних розрахунків.

Особливого значення такі уміння набувають у контексті майбутньої педагогічної діяльності вчителя технологій. У процесі навчання здобувачів освіти майбутній педагог повинен не лише демонструвати технологічні прийоми або пояснювати принципи виготовлення виробів, але й формувати у учнів уміння аналізувати різні способи виконання технологічних завдань, оцінювати їх ефективність і обирати найбільш раціональний варіант. Використання порівняльного аналізу технологічних рішень у навчальному процесі сприяє розвитку у здобувачів освіти критичного мислення, здатності до самостійного прийняття рішень та відповідального ставлення до використання матеріальних ресурсів.

Отже, застосування методу порівняння альтернативних технологічних рішень у процесі виконання курсових робіт дозволяє сформувати у майбутніх учителів технологій важливі професійні уміння: аналізувати виробничі процеси, оцінювати ефективність різних технологічних підходів, оптимізувати використання ресурсів та аргументовано обґрунтовувати прийняті рішення. Опанування цих умінь створює необхідні передумови для формування у здобувачів освіти основ раціонального, економічно обґрунтованого та відповідального підходу до технологічної діяльності, що відповідає сучасним вимогам технологічної освіти.

Проведений аналіз засвідчує, що включення економічного обґрунтування до структури курсових робіт є важливим складником професійної підготовки майбутніх учителів технологій. Такий підхід забезпечує інтеграцію технологічних, організаційних та економічних знань і сприяє формуванню у студентів системного бачення технологічної діяльності як процесу, що поєднує технічні рішення з економічною доцільністю їх реалізації.

Виконання економічних розрахунків у межах курсових робіт дозволяє студентам на практиці застосовувати елементи економічного аналізу під час

проєктування та виготовлення виробів. У процесі такої діяльності майбутні вчителі технологій набувають умінь визначати витрати матеріальних, трудових та енергетичних ресурсів, розраховувати собівартість виробу, оцінювати ефективність використання матеріалів і порівнювати альтернативні технологічні рішення. Важливим результатом є також розвиток здатності аналізувати різні варіанти організації технологічного процесу та обирати найбільш економічно доцільний.

Застосування економічного обґрунтування у курсових роботах сприяє формуванню у студентів аналітичного та критичного мислення, уміння планувати виробничу діяльність, прогнозувати результати реалізації технологічних проєктів і приймати обґрунтовані рішення. Крім того, така діяльність розвиває навички раціонального використання ресурсів, оптимізації технологічних процесів та зменшення виробничих витрат, що є важливими складниками сучасної технологічної культури.

Отже, використання економічного обґрунтування у процесі виконання курсових робіт сприяє формуванню у майбутніх учителів технологій важливих професійних компетентностей: здатності аналізувати виробничі процеси, оцінювати ефективність технологічних рішень, визначати витрати ресурсів і планувати технологічну діяльність з урахуванням економічних факторів. Опанування цих умінь має важливе значення для їхньої подальшої педагогічної діяльності, оскільки дозволяє інтегрувати економічні знання у зміст технологічної освіти та формувати у здобувачів освіти практичне розуміння економічних аспектів технологічної діяльності, підприємницького мислення та раціонального використання ресурсів.

Перспективи подальших досліджень можуть бути пов’язані з розробленням методичних рекомендацій щодо інтеграції економічного обґрунтування у різні види навчально-проєктної діяльності студентів, а також з удосконаленням методики формування економічної компетентності майбутніх учителів технологій у процесі їхньої професійної підготовки.

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CHAPTER 3. THE LATEST BASICS OF AGRICULTURAL DEVELOPMENT

3.1. Ecological Safety and Risk Assessment of Biological Preparations

ЕКОЛОГІЧНА БЕЗПЕЧНІСТЬ І ОЦІНКА РИЗИКІВ БІОПРЕПАРАТІВ

У сучасних умовах стрімкого зростання чисельності населення планети, яке за обґрунтованими демографічними прогнозами досягне позначки у 10 мільярдів осіб до 2050 року, забезпечення глобальної продовольчої безпеки постає як один із найкритичніших і найскладніших викликів для людської цивілізації. Ситуація ускладнюється безперервним антропогенним тиском на природні екосистеми та глобальними кліматичними змінами, які створюють сприятливі умови для поширення та еволюції фітопатогенів. Щороку сільськогосподарські шкідники та хвороби спричиняють безповоротну втрату від 20% до 40% світового врожаю основних продовольчих культур. В економічному еквіваленті ці втрати становлять понад 470 мільярдів доларів США щорічних збитків. Історичний досвід наочно демонструє, що безконтрольне розмноження шкідливих організмів неодноразово призводило до масштабного голоду цілих націй, а сьогодні близько 100 мільйонів тонн сільськогосподарської продукції щорічно знищується ще до моменту збору врожаю або під час його подальшого зберігання. Додатково слід зазначити, що понад 67 000 видів шкідників становлять пряму або опосередковану загрозу не лише для продовольчого забезпечення, а й для здоров'я людини, оскільки майже дві третини населення світу перебувають під перманентною загрозою захворювань, що передаються комахами-переносниками.

Інтенсифікація сільського господарства у другій половині XX століття, відома як «Зелена революція», спиралася переважно на масове та системне використання хімічних (синтетичних) пестицидів. Незважаючи на їхню високу первинну ефективність у підвищенні врожайності, надмірне та безконтрольне застосування агрохімікатів призвело до катастрофічних екологічних наслідків глобального масштабу. До них належать глибока деградація ґрунтів, контамінація поверхневих та підземних водних ресурсів стійкими органічними забруднювачами, різке скорочення біорізноманіття та знищення нецільових корисних організмів, зокрема комах-запилювачів. Крім того, еволюційний тиск синтетичних пестицидів спровокував швидкий розвиток резистентності у цільових видів шкідників, що змушує аграріїв постійно збільшувати дози хімікатів, створюючи замкнене коло токсикологічного навантаження на біосферу.

Відповіддю наукової спільноти на ці глобальні виклики стало впровадження концепції «Єдине здоров'я» (One Health). Ця міждисциплінарна парадигма інтегрує здоров'я людей, тварин, рослин та екосистем у єдину нерозривну функціональну систему, що повністю відповідає Цілям сталого розвитку ООН, зокрема цілям подолання голоду, збереження наземних екосистем та забезпечення відповідального споживання. У цьому концептуальному контексті мікробні біопестициди — високоспецифічні природні агенти, отримані з бактерій, вірусів, грибів, водоростей та нематод — пропонують надзвичайно

потужну, екологічно збалансовану альтернативу традиційним синтетичним препаратам.

Мікробні біопестициди забезпечують цілеспрямований контроль фітопатогенів та шкідників, мінімізуючи при цьому негативний вплив на нецільові організми та довкілля загалом. Проте, масштабування біологічних методів захисту вимагає надзвичайно глибокого розуміння їхніх молекулярно-генетичних механізмів дії, екологічної динаміки у ґрунтових біоценозах, економічної доцільності застосування в агропромислових комплексах та, що є абсолютно критичним, потенційних токсикологічних, імунологічних та епідеміологічних ризиків для здоров'я людини. Ця доповідь містить вичерпний, експертний науковий аналіз ефективності, молекулярно-клітинних механізмів та об'єктивну оцінку ризиків мікробних біопрепаратів.

Біопрепарати відіграють все більш вагому роль у сучасних агрозаходах. Їх застосовують як самостійно, так і в поєднанні з іншими методами, включаючи хімічні препарати, агротехнічні заходи та природних ворогів шкідників. Серед відомих прикладів – успішне застосування *Bacillus thuringiensis* для контролю личинок метеликів, *Trichoderma spp.* як фунгіцидного агента та *Beauveria bassiana* проти комах-шкідників.

Світова практика демонструє значну поширеність цих технологій. Так, в окремих штатах США площі, оброблені мікробними інсектицидами (насамперед препаратами на основі *Bacillus*), складають сотні тисяч гектарів; бразильські фермери на мільйонах гектарів використовують ентомопатогенні гриби та бактерії. Латинська Америка навіть лідирує за обсягом ринку біопестицидів, особливо грибкових, у той час як у ЄС їх частка менша через суворіші регулювання [1].

В Європейському Союзі діє розгалужена та чітко структурована система нормативно-правового регулювання у сфері обігу пестицидів, що охоплює процедури їх схвалення, класифікації та подальшого контролю. Зазначена система поєднує передреєстраційну оцінку ризиків, постмаркетинговий нагляд та регулярний перегляд дозволів з метою підтвердження відповідності засобів захисту рослин вимогам щодо охорони здоров'я населення, безпеки довкілля та захисту харчового ланцюга. Процедура реєстрації ботанічних активних речовин здійснюється в тому самому правовому полі, що й для синтетичних препаратів, — відповідно до Регламенту (ЄС) № 1107/2009 [3]. У межах цієї процедури Європейське агентство з безпеки харчових продуктів (EFSA) здійснює наукову оцінку ризиків, що слугує підґрунтям для прийняття регуляторних рішень, зокрема щодо потенційного впливу біопестицидів на організм людини, нецільові біологічні об'єкти та стан навколишнього середовища. Багаторівнева архітектура цієї системи виключає можливість реєстрації пестицидів, у тому числі біологічного походження, без переконливих доказів того, що рівні експозиції для людини не перевищують допустимих порогових значень.

Реєстрація активної речовини здійснюється за умови підтвердження її безпечності для здоров'я людини та відсутності неприйнятного негативного

впливу на довкілля. Разом із тим окремі речовини рослинного походження отримували дозвіл попри виявлені в ході оцінки прогалини в даних та наукову невизначеність, що унеможливлювала повноцінне встановлення їхнього профілю безпеки. Недосконаліть методологій тестування, недостатня повнота наявних наборів даних та обмеження системи повідомлення про небажані ефекти зумовлюють ситуацію, за якої певні несприятливі наслідки застосування препаратів можуть виявлятися лише після тривалого перебування їх у обігу [4]. У процесі поновлення дозволів препарати залишаються доступними на ринку навіть під час проведення нових оцінок, що нерідко спираються на неповні масиви даних у частині окремих сценаріїв експозиції.

Поряд із регуляторними та токсикологічними аспектами, важливим чинником формування загальної картини безпеки біопестицидів є людський фактор. У науковій літературі ці препарати стійко позиціонуються як екологічно прийнятніші та більш сталі замінники традиційних хімічних засобів, що суттєво впливає на ставлення до них з боку користувачів [5-8]. У документах Європейського парламенту та Інституту європейської екологічної політики біопестициди розглядаються як один із ключових інструментів переходу до сталого сільського господарства, що вписується в логіку Спільної аграрної політики ЄС та цілей Європейської зеленої угоди [9,10].

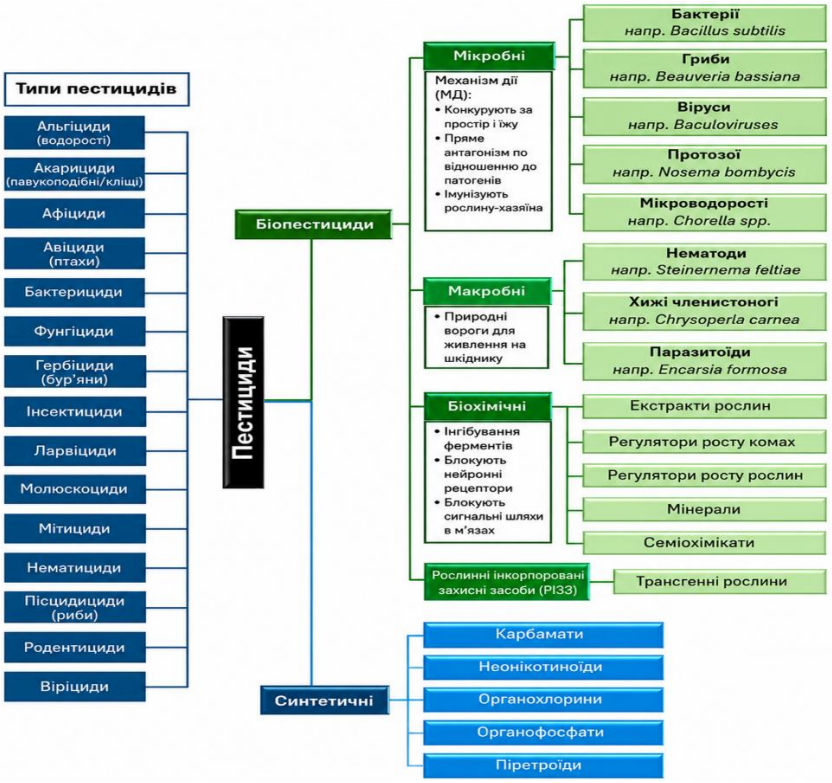

Рис.1. Огляд різних видів пестицидів — синтетичних та біопестицидів [2].

Основні переваги біопрепаратів пов'язані з їх екологічним профілем і біологічною специфічністю. На відміну від широкоспектральних синтетичних

пестицидів, більшість мікробних біопрепаратів діють вузькоцільово – на певні групи шкідників, не ушкоджуючи хазяїна та не накопичуючись у ґрунті чи воді. Якщо розглядати препарати, основним компонентом котрого є *Bacillus*, так звані Bt-кристали стають токсичними лише в лужному середовищі кишківника комах, тоді як у шлунку людини та ссавців вони руйнуються, не завдаючи шкоди. У результаті, біопестициди забезпечують "відносно менше шкідливих впливів на людей та навколишнє середовище, ніж синтетичні пестициди".

Крім безпеки, біопрепарати мають і функціональні переваги. Вони можуть поєднуватися з агротехнікою органічного землеробства, де застосовується менше хімікатів, а отже, знижений рівень залишкових токсинів у продукції. За даними порівняльного огляду, органічна продукція містить значно меншу кількість залишкових пестицидів і набагато нижчої токсичності, ніж конвенційна. Фактично, перехід на біопрепарати сприяє зниженню ризику харчового забруднення пестицидами та дозволяє подовжити інтервали між обробками. З огляду на зростання попиту на продукти органічного походження, впровадження мікробних засобів є взаємозв'язано з прагненням до більш екологічних агротехнологій [11].

Системні дослідження показують, що біопрепарати можуть ефективно контролювати цільові шкідники. Препарати, про котрі було згадано вище, тобто препарати на основі *Bacillus subtilis*, а також *Pseudomonas spp*. індукують системний імунітет рослин, підвищуючи стійкість до грибкових збудників та показали високу летальність для личинок лускокрилих без шкоди для сільськогосподарських тварин і корисних членистоногих.

Інший вид мікроорганізма *Trichoderma spp.* контролюють ґрунтові патогени, стимулюють ріст рослини та мають можливість не тільки захищати рослину від патогенів, а ще й здійснювати біоремедіації ґрунті від важких металів та різного типу хімічного забруднення.

Окрім *Trichoderma*, також гриби виду *Aspergillus* розкладають агрохімікати і токсини, відновлюючи родючість ґрунту. Таким чином, інтеграція біопрепаратів в ґрунтове середовище сприяє підвищенню врожайності та безпечності виробництва у довгостроковій перспективі [2].

Хоча більшість біопрепаратів вважаються безпечними для людей, регулятори вимагають оцінки потенційних інфекційних ризиків. Окремі штами бактерій чи грибів, що використовуються в біопрепаратах, можуть за певних умов проявляти патогенність. Наприклад, *Bacillus thuringiensis* дуже близький до *Bacillus cereus* – збудника харчових отруєнь. Згідно з останнім аналізом, окремі Bt-штами, виявлені в харчових продуктах, пов'язують із випадками діареї у людей. Натомість науковці зауважують, що в цілому «сприйнята безпека» Bt підтримується: Bt-токсини не діють на організм людини через відсутність специфічних рецепторів і відповідного pH. Проте, як підкреслюють Biggel et al. (2022), поодинокі випадки захворювань тим не менше спонукають до комплексної оцінки штамів: необхідно переходити від оцінки безпеки на рівні виду до конкретних штамів з урахуванням наявності генів патогенності [12].

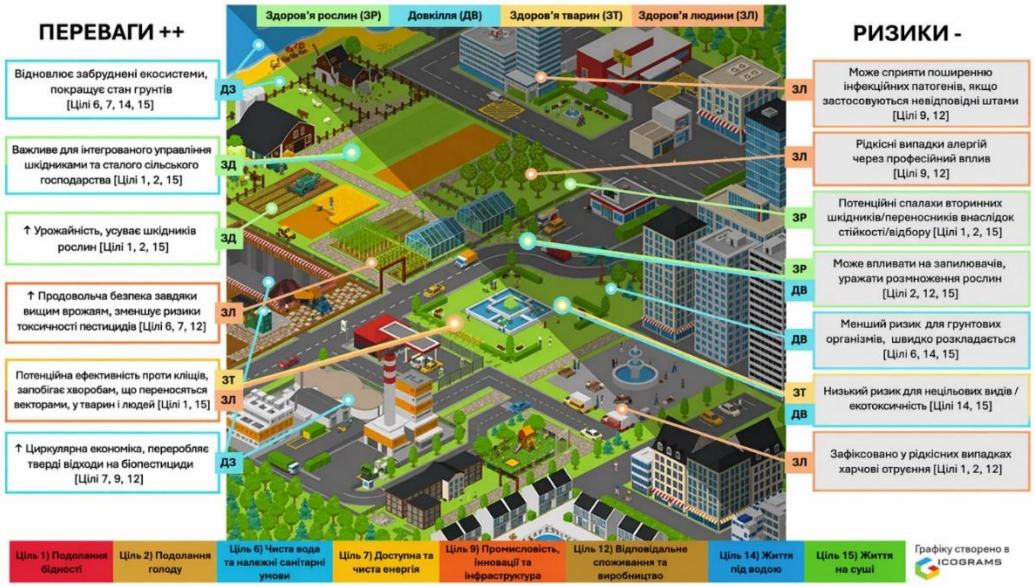

Рис.2. Інфографіка , що зображує переваги та ризики використання біопестицидів у міському середовищі крізь призму політики «Єдине здоров'я» у відповідності до Цілей сталого розвитку ООН [2].

Іншим потенційним ризиком є зараження людей чи тварин інфекційними агентами, що використовуються для біоконтролю шкідників. Наприклад, штами ентомопатогенних грибів (*Metarhizium*, *Beauveria*) можуть випадково викликати поверхневі інфекції або алергічні реакції у людей з ослабленим імунітетом. Так, ряд досліджень виявив у працівників ґрунтових фермерських господарств підвищений рівень IgE-антитіл до *B. thuringiensis*, що свідчить про імунну відповідь [13]. Проте такі випадки поодинокі, а ретельні випробування переважно виявляють відсутність захворювань у контактуваних з біопрепаратами добровольців. Зрештою, сучасна система регуляторного схвалення біопестицидів вимагає детального вивчення токсикологічного профілю кожного штаму, що суттєво знижує ймовірність допуску небезпечного агента [1].

Навіть якщо біопрепарат не викликає інфекцію, він може спричинити алергічну або токсичну реакцію у людей. Існують повідомлення про окремі випадки шкірної сенсибілізації, головного болю, подразнення очей або дихальних шляхів у фахівців, що працювали з біопрепаратами на основі *Bacillus thuringiensis* та інших мікроорганізмів. Хоча такі ефекти зазвичай слабкі, вони підкреслюють важливість використання засобів індивідуального захисту (ЗІЗ) працівниками при обробці полів. Згідно з нормами ЄС, виробники біопрепаратів зобов'язані інформувати про потенційні алергени та проводити оцінку сенсибілізаційних ризиків. Деякі дослідження на моделях тварин також демонструють, що білкові кристали Bt (наприклад, Cry1Ac) мають потенціал викликати імунні або алергічні реакції при потраплянні в організм. Однак ці результати слід інтерпретувати з обережністю: вплив у високих дозах у лабораторних умовах не завжди корелює з реальними умовами експозиції. Загалом, сучасні дані дозволяють стверджувати, що важливим пріоритетом є

навчання персоналу безпечному поводженню з біопрепаратами, а також суворе дотримання інструкцій щодо дозування й застосування [2].

У порівнянні з традиційними пестицидами, біопрепарати мають дуже низьку системну токсичність, і залишки їхніх активних речовин у продукції практично не накопичуються. Європейське агентство з безпеки продуктів харчування (EFSA) не встановлює максимальні залишкові норми для Bt-препаратів саме через їхній мінімальний ризик. Практичні дослідження показують, що під час тривалого прийняття добровольцями харчових добавок з Bt не призводило до негативних ефектів. Відтак випадки харчових отруєнь, пов'язаних із застосуванням мікробних біопестицидів, надзвичайно рідкісні. Великий огляд вказує, що інколи Bt, який потрапляє на фрукти або овочі після обприскування, може спричинити незначний гастроентерит у споживачів, але такі інциденти не виходять за рамки випадкових і потребують додаткового вивчення.

Словом, з точки зору безпеки харчових продуктів, ліпше споживати продукцію, вирощену з біопрепаратами, ніж з хімічними пестицидами. Органічні та екологічні технології, до яких належать біологічні засоби захисту, забезпечують продукцію із значно нижчим вмістом токсичних залишків. Це також знижує ризик побічних ефектів у споживачів, таких як випадки шлунково-кишкового розладу. Проте необхідно уникати контакту з неконтрольованими біоматеріалами та забезпечувати ретельне миття плодів [11].

Біопрепарати зазвичай мають вузький спектр дії, тому їхній прямий негативний вплив на нетаргетні організми (птахів, земноводних, ссавців) є вкрай низьким. Проте непрямі ефекти можливі. По-перше, обмеження чисельності одного шкідника може змінити харчовий ланцюг і вплинути на хижаків чи паразитів, що на нього харчуються. По-друге, нові дані свідчать, що деякі фонові компоненти біопрепаратів або їх метаболіти можуть небажано впливати на нецільові безхребетні. Наприклад, дослідження останніх років виявили, що навіть широко вважані безпечними грибкові препарати (*Metarhizium*, *Beauveria*) можуть інгібувати розвиток корисних комах, хоча здебільшого це відбувається при дуже високих концентраціях.

Окремим ризиком є вплив на запилювачів – бджіл, джмелів, метеликів тощо. Класична позиція полягала в тому, що мікробні біопестициди практично безпечні для дорослих запилювачів (наприклад, Bt не впливає на бджіл безпосередньо). Однак сучасні дослідження підозрюють сублетальні ефекти: зміни поведінки, зниження плодючості та імунітету. Зростає кількість доказів, що біоінсектициди можуть завдавати шкоди медоносним бджолам. Це пояснюють тим, що бджоли можуть контактувати з препаратами, збираючи нектар і пилок, і навіть незначні дози токсинів (навпаки тимчасово нешкідливих для людини) можуть накопичуватися в організмі комах. Отже, сучасні схеми тестування безпеки передбачають спеціальні випробування на бджолах при реальних дозах. На щастя, бічні ефекти проявляються рідко й часто залежать від умов застосування. Однак важливо уникати обприскувань у час цвітіння або під час льоту бджіл, а

також контролювати взаємодію різних біопрепаратів при комбінованому застосуванні [12].

Однією з багатьох переваг біопрепаратів є те, що вони швидко руйнуються під дією сонячного світла та мікрофлори ґрунту, а також мають складні механізми дії (комплекс білків і ферментів), що ускладнює формування резистентності у шкідників. За оцінками, при правильному застосуванні ризик виникнення стійкості до біопрепаратів значно менший, ніж до однотипних синтетичних інсектицидів. Проте ризик не виключений цілком. Мікроорганізми можуть індукувати імунітет рослин чи шкідників, змінювати поведінку популяцій та взаємодіяти в ґрунті так, що з часом окремі шкідники можуть адаптуватися. Саме тому, під час введенння препарату у систему, рекомендують чергувати різні біологічні та хімічні методи, а також використовувати комбінації біопрепаратів із різними діючими речовинами. У ключовій роботі з медоохорони підкреслюється, розумне застосування мікробних біопестицидів в умовах ґрунту, має максимізувати користь для здоров'я людей і екосистем, мінімізуючи при цьому розвиток резистентності [13,14].

Загальна оцінка вище сказаного дає підстави стверджувати, що переваги біопрепаратів переважають потенційні ризики при їх правильному використанні. Біопрепарати безпечніші за хімічні аналоги для людей і довкілля: вони мають вузький спектр дії, низьку стійкість у навколишньому середовищі і високий ступінь специфічності. Водночас ризики зводяться до мінімуму за умови дотримання рекомендацій виробників та міжнародних регулювань. Експериментальний аналіз показує, що біопрепарати не створюють помітного додаткового ризику для споживачів їжі або навколишніх організмів, якщо їх застосовувати з урахуванням термінів карантину, дозування та засобів індивідуального захисту.

На основі аналізу сучасних джерел можна зробити висновок, що біопрепарати є ефективними та екологічно безпечними засобами захисту рослин. Вони дозволяють контролювати широкий спектр шкідників і збудників хвороб, при цьому значно зменшуючи негативний вплив на довкілля порівняно з хімічними пестицидами. Завдяки швидкому природному розкладанню та низькому ризику для нецільових організмів, такі засоби активно впроваджуються в органічне та інтегроване землеробство.

Використання біопрепаратів також позитивно впливає на продовольчу безпеку, оскільки сприяє стабільному підвищенню врожайності та зменшенню втрат продукції без шкоди для людини й екосистем. Разом із тим, їх застосування потребує контролю якості, оцінки можливих ризиків та дотримання технологічних рекомендацій.

Подальший розвиток цієї галузі пов'язаний із вдосконаленням методів контролю безпеки, моніторингом довгострокового впливу на екосистеми та розширенням знань серед агровиробників.

У підсумку, біопрепарати є перспективним напрямом у захисті рослин, який поєднує ефективність і екологічну безпечність та сприяє сталому розвитку сільського господарства.

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CHAPTER 4. EDUCATIONAL PRINCIPLES FOR TRAINING SPECIALISTS IN CONSTRUCTION OF DISTRIBUTED GENERATION SYSTEMS TO ENSURING SUSTAINABLE DEVELOPMENT OF COMMUNITIES

4.1. Theoretical and Methodological Principles of Training Specialists in the Construction of Distributed Generation Systems

The world energy sector in the XXI century is undergoing a large-scale transformation, characterized by the transition from centralized models of electricity production to decentralized, digitalized and environmentally friendly energy supply systems. The main factors of such changes are the need to reduce greenhouse gas emissions, increase energy security, diversify energy sources, integrate renewable energy sources and implement international commitments to achieve climate neutrality.

The problem of modernizing energy systems has become particularly urgent in Ukraine in the context of military aggression by the Russian Federation, accompanied by the systematic destruction of critical energy infrastructure facilities. Significant losses of generating capacity and network infrastructure have demonstrated the high vulnerability of the centralized model of electricity supply and have highlighted the need for widespread implementation of distributed generation systems capable of ensuring autonomy, redundancy and energy sustainability of territorial communities.

Distributed generation is a system of electricity production directly near the places of its consumption using small generating units of various capacities, operating autonomously or integrated into the general energy network. Unlike the traditional centralized model, such a system ensures the reduction of electricity losses during transportation, increased reliability of electricity supply, increased share of renewable energy sources and the ability to respond promptly to emergencies.

According to the International Energy Agency, in the coming decades, distributed generation, solar energy, energy storage and intelligent electrical networks will form the basis of modern energy. At the same time, the requirements for engineering personnel are changing, whose activities are increasingly related not only to the operation of energy equipment, but also to digital modeling, automation, analysis of large data sets, integration of information technologies and artificial intelligence systems into the processes of managing energy complexes [8, 26, 46–51].

In modern conditions, a specialist in the construction of distributed generation systems must possess a set of interdisciplinary competencies that include electric power engineering, electrical engineering, automation, information technology, cybersecurity, energy economics, ecology, project management, and regulatory support for the functioning of energy systems. This necessitates the revision of traditional models of professional training and the transition to competency-based education.

The practice-oriented nature of training is of particular importance. It is practical training that ensures the formation of the ability of future engineers to make technical decisions in real conditions of the functioning of energy systems, to use modern modeling software, to carry out a technical and economic analysis of alternative energy

sources, and to develop comprehensive solutions to increase the energy sustainability of communities [30, 31].

In modern pedagogical science, practice-oriented education is considered as the integration of fundamental theoretical training with professional activities through the implementation of projects, production cases, laboratory research, dual training and student participation in real engineering developments. This approach allows us to reduce the gap between academic education and the needs of employers [18, 20].

Next, we will consider the energy sustainability of territorial communities as a new social demand for the education system.

Decentralization of public administration in Ukraine has significantly changed the role of territorial communities in ensuring their own socio-economic development. Along with issues of financial management, education and healthcare, the competence of local governments increasingly includes issues of energy security, management of local energy resources and implementation of energy efficiency projects.

The energy sustainability of a territorial community is considered as the ability of the local energy system to ensure a continuous supply of energy resources even under conditions of external or internal crisis influences. It is formed due to the combination of several components: diversification of energy sources, development of local generation, use of energy storage systems, digitalization of electrical networks, implementation of modern demand management systems and improvement of energy efficiency [30–39].

Distributed generation systems are increasingly considered as the main tool for ensuring the energy independence of communities. They may include solar power plants, wind turbines, biogas complexes, cogeneration plants, small hydroelectric power plants, gas piston plants, diesel backup power plants, battery energy storage systems and intelligent microgrid control systems [43–45].

At the same time, the effective implementation of such technologies requires highly qualified engineers of a new generation who are able not only to design individual energy installations, but also to carry out comprehensive modeling of local energy systems, assess their economic efficiency, predict operating modes, analyze risks and ensure cyber protection of digital infrastructure.

Thus, the modern system of higher technical education must respond to new challenges by updating the content of educational programs, integrating digital learning technologies, developing practice-oriented forms of professional training and active cooperation with energy industry enterprises.

The modern development of the energy sector is characterized by the integration of information technologies, automation, digital management platforms and renewable energy sources. This necessitates a rethinking of traditional models of professional training of engineering personnel. The educational process can no longer be limited to the transfer of knowledge from individual disciplines, since the professional activity of a specialist in the field of distributed generation requires a comprehensive solution of technical, economic, environmental and managerial tasks.

In pedagogical theory, the methodology of professional training is considered as a system of interconnected scientific approaches, principles, laws and pedagogical conditions that determine the content, structure and organization of the educational process. For the training of future specialists in the construction of distributed generation systems, the most appropriate is a combination of competency, systemic, activity, practice-oriented, interdisciplinary and digital approaches [58, 59, 61–64].

The competency approach is the basic methodological basis of modern engineering education. Its main idea is to form the ability of a graduate to effectively apply the acquired knowledge, skills, abilities and personal qualities to solve professional tasks in real production conditions [12, 31].

According to the recommendations of the European Higher Education Area, competence is defined as a dynamic combination of knowledge, practical skills, ways of thinking, professional values and responsibilities that ensure successful professional activity.

In the field of distributed generation, professional competence includes:

– design of local energy systems;
– calculation of operating modes of electrical networks;
– integration of renewable energy sources;
– use of digital Smart Grid models;
– assessment of energy efficiency;
– use of modern modeling software;
– risk management of energy systems;
– ensuring cybersecurity of digital infrastructure [29, 31].

It is the competency-based approach that ensures the integration of fundamental engineering training with modern labor market requirements.

The peculiarities of the functioning of distributed generation systems necessitate the use of a systems approach.

Any modern energy system is a complex technical complex that includes: generating installations; electrical networks; energy storage systems; automated control systems; information and communication infrastructure; software; electricity consumers; economic mechanisms of functioning.

A future engineer must learn to consider all these elements as a single integrated system, in which changing the parameters of one component affects the functioning of the entire energy network.

Systems thinking allows you to make complex decisions regarding:

– optimal selection of generation sources;
– power supply backup;
– load balancing;
– optimization of operating modes;
– increasing the energy sustainability of the community.

One of the leading principles of modern engineering education is an activity approach, according to which professional competencies are formed not through

passive assimilation of information, but in the process of performing professionally oriented activities.

For future specialists, this means active involvement in: laboratory research; engineering calculations; modeling of power grid operation modes; designing solar and wind power plants; developing local energy projects; assessing the economic efficiency of investments.

It is during the implementation of complex engineering tasks that professional thinking, the ability to make decisions under uncertainty, and responsibility for their implementation are formed.

A practice-oriented approach is key to training modern energy engineers.

Its essence lies in bringing the educational process as close as possible to future professional activity.

The main forms of implementation of this approach are: dual education; on-the-job training; implementation of real engineering projects; case technologies; project learning; problem-based learning; internships; Smart Grid laboratories; digital twins of energy systems; use of professional software.

The use of software complexes DIgSILENT PowerFactory, ETAP, MATLAB/Simulink, HOMER Pro, OpenDSS, PVsyst, which are widely used in the design of modern distributed generation systems [33, 34], is becoming particularly relevant.

A feature of modern distributed generation is the integration of a large number of fields of knowledge.

The training of future engineers should combine: electrical power engineering; electrical engineering; automation; computer science; telecommunications; cybersecurity; information technology; economics; ecology; management; project management.

Such an interdisciplinary nature of professional activity requires the appropriate modernization of educational programs, in which individual disciplines should be integrated around real production tasks.

The rapid digitalization of the energy sector is forming new requirements for professional training.

The concepts of Industry 4.0, Energy 4.0, Smart Grid, Internet of Energy, digital twins, artificial intelligence technologies, big data, cloud services and cyber-physical systems are gradually becoming the standard of modern energy [33, 34].

Therefore, the training of specialists should include the formation of digital competencies necessary for:

– analysis of large energy data sets;

– load forecasting;

– automatic generation control;

– monitoring the technical condition of equipment;

– construction of digital models of power grids;

– application of machine learning algorithms to optimize the operating modes of distributed generation systems.

Analysis of current trends in the development of the energy sector shows that effective training of specialists in the construction of distributed generation systems should be based on a comprehensive combination of competency-based, systemic, activity-based, practice-oriented, interdisciplinary and digital approaches. Their integration creates a methodological basis for the formation of a new generation of engineers capable of working in the conditions of digital transformation of the energy sector and ensuring the energy sustainability of territorial communities.

We should also consider a conceptual model of practice-oriented training of specialists in the construction of distributed generation systems.

The modern development of the energy sector, accompanied by digital transformation, integration of renewable energy sources, implementation of smart networks (Smart Grid), local energy systems (Microgrid) and energy storage systems, requires a significant update of the content of professional training of future engineers. The traditional model of education, focused mainly on the acquisition of theoretical knowledge, no longer provides the formation of competencies necessary for effective professional activity in the context of dynamic changes in the energy sector. In this regard, the development of a conceptual model of practice-oriented training of specialists in the construction of distributed generation systems is of particular relevance [43, 44].

The proposed model is based on the principles of competency-based, systemic, activity-based, interdisciplinary and practice-oriented approaches and involves the integration of educational, scientific and production components into a single educational environment. Its goal is to form a new generation of engineers capable of designing, operating, modernizing and managing distributed generation systems in the context of ensuring the energy sustainability of territorial communities.

The conceptual model includes five interrelated components:

1. Target component. Defines the goal of professional training – the formation of a set of integral, general and special competencies necessary for professional activity in the field of distributed generation. The expected results are the ability to analyze energy systems, design local networks, integrate renewable energy sources, apply digital technologies, assess energy efficiency and manage energy projects.

2. Content component. Provides for the updating of educational programs by integrating disciplines in electrical power engineering, electrical engineering, renewable energy, automation, information technology, digital modeling, cybersecurity, energy economics, project management and ecology. Special attention is paid to interdisciplinary integration and practical orientation of the content of training.

3. Organizational and technological component. It is implemented through the use of modern pedagogical technologies: project-based learning, problem-based learning, case method, STEM approach, dual education, virtual laboratories, digital simulators, automated design systems and digital twins of energy facilities. The educational process is supplemented by the implementation of interdisciplinary team projects that simulate real tasks of territorial communities.

4. Practical component. Provides integration of learning with production activities through laboratory work, industrial practices, internships, student participation in the implementation of real projects to modernize the energy infrastructure of communities, as well as cooperation with energy industry enterprises, distribution system operators, local governments and equipment manufacturers.

5. Evaluation and performance component. It involves a comprehensive assessment of the level of formation of professional competencies according to cognitive, activity, digital, communicative and personal-motivational criteria. It is advisable to use a portfolio, defense of engineering projects, demonstration exams, certification tests, expert assessment of employers and self-assessment of students.

The effectiveness of the proposed model is ensured by a set of interrelated pedagogical conditions:

1. Updating the content of education in accordance with modern trends in the development of the energy industry. Educational programs should take into account the development of Smart Grid, Microgrid, energy storage, digital substations, demand management systems, cybersecurity of energy systems and integration of renewable energy sources.

2. Formation of a modern practice-oriented educational environment. It is necessary to create educational and scientific laboratories equipped with modern equipment, digital measuring complexes, modeling software packages (MATLAB/Simulink, Dig SILENT Power Factory, ETAP, HOMER Pro, OpenDSS), as well as stands for studying the operating modes of local energy systems.

3. Integration of education, science and production. Partnership between higher education institutions, energy companies, territorial communities, scientific institutions and equipment manufacturers creates conditions for students to implement real projects, undergo practice and form a professional identity.

4. Use of digital learning technologies. The use of distance learning systems, digital laboratories, virtual and augmented reality, cloud services and digital twin technologies expands the possibilities of forming practical skills even with limited access to physical equipment.

5. Development of a research culture of students. Involving students in conducting scientific research, participating in grant projects, student scientific circles, conferences and competitions of innovative developments contributes to the formation of critical thinking, the ability to innovate and continuous professional development.

Based on the analysis of modern requirements for engineering activities, it is advisable to distinguish the following groups of competencies:

– integral competence – the ability to comprehensively solve complex engineering tasks in the field of distributed generation;

– general competencies – critical thinking, communication, leadership, project management, the ability to learn throughout life;

– professional competencies – design of distributed generation systems, integration of renewable energy sources, calculation of electrical networks, analysis of electricity quality, ensuring reliability and security of energy systems;

– digital competencies – use of modeling software packages, analysis of energy data, application of artificial intelligence, Internet of Things technologies and digital twins;

– environmental competencies – assessment of the impact of energy facilities on the environment, development of decarbonization solutions and ensuring sustainable development.

Unlike traditional models of training energy engineers, the proposed model:

– integrates technical, digital, environmental and management training;

– is focused on ensuring the energy sustainability of territorial communities;

– takes into account modern trends in the digitalization of the energy sector and the development of Smart Grid and Microgrid;

– is based on practice-oriented training, dual education and intersectoral partnership;

– involves the continuous development of professional competencies throughout life.

4.2. A Practice-Oriented Model for the Formation of Professional Competencies of Future Specialists in the Construction of Distributed Generation Systems

The transition of modern energy to a decentralized model of functioning necessitates a review of approaches to professional training of engineering personnel. Distributed generation systems, including solar and wind power plants, cogeneration plants, energy storage systems, local energy networks and digital control systems, are characterized by a high level of complexity and require specialists capable of making complex technical and management decisions.

The traditional model of training engineers, based on the consistent study of individual disciplines and the reproduction of learned information, does not fully meet the modern requirements of the energy sector. The new model of professional education should provide not only the accumulation of knowledge, but also the formation of the ability to apply them in real conditions, work with uncertainty, carry out innovative activities and adapt energy solutions to the needs of specific territories [16–23, 57–65].

In this context, practice-oriented training is considered as an educational strategy that ensures the integration of theoretical training, practical activities, research work and professional experience. Its essence lies in creating conditions under which the student not only acquires knowledge about energy technologies, but also gains experience in solving real engineering problems.

The practice-oriented model of professional competence formation is based on the following provisions:

– professional competence is formed through activity;

– educational tasks should be close to real production situations;

– the educational process should be interdisciplinary;

– the student should be an active participant in the creation of technical solutions;

– assessment should take into account not only the level of knowledge, but also the ability to perform professional functions.

Professional activity in the field of distributed generation involves a set of competencies that combine technical, digital, organizational, environmental and social components [1–3, 7, 10, 16–23, 57–65].

Energy and technical competence cover knowledge of electrical networks, energy generation and storage systems, which provides the ability to analyze and calculate the operating modes of energy systems.

Design competence consists in the ability to develop technical solutions, resulting in the creation of local energy system projects.

Digital competence involves the use of modern digital technologies and specialized software for modeling Smart Grid and Microgrid systems.

Analytical competence is aimed at assessing the technical and economic parameters of energy systems, which allows you to choose optimal energy solutions.

Management competence includes planning and implementation of energy projects and ensures effective management of community energy modernization processes.

Environmental competence is based on an understanding of the principles of sustainable development and makes it possible to assess the environmental impact of implementing energy projects.

Communicative competence involves effective interaction with customers and other stakeholders, as well as the ability to work in interdisciplinary teams during the development and implementation of energy solutions.

In turn, the formation of competencies of future specialists is carried out on the basis of a system of principles that determine the content and technology of the educational process [1–3, 7, 10, 16–23, 57–65].

The principle of professional orientation – involves the orientation of each educational component to future professional activity. Educational materials, laboratory work and project tasks should be related to real problems of the energy industry.

An example of such an approach is the implementation of tasks by students:

– determination of the energy potential of the community;

– calculation of the parameters of a solar power plant;

– selection of an energy storage system;

– assessment of the economic efficiency of local generation.

The principle of integration of theory and practice – involves ensuring a constant connection between fundamental knowledge and its practical application.

The implementation of the principle is carried out through: laboratory research; practical cases; production practices; team projects; cooperation with enterprises.

The principle of interdisciplinarity – distributed generation systems are at the intersection of several branches of knowledge: electric power; automation; information technology; economics; ecology; management.

Therefore, the educational process should ensure the integration of various disciplines around complex professional tasks.

The principle of innovation – involves the use of modern technologies: digital modeling; artificial intelligence; Internet of Things; digital twins; intelligent control systems.

The formation of professional competencies should be carried out in stages.

The first stage is motivational and orientational.

The goal of the stage is to form an understanding of the importance of distributed generation for energy security and sustainable development.

Main methods: problem lectures; analysis of modern energy challenges; meetings with industry specialists; discussion of real cases.

The second stage is theoretical and professional.

At this stage, basic knowledge is formed: electric power systems; renewable energy sources; digital technologies; energy management.

The third stage is practical and project.

The main result is the ability to apply knowledge in practical situations. Forms of work: implementation of engineering projects; laboratory modeling; practice at enterprises; development of community energy strategies.

The fourth stage is research and innovation.

It involves involving students in: scientific research; development of innovative solutions; participation in grant projects; startups in the field of clean energy.

The implementation of a practice-oriented model of training specialists in the construction of distributed generation systems requires the use of a complex of modern pedagogical technologies that ensure the transition from an information-reproductive model of learning to an activity, research and project model [1–3, 7, 10, 16–23, 57–65].

The choice of pedagogical technologies is determined by the specifics of the professional activity of the future specialist, which involves the ability to analyze complex energy systems, make technically sound decisions, work in a team, and adapt energy technologies to the needs of specific territorial communities.

The most effective technologies include: project-based learning technology; problem-based learning; case technology; STEM/STEAM-learning; simulation and computer modeling; dual education; blended learning.

Let's consider each of them in more detail.

Project-based learning is one of the most effective technologies for the formation of professional competencies, as it provides modeling of real engineering activities.

Its essence lies in the performance of a complex task by students, the result of which is the creation of a completed technical solution.

For specialties of the energy profile, examples of projects can be:

– development of the concept of energy autonomy of a territorial community;
– design of a local Microgrid;
– selection of the optimal structure of Distributed Energy Resources;
– assessment of the potential of renewable energy in the region;
– creation of an energy management system for a social infrastructure facility.

Project activity forms the following competencies: systems thinking; ability to work with technical documentation; teamwork skills; ability to present results; responsibility for decisions made.

The implementation of an educational energy project is carried out sequentially through several interconnected stages, each of which has a defined content of student activities and an expected result.

At the analytical stage, students investigate the energy needs of the community, analyze the current state of the energy infrastructure and identify the main problem that needs to be solved.

The design stage involves the selection of energy generation and storage technologies, comparison of possible technical solutions and formation of the concept of the future energy system.

During the calculation stage, technical modeling, calculation of the main system parameters and economic analysis of the proposed solution are carried out, which allows justifying the feasibility of its implementation.

At the implementation stage, students prepare the necessary technical documentation, draw up the results of calculations and create a completed energy system project.

The final stage is the presentation stage, during which the project is defended before experts, the level of formation of students' professional competencies is assessed, as well as their ability to present and justify the proposed technical solutions in a reasoned manner.

Problem-based learning involves organizing the educational process around real problem situations.

A feature of this approach is that the student does not receive a ready-made solution algorithm, but independently: analyzes the problem; determines the necessary knowledge; searches for information; forms solution options; evaluates their effectiveness. An example of a problem situation: “Providing electricity to critical infrastructure of a territorial community in conditions of instability of centralized energy supply”. In the process of solving such a task, students must: estimate energy consumption; determine available generation resources; choose the type of storage device; calculate Microgrid operating modes; assess economic feasibility.

A feature of training new generation specialists is the need to master digital tools for analyzing and designing energy systems.

In the educational process, it is advisable to use: MATLAB/Simulink; DIgSILENT PowerFactory; ETAP; HOMER Pro; OpenDSS; PVSyst.

The use of such tools allows:

– to model the operating modes of electrical networks;
– to assess the impact of renewable sources;
– to investigate the behavior of Microgrid;
– to forecast generation;
– to optimize the structure of the energy system.

An important advantage of digital modeling is the ability to conduct educational experiments without the risk of damaging real equipment.

STEM education corresponds to the nature of modern energy tasks, as it involves the integration of: Science; Technology; Engineering; Mathematics.

In the field of distributed generation, the STEM approach is implemented through:

– creation of laboratory models of Microgrid;

– development of monitoring systems;

– programming of controllers;

– analysis of energy data;

– creation of prototypes of energy solutions.

The effectiveness of a practice-oriented model of training specialists in the construction of distributed generation systems is determined not only by the quality of mastering the educational material, but primarily by the level of formation of the ability of students to perform professional tasks in conditions close to real activity.

In this regard, the assessment of the effectiveness of the model should be carried out on the basis of a comprehensive approach, which involves analyzing the dynamics of the formation of: professional knowledge; practical skills; digital skills; design thinking; ability to make engineering decisions; readiness to work in interdisciplinary teams [1–3, 7, 10, 16–23, 57–65].

The proposed assessment system is based on a combination of quantitative and qualitative diagnostic methods.

Five interrelated criteria are proposed to determine the effectiveness of the model:

1. Motivational and value criterion. Reflects the formation of professional motivation, awareness of the importance of the development of distributed generation for energy security and sustainable development of communities. Indicators:

– interest in professional activity in the field of clean energy;

– understanding of the role of an engineer in ensuring energy sustainability;

– readiness for professional self-development.

2. Theoretical and cognitive criterion. Characterizes the level of mastering the system of professional knowledge. Indicators:

– knowledge of the principles of operation of distributed generation systems;

– understanding of the processes of integration of renewable energy sources;

– knowledge of methods of modeling energy systems;

– possession of regulatory and technical documentation.

3. Practical and technological criterion. Determines the ability to apply knowledge to perform professional tasks. Indicators:

– performance of engineering calculations;

– design of local energy systems;

– use of software complexes;

– analysis of operating modes of energy networks.

4. Design and research criterion. Reflects the ability to create new technical solutions. Indicators:

– formation of engineering hypotheses;

– conducting a feasibility study;
– implementation of research projects;
– presentation of results to a professional audience.

5. Communication and management criterion. Characterizes the ability to organize professional interaction. Indicators: teamwork; project management; communication with customers and communities; reasoned defense of technical solutions.

Three levels of competence formation have been defined to assess the results of training.

Low level – characterized by insufficient formation of professional knowledge and practical skills. Main features:
– mainly theoretical understanding of processes;
– difficulty in applying knowledge in practical situations;
– need for constant teacher assistance;
– low ability to independently design.

Medium level – implies sufficient preparedness to perform standard professional tasks. Characteristic features:
– mastery of basic calculation methods;
– ability to use software;
– execution of project tasks according to a specific algorithm;
– participation in team activities.

High level – characterized by readiness for independent professional activity. The specialist:
– comprehensively analyzes energy problems;
– develops innovative solutions;
– evaluates technical, economic and environmental aspects;
– carries out professional communication with stakeholders.

To verify the effectiveness of the proposed model, a pedagogical experiment can be used, which involves three stages.

Stating stage.

Purpose: determination of the initial level of formation of professional competencies.

Methods: testing; analysis of learning outcomes; student questionnaires; expert assessment of teachers.

Formative stage.

Provides for the implementation of a complex of pedagogical influences: project learning; practical cases; digital modeling; interdisciplinary projects; cooperation with energy enterprises.

Control stage.

Provides for repeated diagnostics of the formation of competencies and comparison of results. The main indicators of effectiveness are:
– increase in the level of professional knowledge;
– improvement of the quality of practical tasks;
– development of design skills;

– increase in student independence.

Implementation of a practice-oriented model provides:

For students:

– acquisition of practical experience;

– formation of professional identity;

– development of digital competencies;

– readiness to work in the field of modern energy.

For educational institutions:

– updating of educational programs;

– strengthening cooperation with enterprises;

– development of educational and research infrastructure.

For territorial communities:

– possibility of attracting trained specialists;

– development of local energy strategies;

– increasing the level of energy independence.

The practice-oriented model of forming professional competencies of future specialists in the construction of distributed generation systems is a comprehensive educational system that combines target, content, technological and productive components.

Its feature is the orientation towards: real needs of the energy industry; tasks of territorial communities; integration of technical and digital competencies; development of the ability to innovate.

The proposed model creates conditions for training a new generation of specialists capable of ensuring the design and operation of distributed generation systems as the basis for energy sustainability and sustainable development of communities.

4.3. Innovative Educational Technologies for Training Specialists for Distributed Generation Systems in the Context of Energy Transformation

The modern transformation of the energy sector is characterized by the transition from a centralized model of electricity production and distribution to decentralized, digitalized and flexible energy systems. The development of technologies of distributed generation, intelligent electrical networks, local energy systems, energy storage systems and digital management platforms forms new requirements for the professional competence of engineers [15–23, 33–74].

Accordingly, the role of higher education institutions is changing: they must not only transfer a set of professional knowledge, but also create an educational environment in which the future specialist gains experience in research, design, modeling and management of complex energy systems.

Innovative educational technologies in the training of specialists in the construction of distributed generation systems are considered as a set of methods, means and organizational forms of training aimed at:

– formation of professional competencies in accordance with the requirements of modern energy;

– development of engineering and systems thinking;
– gaining practical experience in working with digital technologies;
– integration of educational, scientific and production activities.

A feature of such technologies is their orientation towards the active activity of the student. The student is not a passive consumer of information, but a participant in the process of creating technical solutions.

Digitalization is one of the key areas of development of both the energy industry and the professional education system. In the field of distributed generation, digital technologies provide monitoring, forecasting, optimization and automated management of energy processes.

In the educational process, digitalization is implemented through:
– use of digital educational platforms;
– use of modeling software;
– creation of virtual laboratories;
– use of cloud services;
– analysis of energy data;
– application of artificial intelligence technologies.

One of the promising areas of innovative education is the use of digital twin technology.

A digital twin is a virtual model of a physical object or system that allows for: monitoring parameters; predicting behavior; optimizing operating modes; testing technical solutions.

In the training of specialists in distributed generation, digital twins can be used to model: solar power plants; wind turbines; energy storage systems; local electrical networks; Microgrid [15–23, 33–74].

The advantages of using digital twins in education are:
– the ability to conduct experiments without the risk of damaging equipment;
– developing skills in working with modern industrial technologies;
– developing analytical thinking;
– bringing the educational process closer to real production conditions.

One of the problems in training energy engineers is the need for access to modern equipment, which is often expensive.

The use of virtual laboratories allows you to partially solve this problem by creating a digital environment for performing practical tasks.

Virtual laboratories provide the opportunity to:
– investigate the parameters of energy systems;
– change the conditions of the experiment;
– analyze the results;
– repeat the study an unlimited number of times.

Examples of educational tasks:
– study the impact of solar generation on network parameters;
– analysis of the operation of battery systems;
– optimization of Microgrid modes;

– forecasting generation using digital models.

The development of artificial intelligence technologies is significantly changing approaches to managing energy systems. In the future, engineers will work not only with equipment, but also with intelligent data analysis systems.

In the educational process, artificial intelligence technologies can be used for:

– forecasting electricity production from renewable sources;

– optimizing energy system operating modes;

– analyzing large data sets;

– detecting emergency modes;

– supporting engineering decision-making.

Formation of competencies in the field of artificial intelligence involves:

– understanding the principles of machine learning algorithms;

– the ability to work with energy data;

– the ability to evaluate the results of intelligent systems.

The STEM approach is one of the most promising areas of modernization of engineering education, as it ensures the integration of science, technology, engineering and mathematics [15–23, 33–74].

In the field of distributed generation, STEM training is implemented through:

– creation of educational energy installations;

– development of automation systems;

– programming of controllers;

– analysis of energy processes;

– implementation of interdisciplinary projects.

The STEAM approach complements the technical component with elements of: design; economics; social analysis; communication.

This is especially important for community energy transformation projects, where the technical solution must take into account economic opportunities, environmental consequences and social perception.

Modern training of specialists in the field of construction of distributed generation systems is based on the use of innovative educational technologies that ensure the formation of professional competencies necessary for successful activity in the conditions of digital transformation of energy.

The use of digital twins contributes to the development of skills in modeling and analyzing energy systems, allowing students to study the operating modes of objects, predict their behavior, and evaluate the effectiveness of technical solutions without risk to real equipment.

Virtual laboratories provide the formation of practical engineering skills by performing laboratory work in a digital environment, which makes it possible to practice professional actions under different operating conditions of energy systems.

The use of artificial intelligence technologies develops competencies in the field of forecasting and optimizing energy generation, distribution, and consumption processes, and also supports the adoption of justified technical decisions based on the analysis of large volumes of data.

STEM projects contribute to the formation of systems and engineering thinking, integrating knowledge from natural sciences, technology, engineering, and mathematics when solving complex practical problems.

Project-based learning provides the development of the ability to comprehensively solve professional problems, combining theoretical training with practical design, teamwork, and making technically and economically sound decisions.

Simulation training forms the ability to make decisions in simulated production situations, develops professional thinking, risk analysis skills and readiness to work effectively in real conditions of operation of modern energy systems.

One of the key conditions for effective training of specialists for distributed generation systems is to ensure a close connection between the educational process and real professional activities. That is why the development of a dual form of education, which combines training in an educational institution with practical training at enterprises, scientific institutions and local government bodies, is of great importance.

The specifics of activities in the field of distributed generation determine the need for students to gain experience in working with real energy facilities, technical systems and management processes. Theoretical training without practical application does not fully ensure the readiness of a graduate to perform professional functions.

The dual training model provides for:

– coordination of educational programs with the needs of the energy sector;

– participation of employers in shaping the content of academic disciplines;

– completion of long-term industrial practices;

– performance by students of real technical tasks;

– assessment of learning outcomes by representatives of the educational institution and the enterprise.

Effective training of specialists for distributed generation systems requires the creation of a multi-subject educational ecosystem. Its main participants are:

A higher education institution that performs the functions of: organizing the educational process; scientific support; forming competencies; conducting research.

Energy enterprises that provide: practical training; access to equipment; mentoring; participation in the development of educational programs.

Territorial communities that act as customers for practical solutions: energy strategies; local generation projects; energy management systems; energy independence measures.

Scientific institutions and expert organizations that provide: technology transfer; expert support; implementation of innovations.

Effective training of future specialists in the construction of distributed generation systems requires close interaction between higher education institutions, enterprises, territorial communities and expert organizations. Each of the participants in the partnership model performs certain functions that ensure the integration of education, science, production and practical implementation of innovative solutions.

The university provides educational training for applicants, organizes scientific research, develops educational and methodological support and creates conditions for

the formation of professional competencies of future specialists in accordance with modern requirements of the energy industry.

The enterprise provides practical training for students, provides the opportunity for industrial practice, provides professional mentoring and involves students in performing real production tasks related to the design and operation of distributed generation systems.

The community forms relevant practical tasks that reflect the real needs of the territories in the development of energy infrastructure, participates in the testing of proposed technical solutions and assesses their socio-economic feasibility.

Expert organizations perform an advisory function, independently evaluate the developed projects, provide methodological and innovative support, and also contribute to the introduction of modern technologies and advanced professional experience into the educational process.

The implementation of innovative educational technologies should be carried out systematically and provide for organizational, content and technological changes.

The proposed methodology includes four stages.

The first stage is preparatory and analytical.

The purpose of the stage: determining the needs of the energy industry and forming an educational environment. Main tasks:

– analysis of current trends in the development of the energy sector;

– determination of professional competencies;

– assessment of the material and technical base;

– formation of a partner network.

Result: a concept of innovative training of specialists has been developed.

The second stage is content-technological. It involves updating the content of educational programs.

It is advisable to include the following disciplines in the curricula: “Distributed generation systems”; “Smart Grid technologies”; “Microgrids and energy storage”; “Digital technologies in energy”; “Energy planning of territories”.

The educational process is supplemented by: practical cases; digital modeling; team projects; research tasks.

The third stage is practical and integration.

The main goal: formation of professional experience.

Forms of implementation: dual training; industrial practices; student energy projects; participation in the modernization of community facilities.

Example of the task "Development of the concept of community energy autonomy using local sources of generation".

Within the framework of such a project, students perform: energy audit; assessment of resource potential; technical design; economic calculations; assessment of environmental impact.

The fourth stage is evaluation and correction. It involves analyzing the results of the implementation of innovative technologies. The following are assessed: the level of competence formation; the quality of practical tasks; the ability to make independent

decisions; readiness for professional activity. Based on the results of the evaluation, adjustments are made to: educational programs; the content of disciplines; teaching methods; practical training.

An innovative educational environment is formed as an integrated system that combines:

1. Target component. Purpose: training of a competent specialist capable of designing and operating distributed generation systems.

2. Content component. Includes: professional disciplines; digital technologies; energy management; sustainable development.

3. Technological component. Contains: project training; STEM/STEAM; digital modeling; dual education; research methods.

4. Environmental component. Includes: Smart Grid labs; digital platforms; partnership with communities; cooperation with enterprises.

5. Performance component. Expected result: specialist with developed competences: technical; digital; project; managerial; environmental [15–23, 33–74].

Therefore, innovative educational technologies are a determining factor in the modernization of specialist training for distributed generation systems. Their application provides a transition from the traditional model of knowledge transfer to the competence model of the formation of a professional capable of working in conditions of energy transformation.

It was established that the most effective directions are: digitalization of the educational process; use of digital duplicates and virtual laboratories; application of artificial intelligence; STEM/STEAM approach; dual education; partnership of universities, enterprises and territorial communities.

The proposed model of an innovative educational environment creates prerequisites for training specialists who are able not only to operate modern energy systems, but also to design new solutions to ensure energy sustainability and sustainable development of communities.

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ANNOTATION

CHAPTER 1. MODERN BASICS OF ECONOMICS, MANAGEMENT AND TOURISM

1.1. Olha Podra, Nataliia Petryshyn, Andrew Todoshchuk IMPROVEMENT OF TACTICAL PLANNING OF FOREIGN ECONOMIC ACTIVITY BASED ON AN ALGORITHM FOR EVALUATION AND SELECTION OF PRIORITY FOREIGN SALES MARKETS

The features of improving tactical planning of enterprises' foreign economic activity under conditions of intensifying global competition and increasing uncertainty in international markets are examined. It is substantiated that the effectiveness of export activities largely depends on the quality of decision-making regarding the selection of priority foreign sales markets. It is determined that traditional approaches to market evaluation and selection are often fragmented and do not ensure a comprehensive consideration of economic, competitive, logistical, and risk-related factors. A conceptual approach to forming a consistent algorithm for the evaluation, selection, and prioritization of foreign markets is proposed, based on multicriteria analysis and a step-by-step decision-making procedure. The algorithm includes preliminary market screening, basic analytical assessment, matrix comparison, development of a market attractiveness ranking, and integration of results into the tactical planning system of foreign economic activity. It is proven that the application of the proposed approach contributes to increasing the validity of managerial decisions, reducing uncertainty, and optimizing the allocation of enterprise resources. The implementation of the algorithm ensures a more systematic approach to the diversification of foreign sales markets and enhances the effectiveness of tactical planning of foreign economic activity.

Keywords: tactical planning, foreign economic activity, foreign markets, evaluation algorithm, market prioritization, multicriteria analysis, managerial decisions.

1.2. Nataliia Petryshyn, Olha Podra, Andrew Todoshchuk DEVELOPMENT OF THE TOOLKIT FOR TACTICAL MANAGEMENT OF ENTERPRISE FOREIGN ECONOMIC ACTIVITY BASED ON THE SYSTEMATIZATION OF ANALYTICAL SUPPORT

Theoretical and applied aspects of the development of tools for tactical management of an enterprise's foreign economic activity based on the systematization of analytical support for forecasting have been studied. The increasing role of tactical management of foreign economic activity under conditions of instability in the international economic environment, growing competition, and a higher level of uncertainty has been substantiated. The essence of planning as a management function has been revealed, and its significance for ensuring economic stability, adaptability, and competitiveness of enterprises has been determined. The features of tactical planning of foreign economic activity have been characterized, and its place within the system of strategic and operational management has been established. The main problems of tactical planning of foreign economic activity have been identified, related to insufficient systematization of analytical support for forecasting export indicators and the fragmented nature of information flows. A technology for systematizing analytical

support for forecasting foreign economic activity has been proposed, which includes the unification of data collection processes, standardization of analytical information formats, implementation of regular analysis mechanisms, organization of cyclical forecasting, and regulation of information exchange between departments. The implementation of the proposed technology will contribute to improving forecast accuracy, reducing uncertainty, and increasing the effectiveness of tactical management of the enterprise's foreign economic activity.

Keywords: foreign economic activity, tactical management, tactical planning, analytical support, forecasting, data systematization, managerial decisions.

1.3. Andrew Todoshchuk, Nataliia Petryshyn, Olha Podra RECOMMENDATIONS FOR IMPROVING THE STRATEGIC ACTIVITIES OF ENTERPRISES IN FOREIGN MARKETS

The theoretical and methodological foundations for improving the strategic planning of enterprises' foreign economic activity (FEA) under conditions of geopolitical tension and European integration are substantiated. A five-stage procedure for developing an international strategy is formulated, ranging from SMART goal setting to the creation of flexible feedback systems.

The key internal and external barriers to international expansion are identified, including the linearity of management structures, workforce shortages, and regulatory risks in recipient markets. It is demonstrated that successful business scaling requires not only the diversification of export markets and the digitalization of operations but also a profound transformation of management philosophy based on ISO standards and TQM criteria. The central focus of the study is the optimization of strategic decision-making through the multicriteria SPACE analysis method. A weighted evaluation system based on four dimensions—financial strength, competitive position, industry attractiveness, and environmental stability—is proposed. Mathematical modeling and network models are identified as the foundation for transforming FEA planning into a scientifically grounded decision support system.

Keywords: strategic planning, foreign economic activity, SPACE analysis, multicriteria method, international business, business scaling, European integration, organizational change management.

1.4. Lesia Donchak HUMAN CAPITAL AS A FACTOR IN RESTORING UKRAINE'S SOCIO-ECONOMIC POTENTIAL AMID DEMOGRAPHIC CHALLENGES

The role of human capital in restoring Ukraine's socio-economic potential amid the demographic crisis is examined. The impact of population decline, migration, ageing, and falling birth rates on the country's labour, educational, intellectual, and health potential is analysed. Strategic priorities for preserving and reproducing human capital are substantiated, including demographic support measures, a re-emigration policy, the modernisation of education and healthcare, employment development, the integration of internally displaced persons, and stronger institutional coordination.

Keywords: human capital, demographic challenges, socio-economic potential, post-war recovery, public policy.

1.5. Olha Hirna DEVELOPMENT OF WAREHOUSING ACTIVITIES IN THE COLD LOGISTICS SYSTEM: MODERN LOGISTICS SOLUTIONS

The paper examines the essence of cold logistics and the specific features of warehousing activities within cold supply chains. It analyzes current trends in warehouse logistics development and the requirements for product storage under different temperature conditions. The activities of the Raben Group, with particular emphasis on its Fresh Logistics services, are characterized. An economic and mathematical model is applied to forecast revenue generated from fresh-product customers. The study also substantiates the feasibility of additional capital investments in the warehousing operations of the Lviv branch of Raben Ukraine LLC.

Keywords: cold logistics, cold supply chain, warehousing, fresh-product customers, cash flow, payback period.

1.6. Viktor Pyliavets METHODOLOGICAL TOOLKIT FOR EVALUATING BUSINESS PLANS OF ENTERPRISES: CURRENT TRENDS AND DIRECTIONS FOR IMPROVEMENT

The article examines modern methodological approaches to evaluating business plans of enterprises and identifies their advantages and disadvantages. The criteria and principles for assessing the quality of business planning are summarized, and the need for a comprehensive analysis of the marketing, production, financial and risk components of the project is substantiated. An algorithm for evaluating a business plan is developed. Promising directions for improving the evaluation process based on the use of digital technologies, multi-criteria analysis methods and integration of ESG criteria are identified. The proposed approach contributes to increasing the objectivity of evaluation and the efficiency of making investment and management decisions.

Keywords: business plan; business plan evaluation; evaluation algorithm; multi-criteria analysis; ESG criteria; digitalization.

1.7. Dina Shkvaruk FINANCIAL INSTRUMENTS FOR ENSURING ECONOMIC RECOVERY UNDER GLOBAL CHALLENGES

The paper examines financial instruments for ensuring economic recovery under global challenges. The essence of economic recovery is clarified, the impact of global instability on the financial support of the economy is determined, and fiscal, banking, investment, international, insurance, and digital financial instruments are systematized. An analytical assessment of the financial prerequisites for Ukraine's economic recovery is conducted based on GDP indicators, the state budget, budget deficit, grant support, and debt burden. The role of financial institutions in implementing recovery processes is substantiated, and directions for improving financial instruments are proposed, taking into account the needs of economic resilience, transparency, and long-term development.

Keywords: economic recovery; financial instruments; financial support; state budget; debt burden; international financing; risk insurance; financial institutions.

1.8. Nataliya Smolinska STAFF COMPETENCY DEVELOPMENT AS A FOUNDATION FOR ENTERPRISE RESILIENCE TO CHANGE

The article examines personnel competency development as a key prerequisite for ensuring enterprise resilience in the face of continuous change. It reveals the essence of

the competency-based approach to human resource management and identifies the role of professional, digital, managerial, and behavioral competencies in enhancing organizational adaptability and competitiveness. The study summarizes modern competency development tools and proposes recommendations for establishing a strategic competency management and assessment system. It substantiates that the systematic development of personnel competencies enhances the efficient use of human capital, strengthens organizational resilience, and ensures the enterprise's long-term competitive advantages.

Keywords: staff competencies, competency development, competency-based approach, human resource management, human capital, organizational resilience, enterprise competitiveness, strategic management, digital transformation.

1.9. Nataliya Smolinska, Igor Grybyk CHANGE MANAGEMENT IN ENTERPRISES: IMPACT ON THE SOCIO-PSYCHOLOGICAL CLIMATE OF THE WORKFORCE AND STABILIZATION MECHANISMS

This chapter examines the theoretical and practical aspects of change management in an enterprise, with a particular focus on its impact on the socio-psychological climate of the workforce. It explores the essence of change management, identifies the key factors influencing the formation of a favorable socio-psychological climate, and outlines mechanisms for its stabilization under conditions of organizational transformation. Practical recommendations are substantiated to improve the effectiveness of change management through the development of HR policy, enhancement of internal communication, application of digital tools, regular monitoring of the socio-psychological climate, and comprehensive employee support.

Keywords: change management; socio-psychological climate; organizational change; human resource management; corporate culture; HR policy.

1.10. Oleksandr Zakharchuk CONCEPTUALIZATION OF THE INNOVATIVE DEVELOPMENT OF AGRICULTURAL ENTERPRISES WITHIN THE FRAMEWORK OF SCIENTIFIC APPROACHES

The study systematizes scientific approaches to understanding innovation and the innovative development of agricultural enterprises. Particular attention is paid to the sector-specific characteristics of agricultural production, including seasonality, biological cycles, natural and climatic dependence, resource intensity, and risk exposure. The main technological, organizational, managerial, institutional, digital, and environmental dimensions of innovative development are identified. Innovative development is interpreted as a continuous process of qualitative transformation based on the realization of an enterprise's innovation potential.

Keywords: innovation, innovative development, agricultural enterprises, innovation potential, digital transformation, sustainability.

1.11. Ulyana Balyk PREDICTIVE ANALYTICS AND MACHINE LEARNING IN DIGITAL MARKETING EFFECTIVENESS ASSESSMENT

The article aims to systematize methodological approaches to digital marketing evaluation and to develop an integrated predictive and analytical framework. The study classifies key performance indicators, summarizes methods of analytical assessment, and identifies applications of predictive analytics and machine learning in

conversion forecasting, audience segmentation, behavioral modeling, and churn prediction. An integrated evaluation system is proposed that combines behavioral, conversion, financial, and predictive dimensions and includes a composite effectiveness index with an interpretation scale. The framework may support comprehensive campaign assessment, advertising budget optimization, user behavior forecasting, and more effective digital marketing management.

Keywords: web analytics, conversion analysis, behavioral modeling, marketing funnel, digital communications, audience segmentation, marketing analytics, advertising profitability.

1.12. Sergiy Grytsenko, Kateryna Barda INNOVATIVE APPROACHES TO RISK MANAGEMENT IN INTERNATIONAL INDUSTRIAL LOGISTICS UNDER UNCERTAINTY

The article is devoted to the study and substantiation of innovative approaches to risk management during the international transportation of industrial equipment and machinery. A comprehensive analysis of the classification of exogenous and endogenous logistic threats in conditions of geopolitical and economic turbulence is carried out. The specifics of project logistics of heavy machinery and capital-intensive assets are investigated. The concept of transition from reactive monitoring to proactive predictive risk management is substantiated. The architecture of an intelligent system for forecasting logistic incidents is proposed and its economic efficiency for modern 4PL operators is calculated.

Keywords: logistics risk, predictive management, industrial equipment, supply chain, 4PL provider, IoT monitoring.

1.13. Olha Chubka PUBLIC DEBT OF UKRAINE AND FINANCIAL INSTRUMENTS FOR ITS MANAGEMENT UNDER WARTIME CONDITIONS

The dynamics of Ukraine's external and domestic public debt and the debt-to-GDP ratio over 2015–2025 are presented. The reasons for the change in the debt-to-GDP ratio during the analyzed period are characterized. The structure of Ukraine's public debt by borrowing currency as of the end of 2025 is presented. Ukraine's deep integration into the European financial space and the substantial support provided by international institutions are demonstrated. The main instruments for managing public debt in the context of ensuring financial security under wartime conditions are identified.

Keywords: public debt, domestic debt, external debt, GDP, debt management.

CHAPTER 2. INNOVATIVE AND MODERN FOUNDATIONS OF PEDAGOGY AND PSYCHOLOGY

2.1. Borys Shevel DEVELOPMENT OF THE ECONOMIC JUSTIFICATION OF DECISIONS IN THE PROCESS OF COMPLETING COURSE PROJECTS BY FUTURE TECHNOLOGY TEACHERS

The article examines the features of developing the skills of economic justification of decisions during the completion of course projects by future technology teachers. Its significance as an important element in the formation of their economic competence is substantiated, as it has a comprehensive and interdisciplinary character and promotes the integration of technological, organisational and economic knowledge. Particular

attention is paid to the methodological aspects of developing students' skills to perform economic calculations during technological design.

Keywords: technological education, future technology teachers, course project, economic competence, professional training.

CHAPTER 3. THE LATEST BASICS OF AGRICULTURAL DEVELOPMENT

3.1. Anastasiia Stanhrit, Zoriana Hubrii, Nataliia Monka ECOLOGICAL SAFETY AND RISK ASSESSMENT OF BIOLOGICAL PREPARATIONS

The chapter analyzes the efficacy and ecological safety of microbial biological preparations as an alternative to synthetic pesticides in plant protection. The mechanisms of action of the main groups of biological preparations based on bacteria, fungi, and other microorganisms are examined, along with their advantages in the context of the "One Health" concept. A comprehensive assessment of existing risks is conducted, including infectious, safety-related, toxicological, ecosystemic, and those associated with the development of pest resistance.

Keywords: biological preparations, microbial biopesticides, risk assessment, plant protection, ecological safety, sustainable agricultural development.

CHAPTER 4. Serhii Onyshchenko EDUCATIONAL PRINCIPLES FOR TRAINING SPECIALISTS IN CONSTRUCTION OF DISTRIBUTED GENERATION SYSTEMS TO ENSURING SUSTAINABLE DEVELOPMENT OF COMMUNITIES

The section of the collective monograph substantiates the theoretical and methodological principles of training specialists in the construction of distributed generation systems in the context of the transformation of the energy sector and the transition to sustainable development of territorial communities. Modern requirements for the professional competence of energy engineers are determined, due to the development of renewable energy sources, Smart Grid, Microgrid, energy storage systems and digital management technologies.

A practice-oriented model of the formation of professional competencies of future specialists has been developed, which includes target, content, technological, organizational and evaluation-result components. The pedagogical conditions for its implementation are substantiated: modernization of the content of educational programs, integration of theoretical and practical training, development of partnerships between educational institutions, energy enterprises and territorial communities.

The possibilities of using innovative educational technologies in the professional training of energy specialists are revealed, in particular digital modeling, digital twins, virtual laboratories, STEM/STEAM approach, artificial intelligence and dual education. The proposed provisions are aimed at forming a new generation of specialists capable of ensuring energy sustainability, autonomy and sustainable development of territorial communities.

Keywords: distributed generation, renewable energy, Smart Grid, Microgrid, practice-oriented training, professional competencies, digitalization of education, energy sustainability, sustainable development of communities.

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