KAPITEL 1 / *CHAPTER 1* [1]
A SYSTEMS APPROACH TO PROACTIVE MANAGEMENT IN UKRAINIAN INDUSTRIAL ENTERPRISES

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Introduction

Industrial enterprises are the key organizational structures of a country's economic system, producing and supplying a range of high-quality goods, technologies, and services to the commodity market. In the face of fierce competition and the constant increase in production volumes of various goods and services, it is necessary for enterprises to employ qualitatively new approaches to management to ensure their sustainable functioning and efficient development.

Each industrial enterprise has its own mission and a wide range of goals that require the company to have a resource base, technologies, and a strategy for achieving these goals. The mission of any industrial enterprise is formulated as a continuous process of "enhancing", "improving", or "ensuring" a higher standard of living, material well-being, safety, and so on. The spectrum of enterprise goals consists of numerous continuous processes that expand and specify the paths for achieving the mission. Among the dominant goals of an industrial enterprise are economic objectives such as income, profitability, labor productivity, sales volume, market share, and competitiveness. All economic goals are positively correlated with each other – the growth of one leads to the growth of all or most of the others. For a competitive industrial enterprise in developing commodity markets, it is expedient to use a more general goal – coordinating the development trends of the commodity market with the enterprise's development trend, taking into account proactive management of the industrial enterprise. In this regard, two types of proactive management of an industrial enterprise can be distinguished: active and passive. Passive proactive management of an industrial enterprise involves timely assessment of all deterministic and stochastic trends in the commodity market and their minimal delay in alignment with the enterprise's development trends. Active proactive management of an industrial enterprise entails active participation of the enterprise in shaping the trends of the commodity market by introducing new consumer goods, means of production, and services.

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By determining the degree of inconsistency between the development trends of the industrial enterprise and the commodity market in the form of a certain norm, when the norm value differs from zero, it indicates the emergence of an undesirable problem for the enterprise. If the norm exceeds a certain threshold value, it indicates a crisis for the enterprise. Thus, the main idea of proactive management is based on anticipating potential problems and managing them before they become critical. Despite its simplicity and obviousness, proactive management, when implemented, determines the ways for the survival, sustainable functioning, and efficient development of an industrial enterprise in the face of fierce competition and continuous growth in the production of new high-quality goods and services. The practical implementation of proactive management by an industrial enterprise encompasses all types of activities, from production and economic to financial, innovation, investment, personnel management, and more.

The process of proactive management in an industrial enterprise consists of two stages:

– identification and analysis of the development trends of the enterprise and the commodity market.

To implement proactive management in an enterprise, various methodologies are used today, such as Business Process Reengineering (BPR), Key Performance Indicators (KPI), Balanced Scorecard (BSC), budgeting, modeling based on standards like IDEF0, IDEF3, SADT, UML, and many others [1].

The real-time implementation of proactive management is crucial for the survival, sustainable functioning, and effective development of an industrial enterprise in the face of fierce competition and the increasing production volume of various goods and services.

1.1. Analysis of the problem

The transition from an industrial to a post-industrial and information-based economy has led to significant shifts in the understanding of principles and rules for managing economic processes and the search for new economic development paths.

The main organizational structure of the economic system of any country is the enterprise [1]. An enterprise is a complex and dynamic system that consists of elements and their interconnections and operates as an independent economic entity with the goal of generating profit.

The main directions of enterprise activities, which are carried out concurrently and sequentially, include [3–5].

- Economic activities: forecasting, planning, pricing, labor remuneration, resource provision, foreign economic and financial activities, accounting, and reporting.
- Market research: comprehensive market analysis, product competitiveness assessment, consumer requirements, demand generation methods, and distribution channels.
- Innovation activities: implementing new scientific and technological developments, design and technological preparation of production, utilizing effective innovations, and forming investment resources for innovative activities.
- Production activities: justifying production volume in line with market demand, aligning production programs and capacity, ensuring necessary resources for production, and adhering to operational schedules.
- Commercial activities: organizational and economic measures to achieve expected profitability and other financial performance indicators of production.
- Sales activities: carrying out contractual obligations for product sales, warranty servicing, and repair.
- Social activities: training and skill development of personnel, providing suitable working and leisure conditions, and ensuring social protection for employees.
- Legal foundations of functioning.

Depending on the direction of activity, enterprises utilize various types of development, including sustainable, managed, organizational, and strategic development.

Sustainable development is characterized by long-term stability and quality. Managed development involves the use of innovative management tools and methods. Organizational development focuses on improving internal management within the enterprise, while strategic development is realized through a development strategy.

To achieve strategic goals, an enterprise must have the necessary economic resources [6], which are a set of means through which the economic entity can achieve its objectives and obtain the expected results.

The economic resources include:

- labor resources;
- financial resources;
- material resources, which consist of fixed assets and current assets;
- intangible resources;
- information resources.

To achieve strategic goals and optimize resource utilization, enterprises need appropriate management mechanisms for each resource individually and as a whole.

In order to effectively utilize labor potential, enterprises implement labor management, which includes analyzing the human resource potential and its utilization level, determining the need for employees of various specialties, forecasting and planning the workforce for the entire enterprise and its specific units across different structural groups, employee placement and coordination of their activities, motivation of employee work, tracking employee work results, and monitoring the execution of tasks, instructions, orders, and directives.

Financial resources are funds that are formed during the establishment of an enterprise and replenished through economic activities, namely:

- by selling goods, providing services, and performing work;
- through the attraction of external sources of financing;
- by developing forecasts and plans for the formation and utilization of financial resources in the near future;
- through the development of the financial policy of the enterprise, including profit distribution, fulfilling tax obligations, etc.;
- by determining the feasibility of additional financial resource mobilization through issuing shares, bonds, obtaining financial credit from banks, etc.;
- by organizing the process of formation and utilization of financial resources within the enterprise;
- by accounting for and controlling the processes of formation and utilization of financial resources.

Material resources include fixed assets and current assets of an enterprise. Fixed assets refer to the portion of the enterprise's property used as means of production for manufacturing goods (performing work, providing services) or for management purposes over a certain period.

Managing fixed assets of an enterprise is a complex system. The challenge lies in the fact that fixed assets are formed during the establishment of the enterprise and serve for a considerable period.

Managing the utilization of fixed assets in economic turnover is a key aspect of their efficient management. Therefore, managing the production assets primarily involves ensuring their timely renewal and increasing efficiency.

Managing current assets means analyzing the need for them at each stage of the turnover cycle, determining the constant and variable value of current assets at each stage, forecasting and planning the demand for specific types of current assets, regulating and organizing the process of turnover of current assets, stimulating its acceleration, evaluating the efficiency of their utilization, making appropriate operational, current, or strategic decisions regarding their formation and utilization.

Intangible resources are a part of an enterprise's property that characterizes intellectual property objects and similar rights owned by the enterprise.

Intangible assets are formed as needed. In the conditions of a market economy, an increasing number of enterprises include intangible assets in their asset composition. These assets may include patents, computer programs, various licenses, certificates for the right to conduct activities or use certain property, inventions, know-how, land ownership rights, and so on.

Managing intangible assets primarily involves timely acquisition of such assets, their reproduction through depreciation, and skillful utilization in the process of production or other economic activities.

Information resources comprise the totality of internal and external information necessary for the management of an enterprise, as well as all its departments and units, to achieve the set goals and expected results.

Internal information is formed during the course of economic activities. It is divided into operational, accounting, and planning information. The main sources of internal information are the data of management and financial accounting of the enterprise, as well as materials of operational dispatching records.

External information is received by the enterprise from various sources, including legislative acts, regulations and decisions of state and local authorities, judicial and other bodies of the legal system, statistical agencies, newspapers, journals, materials from research institutions, higher education institutions, and others.

The management of information resources is aimed at maximizing the efficient use of internal and external information for making necessary and timely decisions that ensure the achievement of goals and the resolution of specific operational, tactical, or strategic tasks.

Ensuring the sustainable development of an industrial enterprise as a production-economic system is related to the organization of effective management processes and the formation of a specific organizational and management mechanism for this purpose.

Enterprise management involves establishing strategic guidelines to ensure high profitability and performance in competitive conditions. This goal is achieved through three main directions of industrial enterprise functioning: scientific organization of production, scientific organization of management, and organization of labor and management. Each of these directions has its own tasks related to increasing production efficiency and enterprise management [4–7].

The main management tools for an industrial enterprise are as follows:

- economic tools that focus on creating optimal conditions for enterprise development;
- technological tools that provide technical and technological basis for development management processes;
- administrative-legal tools that have a mandatory nature, are normatively formalized, and are aimed at regulating and organizing relations in the process of development management;
- socio-psychological tools that include corporate culture, moral norms, ethics, internal regulations, conditions for rest and work, occupational safety;
- controlling, which is responsible for feedback in the management process;
- motivation, which stimulates the effective work of enterprise employees;
- benchmarking, reengineering, outsourcing, and grading tools;
- digitalization of the enterprise.

Digitalization is an important management tool for modern enterprises, as it allows for the implementation of digital technologies and tools in all aspects of enterprise activities to increase efficiency and competitiveness. This process may include automation of production processes, digitization of document flow, implementation of IoT (Internet of Things) and cloud technologies, use of artificial intelligence and data analysis for decision-making, development of digital products and services, and much more. This enables enterprises to optimize resource utilization, reduce costs for labor and materials, improve the quality of products and services, increase customer satisfaction, and enhance communication [6–8].

The internal structure of an enterprise is characterized by the totality of all production, non-production, and managerial structures (departments, bureaus, services) with a system of corresponding connections, subordination, and interaction.

An industrial enterprise is a complex production-economic system that, on the one hand, is subordinated to or forms part of a higher hierarchical level system (territorial and national economic system, industry or sub-industry), and on the other hand, plays an integrative role in coordinating and managing the activities of lower-level production subsystems that belong to its internal composition (divisions, groups, and individual employees). The state and dynamics of processes of functioning and development of an industrial enterprise are primarily determined by the influence of changes from the external environment or internal transformations associated with the self-organization of the production-economic system.

From the perspective of an enterprise as a system, the following characteristics can be distinguished.

The first characteristic is that an industrial enterprise is an artificial, open, stochastic system that operates in a stochastic environment. Stochastic systems anticipate the future with some degree of error, using statistical analysis of the system's behavior in the past and its characteristics today. Therefore, the state of operation of any production unit and its main results have a probabilistic nature.

The second characteristic of an enterprise as a system lies in the fact that an enterprise is a system that can exist only through active interaction with the surrounding environment. Such systems are not self-sufficient; they depend on resources, information, and materials that come from the outside. Additionally, an open system has the ability to adapt to changes in the external environment and must do so in order to continue its functioning.

The third characteristic of an enterprise as a system is that it is a purposeful, rational system created by humans for their own interests, primarily for cooperative work. Economic subsystems, including production subsystems, hold an important place among artificial systems.

The production subsystem is a part of the overall enterprise system that is capable of independently or in interaction with other production and economic subsystems creating products or services to satisfy societal needs. Any production system should be regarded as a living, dynamically functioning system in space and time of production, as well as a complex integrated system comprising production processes, objects, and subjects of production.

The organizational subsystem of an enterprise is a set of departments, services, and systems of interconnections between them and production units in the production process, which ensures the implementation of management functions of the enterprise.

The tasks of the organizational structure include work planning and control, development of technical plans for enterprise development, implementation of new equipment and technology, implementation of advanced methods of production and labor organization, technical preparation of production, and its regulation.

Thus, a modern enterprise is a complex entity, the harmony and dynamism of which are ensured by the management mechanism.

Enterprise management is the process of planning, organizing, motivating, controlling, and regulating the actions of personnel, setting strategic goals and tactical tasks for the enterprise, making management decisions, and ensuring their implementation [8–10].

The enterprise faces a choice: either to adopt one of the classical management strategies and find its place among existing structures or to become the driving force in the development of its activity environment - market, competition, social, political, technological - on the platform of new management methods.

Globalization processes lead to the emergence of new complex tasks, which necessitates continuous development and improvement of management methods. The scientific substantiation of management decisions, their optimality, depends, on the one hand, on the level of perfection of the methods used in the process of decision-making and implementation, and on the other hand, on the level of knowledge and mastery of the personnel in managing the complex of methods.

The success of any enterprise depends on the substantiation of management decisions. Currently, a number of new scientifically substantiated management methods have been developed [8–14]. However, these methods are not yet actively used in management practice.

The enterprise faces a choice: either to adopt one of the classical management strategies and find its place among existing structures or to become the driving force in the development of its activity environment - market, competition, social, political, technological.

Simultaneous use of different management methods and scientific approaches ensures high effectiveness in making management decisions [15–18].

Hence, there is a need to develop new and improve existing methods of managing industrial enterprises, taking into account the specific tasks they face.

1.2. Problems of Industrial Enterprise Management

Management of an industrial enterprise is the process of coordinating and controlling the company's activities aimed at achieving set goals and objectives.

In the management of a modern industrial enterprise, innovative approaches are crucial. With the increasing automation and complexity of modern production, it is necessary to utilize innovative management methods to improve the efficiency and competitiveness of the enterprise. Innovative methods may involve the use of new technologies, application of quality and process management methods, as well as the implementation of new management strategies. They help improve productivity, product quality, reduce production costs, and increase the profitability of the enterprise [2–9].

The following approaches are relevant for enterprise management:

1. Reactive approach: This management method is based on reacting to events occurring within the enterprise. It is used when problems arise and need to be addressed promptly. The reactive approach does not allow for problem prevention, only reacting to them.
2. Situational approach: This management method is based on analyzing specific situations and choosing an appropriate management strategy based on the circumstances. This approach enables the enterprise to quickly adapt to changing conditions and solve problems based on their unique characteristics.
3. Proactive approach: This management method is based on anticipating potential problems and taking preventive measures. This approach allows the enterprise to be prepared for possible issues and resolve them before they occur. The proactive approach is more effective than the reactive approach as it enables problem avoidance rather than just solving them [1, 14].

Situational management and proactive management differ in their fundamental approach to management. Situational management is typically applied in crisis situations when there is a need to respond to unforeseen events. It relies on making decisions based on the current situation and previously made decisions. The main task of situational management is to minimize the damage that can be caused to the enterprise due to unforeseen circumstances.

On the other hand, proactive management is based on anticipating potential problems and managing them before they become crises. It involves continuous optimization of processes to minimize the possibility of unforeseen situations.

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The main task of proactive management is to create conditions for maximum efficiency of the enterprise.

Based on the definition of proactive behavior, the concept of "proactive behavior management" has been formed as a system of measures aimed at shaping the principles of proactivity by the management [19–22].

The proactive approach contributes to the formation of a more flexible management organizational structure capable of responding to changes in the internal and external environment. It ensures clear distribution of management goals, tasks, functions, and responsibilities for their implementation.

Thus, the main difference between situational and proactive management lies in the fact that situational management is intended for reacting to unforeseen situations, while proactive management focuses on prediction and prevention of negative phenomena.

Therefore, the most promising approach that can be identified is the proactive approach to enterprise management.

The proactive approach to enterprise management emerges as the most promising. Proactive management involves not only reacting promptly to current situations but also anticipating potential issues in advance. In some cases, minor changes in processes can have a significant impact on the overall performance of the entire company.

The application of the "Pareto principle" in proactive management enables the identification of key threats and risks that may lead to critical situations within the company. This helps in focusing attention and resources on the most important tasks and taking preventive measures.

Proactive enterprise management offers several advantages, including:

- prioritizing and addressing crucial tasks first;
- estimating resources and preparing project participants in advance;
- adjusting work plans after implementation;
- incorporating new tasks that arise during the process;
- allowing additional time for analyzing current results and work quality;
- planning and controlling to address problems at their early stages;
- allocating extra time for team strengthening.

Proactive management involves anticipating unforeseen situations. To achieve this, it is essential to develop detailed plans and organize work in a manner that

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considers any deviations. Effective time management enables timely task completion without compromising productivity. The ability to set priorities helps to focus on the most important and critical tasks. Change management must be swift and efficient to save time and ensure seamless coordination in documentation work [14–23].

One way to enhance the effectiveness of a proactive approach is by leveraging modern data analytics and machine learning tools. These tools facilitate rapid analysis of large volumes of information, uncovering hidden dependencies and trends, thereby facilitating informed decision-making based on current data.
By utilizing mathematical, technical, organizational methods, and modern technical means, it is possible to establish an efficient proactive industrial enterprise.

A proactive industrial enterprise aims to prevent potential issues and continuously improve its processes before serious problems arise. Proactive enterprises actively employ data and analytics to identify potential problems and improvement opportunities. They constantly analyze their operations and restructure them to optimize efficiency, safety, and quality.

The advantages of proactive enterprises include:

- Increased productivity and efficiency: Proactive enterprises actively seek opportunities to improve processes and optimize efficiency, ultimately enhancing productivity.
- Risk reduction: Through active identification and elimination of potential problems, proactive enterprises can reduce the likelihood of emergencies and significantly mitigate risks.
- Improved quality: Proactive enterprises continually enhance their processes and introduce new technologies to improve the quality of their products or services.

Notable examples of proactive industrial enterprises include companies such as Toyota, Boeing, General Electric, and Procter & Gamble. These companies actively apply proactive management methodologies, including Lean Manufacturing, Six Sigma, and Kaizen, to optimize their operations and increase efficiency [15–23].

Comparing different methods and approaches to industrial enterprise management allows for several conclusions:

- Each method and approach has its advantages and disadvantages, and the choice of a specific strategy depends on various factors, such as company size, type of industry, competitive environment, customer needs, etc.
- Preventive management, proactive approaches, and quality management have

become the main directions in industrial enterprise management, as they help prevent problems, minimize costs, and enhance customer satisfaction.

- In today's world, there is a growing need to organize industrial enterprise management using new technologies, such as artificial intelligence, the Internet of Things, big data, etc. These technologies help improve the efficiency and accuracy of management processes while providing new business development opportunities.

1.3. Problems of proactive risk management in an industrial enterprise

1.3.1. Risk assessment of an industrial enterprise

The activities of enterprises are always associated with a range of factors whose impact on performance outcomes cannot be precisely determined in advance. Uncertainty leads to the emergence of risks. The category of risk holds a significant place in economic science and practice, and as a socio-economic category, it is an integral component of production relations and organically fits into the economic mechanism [23].

Risks are complex and multifaceted phenomena that can be found in various areas of the financial and economic activities of business entities. They arise in the implementation of any type of activity and are related to production processes, the production of new products, goods, works, services, as well as the development and implementation of socio-economic and innovation-investment projects.

In general, risk is considered as a measure of the possibility of an adverse event or a combination of such events. The manifestation of a risky situation lies in the deviation of actual values of critical indicators from a normal, stable, average, or alternative level.

Risk in the activities of an industrial enterprise can be characterized as follows:

– it is the probability of losses arising from the investment of funds by the enterprise in the production of new products, services, the development of new equipment and technologies that may not find the expected market demand, as well as the investment in the development of managerial innovations that may not yield the expected effect.

– measurable probability of failure to achieve profit or loss of value in a portfolio of financial assets, income from a venture project, a venture company as a whole, and so on [24–31].

Risk arises when making any management decision in conditions of uncertainty, and uncertainty is an inevitable condition of economic activity. The occurrence of uncertainty is primarily due to the fact that most processes related to enterprise activities are non-deterministic because it is practically impossible to determine in advance the rates and directions of scientific and technological development, changes in market conditions, consumer preferences, the manifestation of various external influences, and so on.

Identification of the causes and nature of risks, as well as forecasting the consequences of risks, is necessary primarily for making effective management decisions. Assessing the degree of risk and developing prospective programs for its reduction are part of daily management work and one of the functions of enterprise management. This problem becomes particularly relevant in modern conditions of an unstable economy, which is caused by phenomena of uncertainty and risk.

The activities of an enterprise are influenced by external and internal factors, among which are the following:

- Demand for goods or services: Changes in consumer tastes, market conditions, and economic factors can lead to changes in demand for the enterprise's products or services.
- Competition: The activities of an enterprise can be influenced by competitors who may outperform it with new products, services, or more attractive offers for consumers.
- Price volatility: Changes in market prices, including prices of raw materials, energy, and other costs, can impact the profitability of the enterprise.
- Changes in legislation and regulation: Changes in the legal environment, tax policies, regulations, and standardization can affect the operations of the enterprise.
- Technological changes: Rapid technological advancements can impact production processes, efficiency, and the competitiveness of the enterprise.
- Financial risks: Changes in interest rates, availability of financing, currency exchange rates, and other factors can affect the financial stability of the enterprise. Market price instability, changes in interest rates, currency exchange rate fluctuations, and other financial factors can impact profitability, liquidity, and financial stability of the enterprise.
- Macroeconomic instability: Changes in inflation levels, unemployment rates, currency exchange rates, financial crises, and other macroeconomic factors can have a

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significant impact on the operations of the enterprise.

- Natural disasters and climate change: Floods, earthquakes, hurricanes, droughts, and other natural disasters can cause material losses and disruptions in production and supply chains.
- Environmental risks and sustainable development: Increasing awareness of environmental issues, resource conservation requirements, and the implementation of sustainable development standards may require changes in production processes and the creation of environmentally responsible products.
- Currency risks: Exchange rate fluctuations can affect the cost of imported raw materials, the export value of goods, and the financial indicators of the enterprise.
- Insufficient innovation and technological changes: Insufficient innovation and lagging behind competitors in the use of advanced technologies can lead to a loss of market share and failure to meet consumer demands.
- Innovation risks: The introduction of new technologies, products, or services may be accompanied by uncertainty regarding their acceptance in the market, research and development costs, and potential technological issues.
- Unforeseen events: Unexpected events such as terrorist acts, epidemics, natural disasters, wars, global conflicts, or political crises can have a significant impact on the operations of the enterprise.

These listed risks can be classified into several types based on their nature and sources. The main types of risks that can be identified include:

- Financial risks: These are associated with changes in financial conditions, such as price fluctuations, exchange rates, interest rates, liquidity, and more.
- Operational risks: These risks are related to daily operational processes of the enterprise, such as supply issues, production, logistics, which can lead to delays, quality losses, product deficiencies, or personnel problems.
- Market risks: These risks are associated with uncertainty and fluctuations in consumer demand, market competition, changes in consumer tastes and preferences, fashion trends, tariffs, and regulations.
- Reputation risks: These risks arise from negative impacts on the reputation of the enterprise, such as poor product quality, scandals, unethical behavior, violations of ethical norms, or non-compliance with corporate social responsibility.
- External environment risks: These risks are associated with the influence of external factors, such as political changes, economic instability, natural disasters,

technological shifts, demographic changes, and more.

- Management risks: These are risks associated with ineffective management, poor planning, lack of coordination, insufficient control, and decision-making capabilities.

The main goal of "risk analysis" is to establish the maximum acceptable risk for a specific set of circumstances and, for researched and known risk factors, the maximum acceptable risk values.

There are various algorithms for risk assessment [32–42]. According to the algorithm (Figure 1), during the "Information Acquisition and Processing" stage, the selection of risk factors that need to be reduced in their impact on enterprise activities is conducted.

Quantitative and qualitative analysis are the two main types of risk analysis conducted based on the obtained information.

The specific characteristic of qualitative approach in risk research is that risk identification is performed first, followed by the cost evaluation of the consequences of risks and the development of measures to mitigate them.

Qualitative analysis is conducted during the task development stage. Quantitative analysis, based on the tools of probability theory and mathematical statistics, involves a numerical assessment of the impact of project risk factors on project performance, relying on the baseline project plan and the conducted qualitative analysis [30–32].

Thus, qualitative analysis is responsible for the identification of all possible risks, determining risk factors, the sequence of activities that involve risk, and so on.

Loss magnitudes from risks are determined through quantitative analysis, which identifies the causes, sources, and the magnitude of probable consequences. The risk monitoring and diagnostic system allows for their evaluation and outlines ways to overcome or minimize them.

The statistical method of risk assessment examines the information array of losses and gains of the company, determining the size and frequency of risk events.

Quantitative risk assessment methods enable the quantitative evaluation of risks, with their main parameters being the determination of the probability of loss occurrence (i.e., the probability of risk realization) and the magnitude of those losses (the negative impact of risk on the entity's operations or the extent of damages from the realization of an adverse event).

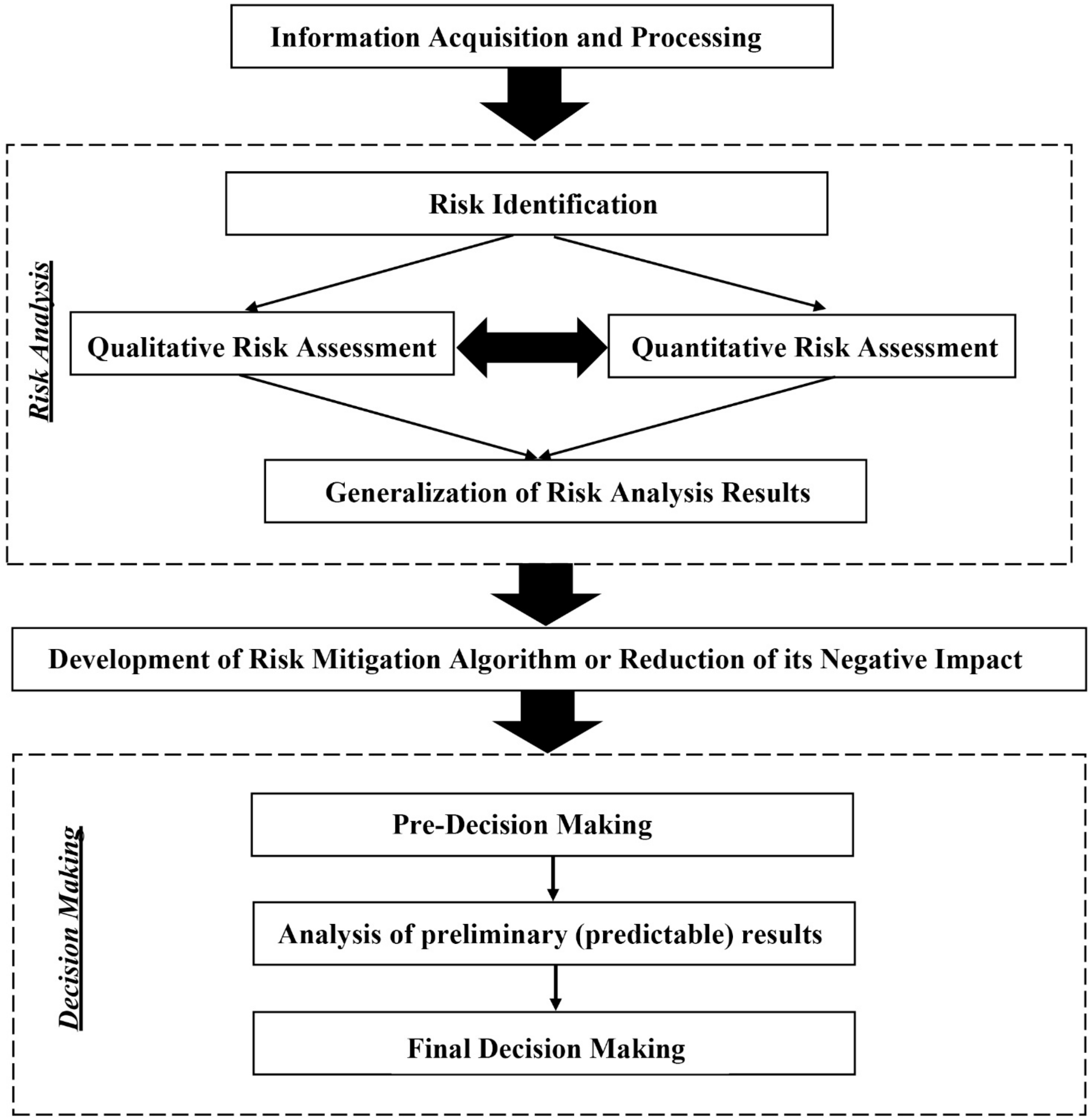

Figure 1 – Risk Assessment Algorithms

Based on these methods, the decision-maker takes managerial decisions considering the probabilities of occurrence of various risks, thus assisting in forecasting performance indicators.

There are two approaches to risk assessment, which serve as a quantitative measure of uncertainty (see Figure 2). One of them is based on actual data, i.e., retrospective analysis. In this case, statistical processing of information is conducted, and based on that, forecasts of development indicators (estimations) are made, and the development trend is determined.

In addition to the retrospective approach, there are risk assessment methods based on forecasted data. In such cases, information from projected development projects is analyzed, which, being of a predictive nature, entails uncertainty. The focus of risk assessment in this context is the analysis of this uncertainty. Various factors that can influence enterprise activities, such as economic, political, technological, social, etc., are considered.

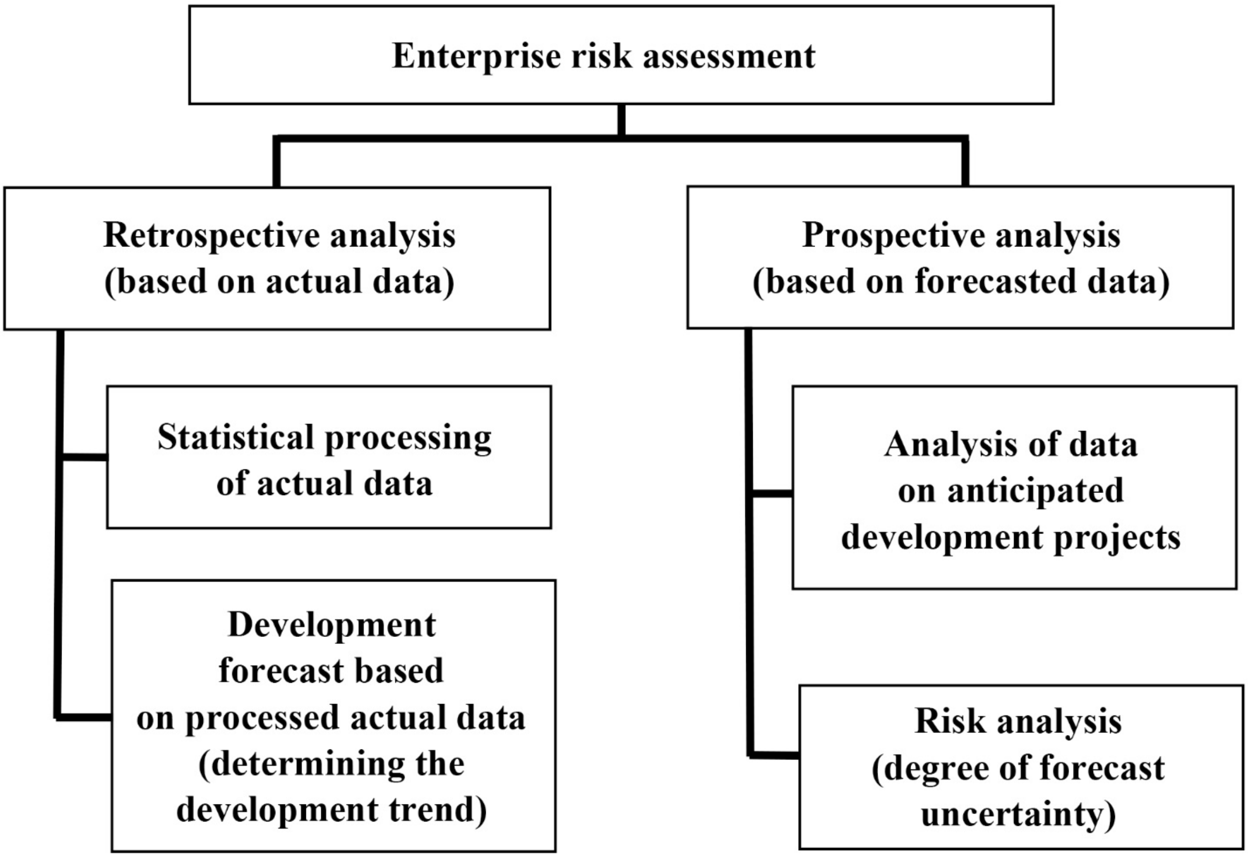

Figure 2 – Risk Assessment Methods

Prospective analysis enables the evaluation of potential risks and the identification of the most effective strategies and methods for their minimization.

The combination of risk assessment methods ensures more efficient enterprise safety management, as each method possesses its own advantages and limitations. For instance, retrospective analysis can provide precise risk assessments based on factual data but may overlook new opportunities and changes in the surrounding environment. On the other hand, prospective analysis can evaluate potential risks based on forecasted data but might be less accurate due to uncertainty and forecasting errors [37–42].

By combining both methods, a more comprehensive and accurate risk assessment can be obtained, leading to the development of more effective strategies and methods for risk management within the enterprise.

Risk assessment is a complex and responsible task for the enterprise, as its outcomes shape the subsequent actions and determine the degree of risk impact. While not all risks can be eliminated, their impact can be minimized.

Based on the assessment, an action plan is developed to mitigate or reduce the impact of the risk on the enterprise, aiming to prevent unforeseen situations.

Quantitative methods for determining risk using mathematical decision-making methods include the following:

1. Methods of mathematical game theory.
2. Statistical methods (methods of mathematical statistics; methods of statistical decision theory).
3. Methods of mathematical programming.

To assess the level and probability of risk associated with an array of input information, two-factor models, Altman coefficients, four-factor Taffler models, expert assessments, cost effectiveness, and analytics are employed [26–27].

Enterprises perform risk monitoring and control, identify and forecast potential new risks, investigate identified risks, including those present in the database, for continuous monitoring, verification, and execution of risk response operations, and evaluate their effectiveness throughout the enterprise's life cycle [32–37].

Regarding the risk management process, one of its vital components is decision-making, which is grounded in risk analysis considering both external and internal influencing factors.

Enterprises develop tactics and strategies, analyze and compare potential preventive and regulatory measures, and select tactical actions aimed at minimizing existing risks.

The critical phase of the risk management process is the selection of the optimal decision, which determines the level of risk, cost estimation, and alternative solutions for risk reduction. Subsequently, a decision is made regarding the implementation of risk reduction measures or the decision to further monitor the risk in case of high uncertainty.

The decision-making process is associated with the components of the systemic risk management model (Figure 1).

The risk management system encompasses the following [37]:

1. Definition of procedures and methods for risk analysis and formulation of measures and implementation of changes.

2. Risk analysis is one of the most common components of management. It involves the identification of risk processes and factors, analysis of identified risks, identification of sources, cause-and-effect relationships, interdependencies, effectiveness of preventive and protective measures, and potential consequences. The analysis results in prioritizing based on the degree of risk for the organization, processes, people, and economic outcomes.

3. Risk management. The main goal of this component is to prevent adverse events and reduce their consequences. It includes planning actions, identifying critical success factors or conditions, ensuring effective execution of tasks, searching for necessary resources (human, financial, informational, methodological).

4. Risk monitoring and impact assessment. Risk analysis can be conducted on a one-time basis. However, continuous risk monitoring as a systemic tool of corporate governance is more beneficial and effective.

5. Optimization (communication and risk awareness) of the corporate risk management system. The results of risk monitoring can be utilized on a continuous basis to improve risk management procedures.

To minimize risk, other approaches can be utilized, such as risk insurance, self-insurance, diversification, limitation, alternative planning, creating a flexible production structure, establishing contingency funds, information monitoring, training and development, and employing flexible technologies.

Currently, the concept of management has acquired relevance, which differs from the classical approach by recognizing and assessing the uncertainty of the operating environment of economic entities and shifting from pursuing stability to flexibility, ensuring long-term performance with the use of not only quantitative but also qualitative indicators and investigating the causes of their deviations.

A characteristic feature of the modern stage of economic development is radical changes in all its spheres, which affect the entire enterprise management system. This confirms the objective necessity to consider it as a dynamic process since its forms, methods, and functions are influenced by multiple factors: the scale of the enterprise, profitability level, competitiveness, and so on.

Management should be considered from two perspectives: as a state and as a process. In the general context, management is understood as a process whose main goal is to ensure the ability of socio-economic systems to maintain and, within certain limits, change their qualitative and quantitative determinacy.

Risk management is the process of making managerial decisions that minimize the adverse impact of external and internal factors on the enterprise and reduce losses caused by random events. Minimizing potential adverse impacts is a priority task, the solution of which prevents situations where the enterprise faces losses and other damages.

Risk management includes the development of a strategy and tactics for risk management within the enterprise. The key principles necessary for the development and implementation of a management strategy include systematicity, continuity, a balance of responsibility and initiative, a combination of analysis and risk heuristics, multivariate analysis, and proactivity.

Regarding the risk management process, one of its important components is the decision-making process based on risk analysis, taking into account economic, technical, social, and political risks. The entrepreneur develops tactics and a course of action, analyzes and compares possible preventive and regulatory measures, and then selects those that will minimize the existing risk.

The critical phase of the risk management process is the selection of the optimal decision. This phase begins with determining the level of risk, followed by assessing economic costs and alternative solutions for risk reduction, as well as calculating potential economic benefits. Subsequently, a decision is made regarding the implementation of risk reduction measures or the decision to further monitor the risk in case of high uncertainty associated with the current level of knowledge and the impossibility of risk reduction at the decision-making stage.

1.3.2. Analysis of the Proactive Risk Management of an Industrial Enterprise

Risk management is a process that requires constant monitoring and updating. An enterprise must establish risk monitoring mechanisms to timely identify new risks, assess the effectiveness of applied strategies, and make changes to the risk management strategy when necessary.

Implementing a risk management strategy can positively impact the efficiency of enterprise functioning through the following:

- Loss reduction: By identifying and analyzing risks, the enterprise can take preventive measures to prevent or reduce losses. This can include implementing safety measures, insurance, process controls, and other measures that help avoid or mitigate risks, leading to reduced damages and expenses, thus enhancing overall enterprise efficiency.

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- Resource optimization: Risk management helps identify critical risks and prioritize managerial efforts and resources. The enterprise can concentrate its efforts on managing the most significant risks, optimizing resource utilization, and ensuring more effective achievement of strategic goals.
- Enhanced enterprise resilience: Risk management contributes to the creation of a more resilient organization. This means that the enterprise becomes better prepared to withstand the impact of negative events or changes in the external environment. By developing crisis management plans, preventing losses, and ensuring rapid recovery, the enterprise can reduce the adverse effects of risks and quickly restore normal operations.
- Increased competitiveness: Effective risk management allows the enterprise to be more competitive in the market. The ability to identify and manage risks enables the enterprise to adapt faster to changing conditions and negative events, ensuring stability and long-term success.

Implementing a risk management strategy involves a systematic approach to risks and their management, enabling the enterprise to be more adaptive, flexible, and efficient in uncertain and changing conditions.

The implementation of proactive risk management enables forecasting the future and achieving better results [25–27].

The advantages of proactive risk management include preventing threats of any nature and addressing problems, or facilitating their resolution; improving productivity, efficiency, and the quality of the end product.

Proactive risk management at an industrial enterprise involves five main stages:

1. Risk identification: This stage involves identifying potential problem areas that can impact the operations and financial results of the enterprise. By analyzing production processes, management activities, and the market environment, possible risks are determined.
2. Risk analysis: The probability of each risk occurring and its potential impact on the enterprise are assessed during this stage. Quantitative and qualitative risk assessment methods are applied within the analysis.
3. Development of risk management strategies: Based on the conducted risk analysis, the best methods for reducing or eliminating risks are determined. Strategies and measures for risk prevention, mitigation, or transfer are developed.
4. Implementation of risk management strategies: This stage involves

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implementing the strategies and ensuring their execution. Implementation includes specific steps for risk management and mechanisms for control and reporting.

5. Monitoring: Continuous analysis and adjustment of risk management strategies are carried out based on changes in the internal and external environment of the company. This involves assessing the effectiveness of proposed measures and adjusting strategies according to changes in risks and the company's environment.

The application of proactive risk management at an industrial enterprise not only enhances its operational efficiency and minimizes potential negative consequences but also increases the company's resilience in the long term in the following ways [28–38]:

- Reducing financial losses: Risk management helps prevent or reduce potential financial losses associated with risks, significantly lowering the company's expenses.
- Enhancing product quality: Risk management in an industrial enterprise can contribute to improving product quality by identifying and addressing potential issues before they lead to serious consequences (such as premature equipment aging, subpar raw materials, incompetent staff, etc.).
- Improving safety: Risk management helps prevent potential accidents and incidents, thus increasing the level of safety within the enterprise.
- Increasing competitiveness: Through risk management, an industrial enterprise can enhance its competitiveness by improving product quality, reducing costs, and increasing safety.
- Decreasing legal risks: Risk management helps prevent potential legal problems associated with violations of legislation and regulatory requirements, reducing legal risks for the enterprise.
- Enhancing reputation: An enterprise that successfully manages its risks can improve its reputation and image in the eyes of customers, partners, and the public.
- Optimizing management: Risk management enables the optimization of enterprise management by identifying and addressing potential problem areas and improving production processes.
- Reducing stress for employees: Effective risk management can make employees feel more protected and confident in their work, leading to reduced stress levels.

There are several mathematical models for risk management used in industrial enterprises, including [39–40]:

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- Weighted Average Expectations (WAE) model: This model allows determining the probability and magnitude of potential losses when making risk management decisions.
- Stochastic Process Model (SPM): This model is used to analyze the probability of risks occurring and their impact on the financial results of the enterprise.
- Multi-Criteria Optimization (MCO) model: This model helps determine the optimal risk management strategy by considering multiple criteria.
- Risk Assessment Model (RAM): This model is used to identify and assess risks in an industrial enterprise.
- Probabilistic Analysis Model (PAM): This model allows determining the probability of risks occurring and their potential impact on the enterprise.
- Stochastic Programming Model (SPM): This model is used to determine the optimal risk management strategy under uncertainty.
- Game Theory Model (GTM): This model enables the determination of the optimal risk management strategy based on the analysis of interactions among participants.
- Interconnected Risk Model (IRM): This model is used to analyze interconnected risks and their impact on the enterprise.

The choice of a specific proactive risk management model depends on various factors, including the nature of risks to be managed, the level of uncertainty, the availability of data and resources, as well as the preferences and strategies of the enterprise's management [38–42].

When selecting proactive risk management models for an industrial enterprise, it is necessary to consider several factors, such as the goals and objectives of the enterprise, its activities, size and type of the enterprise, identification of potential risks, budget, competencies, and experience of employees, and more.

Currently, there is an urgent need for the development of a comprehensive proactive risk management system that is adapted to the modern trends in economic development.

1.4. Analysis of Forecasting Issues for Industrial Enterprise Performance Indicators and the Commodity Market

As mentioned earlier, an industrial enterprise, as a management object, belongs to the class of dynamic systems that operate in a stochastic environment.

It is known [43] that optimal control of a dynamic system is determined by the values of the input variable vector (estimates of the state of the commodity market), the vector characterizing the state of the management object (the industrial enterprise), the vector of external parameters, and the control vector.

The main idea behind passive proactive management of an industrial enterprise is to timely assess all deterministic and stochastic trends in the commodity market and align them with the enterprise's development trends with minimal delay. Active proactive management of an industrial enterprise involves active participation of the enterprise in shaping the trends of the commodity market by offering new consumer goods, production facilities, and services. Thus, for practical implementation of proactive management by an industrial enterprise, an effective forecasting toolkit for the state of the enterprise and the commodity market is necessary. Let's consider these issues in more detail.

1.4.1. Forecasting Issues for Industrial Enterprise Performance Indicators

The state of an industrial enterprise at any given time is characterized by a vast number of indicators that quantify and qualify various aspects of the enterprise's activities: assortment and quality of products and services, consumption of all types of energy resources, technical condition of technological and logistical equipment, production and labor efficiency, finances, inventory, marketing, innovation activities, personnel, and so on.

The numerical values of quantitative indicators of the enterprise's state are obtained from a continuous monitoring system based on Industrial Internet of Things (IoT) technology in the form of sensor networks and intelligent sensors with built-in analytics, providing real-time continuous monitoring of the enterprise's state indicators. Each indicator is vector-based, which requires obtaining and processing large volumes of data. Moreover, not all indicators are independent of each other, so cloud technologies such as BIG DATA and Data Mining are used to detect and evaluate functional or correlation dependencies among different indicators of the enterprise's state and with external factors. This allows for selecting only independent indicators that characterize the state of the industrial enterprise at the current moment. Having information about the numerical values of the enterprise's state indicators in previous time periods and forecasts of changes in external factors is a necessary condition for calculating the predicted state of the industrial enterprise at a given time with a specified lead time [11–13].

A forecast of the industrial enterprise's state represents the most probable state of the enterprise in future time periods with a specified lead time when enriching the employed management strategy. A comparative analysis of the current and predicted state of the enterprise allows for assessing the nature and parameters of stochastic and deterministic trends for each indicator. The results of the comparative analysis of the predicted development trends of the enterprise with the predicted development trends of the corresponding sectors of the commodity market provide an objective basis for formulating and implementing proactive management interventions for the industrial enterprise. Thus, forecasts of the state of the industrial enterprise and the commodity market are a primary form of information support for proactive management of the industrial enterprise.

Forecasting, by its nature, is a continuous process. Modern enterprises conduct research on their development based on a continuous information processing system. This enables the improvement and refinement of forecasts in the face of constantly changing external factors, new data, and emerging phenomena in the process. Analysis of forecasting studies for enterprises demonstrates their multilevel nature, involving a sequential transition from determining the development patterns at the general level (for the entire enterprise) through local forecasts to the forecast of economic indicators for its individual structural components. This approach allows for justifying management decisions based on forecast assessments.

Forecasting involves a bilateral task: on one hand, based on the past and present, it aims to provide a picture of both the near and distant future, and on the other hand, it aims to establish the foundations of current activities with scientific prediction.

The process of forecasting involves several stages:

1. Determination of the volumes of training samples of indicators of the industrial enterprise's state and external factors, i.e., selecting an optimal amount of input data directly related to the task at hand.

2. Construction of models for forecasting changes in external factors and indicators of the company's state (identifying the structure of models, estimating parameters of stochastic and deterministic trends such as polynomial and polyharmonic

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trends, checking the degree of adequacy of models to training samples).

3. Calculation of forecasts and their confidence intervals with a specified warning.

Various forecasting methods exist, each requiring a specific sequence of steps to obtain the most accurate forecast results and perform actions to evaluate the quality of forecasted values. Choosing the appropriate method for a particular situation is a challenging task.

Developing forecasting models is an integral part of proactive enterprise management as it allows the enterprise to anticipate the future and make decisions based on these forecasts.

To develop the enterprise, it has been expedient to combine the indicators of the industrial enterprise's state into the following predictive models:

1. Product model: This model forecasts changes in demand for the enterprise's products and the production capacities required to meet this demand. It helps the enterprise understand which products will be popular in the future and what production capabilities are necessary for their manufacturing.

2. Technological model: This model forecasts changes in technologies and innovations that may occur in the enterprise. It helps the enterprise plan its investments in new technologies and improve its production processes to ensure competitiveness. Another possibility for such models is to analyze and forecast the reliability of production equipment based on technical maintenance.

3. Supply chain model: This model forecasts changes in the supply chain used by the enterprise to obtain materials and components for its production. It helps the enterprise understand which materials and components will be available in the future and what changes may occur in the supply chain.

4. Economic model: This model forecasts financial indicators of the production enterprise, such as production costs and production volume. It helps the enterprise determine its financial capabilities and risks, as well as develop optimal financial management strategies.

5. Resource efficiency and resource expenditure model: This model forecasts the level of resource consumption, particularly energy resources, by the enterprise in the future and identifies ways to reduce expenditures.

In conclusion, forecasting is an essential tool for proactive management of any enterprise, driven by significant and rapid changes in the economic, political, and market situation in the country. Hence, it is necessary to improve the forecasting processes, systematize them, and utilize new methods.

Let's consider, as an example, the information technology for constructing a model of forecasting energy resource consumption at an enterprise, where the forecasting results can have the greatest impact on the overall efficiency of industrial operations.

This model can include the following elements:

- Analysis of the usage of all types of energy resources: This element allows determining which production processes consume the most resources and identifies areas where consumption can be reduced.
- Forecasting resource consumption: This element enables predicting future resource consumption levels based on data from previous resource usage and forecasts of process changes at the enterprise.
- Development of resource expenditure reduction plans: This element involves developing plans to reduce resource expenditures, which may include measures to improve resource efficiency, utilize renewable energy sources, and optimize production processes.
- Determination of resource costs: This element involves determining resource expenditures and analyzing factors that influence these costs, such as energy prices and demand. This helps the enterprise plan expenditures and production more effectively, considering resource costs.

Currently, the high energy intensity of industrial enterprises is a problem that affects the economies and ecologies of many countries. Energy consumption levels in any industrial sector are significant [44–45], and thus, the efficiency of enterprise operations directly depends on the available resources, particularly energy carriers.

The dependence of resulting energy resource costs on their consumption volumes and the difference between declared and actual consumption over a specified time interval makes the task of monitoring energy resource expenditures at an enterprise extremely relevant. This includes control, accounting, analysis, and forecasting of energy resource expenditures. Therefore, developing models of energy efficiency and energy consumption is an important task for ensuring the economic and ecological sustainability of industrial enterprises.

The process of forecasting resource consumption is significantly influenced by the following factors:

- Chronological factors (season, month, day of the week, hours of the day).

- Meteorological factors (ambient temperature, wind speed and direction, humidity, etc.).
- Technological factors (planned production volumes, activation/deactivation of technological equipment, etc.).

The complex impact of these factors on energy resource consumption processes, combined with the random nature of these factors, leads to the processes being typically heterogeneous, non-stationary, and stochastic.

The influence of chronological factors on energy resource consumption processes results in the emergence of polyharmonic trends, the nature of which is determined by the cyclicality of technological processes.

The impact of ambient temperature, wind speed, and direction on energy resource consumption processes leads to the appearance of polynomial trends caused by changes in weather conditions. Changes in the consumption of natural gas, for example, in response to weather changes, always occur with some time lag due to the thermal inertia of the enterprise's structures and their interaction with the environment.

The influence of technological factors on energy resource consumption processes disrupts their homogeneity and leads to significant changes in the dynamic properties of these processes.

The complex influence of uncontrolled factors and factors that cannot be observed on energy resource consumption processes results in the presence of stochastic trends.

These factors should be considered when modeling the forecasting process and creating a predictive model that utilizes systemic properties and external influences.

There have been numerous studies and a large number of models developed for forecasting energy consumption reduction processes. The models have become more complex and sophisticated, taking into account an increasing number of input factors and utilizing new methods and approaches, including the development of new algorithms [46–51].

The main requirement for energy carrier forecasting methods is to calculate consumption volumes in different time intervals. While linear regression methods could be used in the past, the current challenge lies in considering nonlinear phenomena and the influence of external factors. This necessitates the development of new and justified methods for studying the energy-saving process.

Various approaches and forecasting methods are used to study predictive models for future energy consumption, each with its own peculiarities. Most approaches emphasize the accuracy of the method. However, when the forecasting process is related to many external factors, accuracy alone cannot be the sole criterion.

Practical experience shows that there is no perfect method that considers all the peculiarities and factors influencing the determination and change of resource consumption volumes in an industrial enterprise.

Since there is a wide range of methods available for forecasting consumption processes, including energy resources, the question arises about selecting the best method [47–53].

After constructing any model, it is important to assess its adequacy. This can be done through visual analysis by shifting the forecast back a few steps. Additionally, residual analysis, a standard method for testing the adequacy of any statistically built model, can be employed. Here are some approaches and methods commonly used in forecasting specific phenomena:

Statistical approaches to forecasting allow for the use of an unlimited number of different input parameters (samples), and the influence function of an input parameter on the output result can have any complexity, including nonlinearity and non-stationarity, among others. However, not all parameters are measured in the same units. Some input parameters in the model are numerical (time of day, air temperature, etc.), while others are categorical (cloud type, etc.). The main drawback of statistical methods, which form the basis of mathematical forecasting models, is the low level of detail in the forecasted indicators and the low level of confidence in the obtained results.

There is a wide variety of forecasting methods based on extrapolation, which involve smoothing the time-dependent curves of the forecasted influence factors. The degree of smoothing of the experimental curve is directly proportional to the sliding period, taking into account the following factors:

– the larger the studied period, the less sensitive it is to changes in the model parameter, i.e., the sliding average.

– a curve with a small study period will result in a large number of errors.

The main disadvantages of methods based on extrapolation with sliding averages include:

– the inability to consider a large number of different types of factors that influence the energy consumption processes of any enterprise.

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– trend element analysis does not allow for the consideration of local minimums and maximums of series fluctuations associated with the non-stationarity of the energy consumption process.

Regression analysis allows for considering the influence of external parameters on the forecast, obtaining estimates of dependencies in the research data, and causal relationships. The advantage of regression analysis is the ability to predict the value of the dependent variable based on the indicators of independent variables, assuming they are uncorrelated, and there is no multicollinearity among them. The simplicity of use for forecasting is a significant advantage of regression models, while their disadvantages include the unpredictability of parameters affecting the actual value of the forecasted variable. Sharp changes in the historical data being analyzed lead to a decrease in forecast accuracy and do not provide high accuracy for the predicted data.

Time series analysis (time series method) has a distinctive structure, composing statistical data of the studied process at different points in time [51–52], considering autocorrelation, correlations, and trends based on seasonal patterns. For non-stationary time series, the Box-Jenkins model (ARIMA) is used.

Methods based on time series theory, along with regression and extrapolation methods, allow for the construction of short-term forecasts of energy consumption. This is particularly applicable to retail market subjects, such as industrial and supply enterprises, which possess a large amount of historical consumption data. These methods analyze significant volumes of data and enable the consideration and utilization of consumption and resource expenditure forecasting patterns.

The drawbacks of these methods include the inability to achieve the required accuracy of forecasting for enterprises. However, when the time series method is used in combination with intelligent data analysis methods, such as data mining, the necessary accuracy of the model can be achieved.

In conditions of uncertainty and risks, it is advisable to use alternative methods, one of which is the Monte Carlo method [12].

The basis of modern resource consumption forecasting methods is the decomposition of the forecasted and exogenous time series into deterministic and residual components, which are subsequently jointly used for forecasting. This approach increases the accuracy and stability of the models, taking into account complex interrelationships between processes [52–53].

The SSA "Caterpillar" method is an alternative to the application of well-known approaches. Models such as "trend-noise" or "autoregression-moving average" are suitable only for time series with relatively simple structures, while Fourier analysis, regression analysis, or wavelet transformations result in strict periodicity due to the decomposition of the original function into a fixed system of basis functions [47].

On practice, different modifications of the methods are used. Consequently, two main directions of their application can be distinguished: solving general-type problems (trend extraction, smoothing, detection of periodicities, forecasting), and spectral analysis of stationary time series to study the nature of their dynamics.

Expert estimation methods are used in forecasting energy consumption in the following cases:

- in the absence of sufficient input data to construct a forecast.
- in the case of uncertainty regarding the object being forecasted (sudden changes in ambient temperature, etc.).
- in situations with time constraints and emergencies.

The main advantages of intelligent algorithms in forecasting processes, including SVM (Support Vector Machines), are their ability to make accurate decisions with incomplete and recalculated data and the capability to consider a large number of additional factors that affect the accuracy and quality of the forecast. The disadvantage of this method is the requirement for training and the demand for hardware resources.

1.4.2. Challenges in Forecasting Indicators of the State of the Commodity Market

The state (condition) of the commodity market [55] refers to the economic situation that exists in the market and is characterized by the assortment of goods and services offered, levels of demand and supply, market activity, prices, sales volumes, interest rate movements, exchange rates, wages, dividends, as well as the dynamics of production and consumption. The market's condition depends on numerous factors, with the main ones being consumer incomes, prices of goods, the seasonal nature of production and consumption of goods and services, the supply-demand ratio of securities, their profitability [56]. All factors influencing the market's condition are classified as either constant or temporary (based on the periodicity of their impact), which either stimulate or restrain market development.

The state of the market is characterized by a set of indicators that allow for a quantitative assessment of the changes occurring in it and identify trends in their development. Such indicators are typically categorized into the following groups [56]:

- dynamics of production, introduction of new goods and services, utilization of production capacity, dynamics of investments in the industry, order portfolio movement, production cost dynamics, employment and unemployment rates, the impact of strikes on production volume and wage fund growth, securities exchange rate movement, and mor;
- dynamics and structure of demand and supply, the influence of scientific and technological progress on consumption levels and quality requirements for goods, dynamics of wholesale and retail trade, market capacity (volume of goods realized within a certain period), sales on credit, movement of inventories, product assortment, cost of living indices, and more;
- state of international trade, its dynamics, major exporting and importing countries, new forms and methods of trade and after-sales services, and more;
- dynamics of wholesale prices in leading producer and consumer countries for a particular product, export prices, the impact of inflation on prices, changes in prices of raw materials and energy resources, currency exchange rate changes, the influence of monopolies on price levels, government regulation of price formation, and more.

The main challenges in forecasting indicators of the state of the commodity market are associated with the need to collect, process, and analyze vast amounts of economic information, as well as identify multidimensional functional or correlation dependencies between indicator values and numerous external factors. Typically, these dependencies are not obvious and deeply hidden, and their discovery is possible through the use of cloud technologies, BIG DATA, Data Mining, and artificial neural networks. Research has shown that one of the most effective forecasting tools for indicators of the state of the commodity market is Convolutional Neural Networks (CNN) [57].

CNN has advantages such as fast learning algorithms and the ability to work with hidden causal relationships and significant noise in input data.

It is known [57–66] that CNN utilizes Deep Learning methods for data forecasting in various fields, including finance, medicine, materials science, energy, and many others. CNN can help discover complex dependencies between data and make accurate

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forecasts based on these dependencies.

CNN and Deep Learning employ neural networks with multiple layers to address complex forecasting problems related to trends in indicators of the state of the commodity market, including prices of goods and services, stocks, currency, technology, and intellectual property.

Therefore, based on the review of existing forecasting methods, the characteristics of their application have been identified and the advantages and disadvantages have been analyzed. This will allow for their consideration in the process of modeling enterprise activities and contribute to economic development.

1.5. Proactive Management and Industry 5.0

The realities of today dictate new requirements for managing industrial enterprises, one of which is the need to use modern technologies.

Industry 5.0 is an innovative production development technology characterized by:

1. Global implementation of intelligent robots and cobots in production, which utilize synergy between humans and machines to perform technological operations. This allows for cost reduction, increased efficiency, and improved quality of products and services. Reducing losses and increasing productivity enables significant improvement in the financial stability and competitiveness of the enterprise.

2. The reintroduction of the human factor in the development of new technologies and the production of competitive products and services. This involves creating new job positions, developing education, and increasing the qualifications of labor resources based on the use of virtual models of technological processes, products, and services (digital twins). The use of digital twins is an essential tool for developing sustainable development strategies for enterprises, as well as managing and personalizing future products and product lines. Digital twins are considered as reference models, and the combination of digital twins with real technological processes allows production units to analyze data, control the production process, manage risks before they occur, and reduce downtime, among other benefits. Considering the uncertainty of market demand for goods and services, digital twins offer significant opportunities for adapting the production programs of the enterprise to market demands, reducing losses, increasing production

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productivity, and service efficiency.

3. Extensive use of the Industrial Internet of Things (IIoT) in the form of sensor networks and intelligent sensors with embedded analytics. These sensors provide continuous real-time monitoring of technological equipment (load level, technical condition, quality, and time of performing technological operations), energy consumption (electricity, petroleum products, gas), hot water consumption, wastewater management, as well as external and warehouse logistics, and personnel. These sensors monitor, process, and analyze vast amounts of information, transmitting only the necessary information flow to a higher level for analysis, prediction, and proactive management. The storage and processing of information received from the sensor network are performed in the cloud to ensure effective autonomy and cybersecurity based on Web technologies.

4. Continuous training of enterprise personnel in virtual or simulated environments, such as digital twins. Digital twins (augmented virtual reality) provide a safe, adequate, and cost-effective learning environment for practical training of all employees in standard and extreme conditions that they may encounter in real-life situations. Training on digital twins (simulators) ensures optimal and efficient management of workforce preparation, which is one of the key tasks for manufacturers.

5. Environmentally friendly production using renewable energy sources.

The practical implementation of Industry 5.0 in Ukraine will inevitably face a number of problems and challenges that may slow down the transition process to a new stage of production development.

The first problem lies in the insufficient level of digital literacy among Ukrainian enterprises and their employees. Effective implementation of Industry 5.0 requires the ability to develop and use new technologies and employ digital solutions, which necessitates organizing professional training and retraining programs for qualified personnel.

The second problem is related to the lack of infrastructure to support Industry 5.0, such as broadband Internet, cloud technologies, and digital platforms. The availability of such infrastructure can be critical for the successful implementation of Industry 5.0 in Ukrainian enterprises.

The third problem lies in the lack of sufficient funding for the implementation of Industry 5.0 in Ukrainian enterprises. The adoption of new technologies and services is an extremely costly process that requires significant investments in Ukraine.

Currently, Ukrainian industry is insufficiently prepared for the implementation of Industry 5.0 standards. Most enterprises have outdated equipment and technologies that need to be replaced and modernized.

In general, the implementation of Industry 5.0 in Ukraine may face certain challenges and problems. However, with sufficient funding, infrastructure, and skilled workforce, success can be achieved in transitioning to a new stage of production development.

The plan for implementing Industry 5.0 standards for Ukrainian enterprises should be based on an accelerated transition to new production technologies for in-demand products and the provision of requested services, taking into account the specific conditions and capabilities of each enterprise.

After the war, Ukraine has the potential to become a global leader in the implementation of Industry 5.0 for several reasons.

Firstly, Ukraine's industry is practically devastated, and its revival requires significant investments, which are expected to come from the global community and Russia in the form of contributions. The main task will be their efficient allocation and utilization, specifically in Industry 5.0 rather than Industry 3.0 or 4.0.

Secondly, Ukraine possesses unique natural resources and a high manufacturing potential, along with substantial experience in the production of industrial goods.

Thirdly, Ukraine is a country with a high level of education and low labor costs, which is attractive to investors and enables enterprises to enhance their competitiveness in the global market for both agricultural and industrial products.

Fourthly, in a modernized Ukrainian economy based on Industry 5.0, agricultural and industrial products will be environmentally friendly, with lower costs and higher quality.

Thus, Industry 5.0 is the result of proactive management, sustainable development of industrial enterprises, and a strategic direction for realizing Ukraine's industrial potential in the post-war period.

1.6. Challenges in Developing Instrumental Means for Proactive Management of Industrial Enterprises within the Industry 5.0 Concept

The practical implementation of proactive management in industrial enterprises necessitates a fundamental transformation of practically all aspects of enterprise activities.

Effective solutions for proactive management can be realized through information systems based on appropriate models, methods, algorithms, and hardware-software implementations [67–70].

For instance, in the machining industry, achieving higher production efficiency and product quality can only be accomplished through full automation. Thus, the production of intelligent industrial robots with built-in systems of intelligent sensors for monitoring their technical condition and embedded analytics becomes a key focus within the Industry 5.0 concept. The embedded analytics, including video analytics, enables not only the monitoring of robot performance and the quality of incoming workpieces but also their recognition, automatic selection of technology, and quality control during processing and assembly. All robots and production lines are interconnected through the Internet of Things technology on respective platforms.

These platforms facilitate real-time monitoring of the controlled activities of the enterprise by querying a vast number of intelligent sensors, intelligent processing of acquired data, analysis, trend recognition, and dissemination of obtained results to other platforms while ensuring their security.

Recognizing the onset of negative trends and employing a temporary lag enables the implementation of optimal proactive management, wherein the speed of response surpasses the rate of change. This is a significant advantage of proactive management as it allows the identification of the need for process corrections before a crisis situation arises.

Within comprehensive software and hardware information systems for proactive management, the platform serves as the technological base or foundation upon which other system components are built. It provides common standards, tools, services, and infrastructure for the development, deployment, and operation of system applications and modules.

The platform may encompass hardware, operating systems, development environments, databases, networking capabilities, data analysis tools, and other components necessary for system construction and efficient operation.

The platform empowers developers to create new applications and modules that integrate with existing system components. It also offers a unified access point to system functionality, access rights management, scalability, and other services to support the operation of all components.

Utilizing a platform in comprehensive software and hardware systems for proactive management facilitates rapid deployment, integration, and system development, reduces efforts and costs associated with software development and maintenance, and eases overall system management.

Therefore, it can be stated that platforms within the Industry 5.0 concept are software and hardware means that enable real-time monitoring of controlled enterprise activities by querying a vast number of intelligent sensors, intelligent processing of acquired data, analysis, trend recognition, and dissemination of obtained results to other platforms while ensuring their security. Such platforms are developed for nearly all areas of industrial enterprise activities.

Such platforms can be divided into two categories: data collection systems and data analysis systems. Data collection systems include various sensors and other hardware devices that collect data about production processes and other aspects of enterprise activities, with subsequent preprocessing and storage in a certain form (locally or using cloud solutions).

Data analysis systems using intelligent analysis (data mining) enable processing and analyzing this data to make informed decisions and improve proactive management methods.

These systems allow enterprises to obtain a significant amount of data and information about their activities. This helps enterprises make decisions based on factual data and avoid risks, which is embedded in the risk management concept.

The development of such platforms and expanding their functionality for all types of enterprise activities is one of the key challenges in creating instrumental tools for proactive management of industrial enterprises. In this regard, the main direction of producing production control tools and providing services in Industry 5.0 is the production of intelligent sensors with built-in analytics and the global integration of systems both within the enterprise and across multiple enterprises within the framework of business interaction in one or several related industries [71–76].

The use of platforms plays a key role in ensuring the integration of diverse systems into a single unified system and achieving effective results in their operation.

Here are several ways in which platforms contribute to these processes:

- Standardization and unification: Platforms provide common standards, protocols, and methods of interaction between different systems. This allows heterogeneous systems to communicate and exchange data in an intuitive and

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understandable way. The use of common standards enables the connection of new systems to the existing infrastructure without the need for significant redesign.

- Data integration: Platforms provide mechanisms for collecting, processing, and aggregating data from various sources. This allows for the integration of data from different systems into a centralized data repository, where they can be analyzed and used for decision-making. Data integration ensures a single point of access to information and enhances its quality and reliability.
- Process management: Platforms can include functionality for modeling and automating business processes. This enables the integration of cross-cutting processes between different systems and provides for the automatic processing and management of these processes. As a result, the efficiency of the system as a whole is increased, and the likelihood of errors is reduced.
- Scalability: Platforms provide flexibility and scalability for integrating new systems, expanding functionality, and handling large volumes of data. They allow for easy deployment of new modules and applications, increasing computational resources, or expanding the system infrastructure without significant disruptions in operation.

Overall, the use of platforms helps integrate various systems into one, ensuring their interaction and coordination, and improves efficiency through standardization, data integration, process management, and scalability.

Different types of platforms are used for enterprise management within the concept of Industry 5.0:

- Monitoring and prediction of enterprise status. These systems allow real-time data collection on various processes within the enterprise and analyze them to forecast future developments. For example, an equipment monitoring system can detect signs of malfunction and predict possible breakdowns in advance.
- Planning and optimization. These systems facilitate the creation of optimal production plans and inventory management, ensuring efficient resource utilization. For instance, a production planning system can consider equipment, resource, and personnel constraints to generate an optimal production plan. These systems utilize data from monitoring and prediction systems.
- Market monitoring and prediction. These systems provide data analysis on the market and competitors to forecast market development and identify potential risks and prospects. For example, a market analysis system can use pricing, sales, and consumer

behavior data to predict demand for products.

- Logistics management. These systems enable enterprises to plan, control, and optimize logistics processes. They assist in tracking the movement of goods, ensuring efficiency and accuracy in logistics operations.
- Quality control. These systems enable enterprises to control product quality at various production stages. They facilitate quality parameter measurement and early defect detection, helping reduce deviations and ensuring compliance with standards and customer requirements. Quality control systems help avoid the distribution of defective products, which can damage a company's reputation and lead to losses.
- Automated inventory management. These systems allow enterprises to efficiently manage inventory by providing accurate information on the movement and quantity of goods in stock. They facilitate order planning, cost control, and quick access to inventory information.
- Decision support. These systems support decision-making processes by providing data and information analysis. They assist enterprises in making informed and effective decisions, considering various factors such as economic, technical, and social aspects.
- Supply chain management. These systems optimize logistics and supply management, ensuring effective control over the supply chain and monitoring different stages of the delivery process.
- Customer relationship management systems (CRM). These systems enable enterprises to collect, store, and analyze customer data, facilitating more efficient interaction, increasing customer satisfaction, and improving profitability.
- Human resource management systems (HRMS). These systems help enterprises effectively manage personnel, including processes such as recruitment, dismissal, training, and performance evaluation.
- Project management systems (PMS). These systems allow enterprises to manage projects, ensuring efficient resource utilization, monitoring project progress, and tracking results.
- Electronic document management systems (EDMS). These systems enable efficient document management, storage, and processing in electronic format.

There are numerous systems of different types aimed at enhancing the efficiency of modern enterprises.

These systems align well with the concept of Industry 5.0, as they often include both hardware components (IoT and/or embedded) and software components for data storage and processing (server infrastructure), and in some cases, data analysis and prediction modules, including advanced mathematical models and artificial intelligence.

1.7. Example of constructing an information platform for proactive enterprise management

Let's provide an example of a monitoring and forecasting system using the data collection and processing system of an industrial enterprise. Such a system supports data collection and processing on energy resource consumption, equipment operation, temperature, humidity, and raw material and consumables consumption. The mentioned parameters require careful monitoring and monitoring at both the level of the entire industrial enterprise and its individual components, and forecasting support helps achieve the goals of proactive management within the Industry 5.0 concept.

To solve this problem, it is advisable to use the method of information modeling as a specific forecasting method [77]. It is based on the fact that the characteristic features of mass information flows create conditions for forecasting the development of specific objects based on the analysis of the maximum possible number of factors related to production and financial-economic indicators, taking into account the extent of their interaction.

To effectively solve the monitoring tasks of consumption, the construction of efficient information systems (platforms) based on corresponding models, methods, algorithms, and their hardware and software implementation is necessary.

The creation and implementation of such an information platform allow:

– having a transparent resource accounting system, balance calculation for industrial facilities, including energy resource types, both for the entire enterprise and its specific sections and equipment types;

– increase the efficiency of energy resource utilization, reduce consumption costs, optimize the distribution of energy resources;

– increase the accuracy of planning energy resource consumption and equipment utilization based on the analysis of information on actual consumption

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volumes and production output for previous periods;

– create a software product to implement tasks for operational and prospective forecasting of energy resource consumption, equipment control, consumables, raw materials, humidity, and temperature, among others.

The use of the information-analytical resource monitoring system (IARMS) not only reduces direct resource costs but also controls parameters such as equipment performance, its depreciation characteristics, frequency of maintenance and modernization, environmental and hygiene indicators, product quality, and more [79].

In this regard, the following issues need to be considered:

– development of architecture and key elements of the enterprise resource monitoring and equipment usage control information-analytical system (IARMS) module;

– analysis of forecasting models for resource monitoring and accounting processes of the enterprise and control of equipment usage and maintenance;

– selection and justification of the numerical implementation method.

Thus, the creation of an information system is aimed at solving the following tasks:

– equipment working time control tasks;

– timely implementation of maintenance procedures;

– providing notifications about deviations from specified production parameters for equipment in industrial enterprises;

– development of a software module within the aforementioned system to address equipment usage control and monitoring tasks;

– conducting a computational experiment and making decisions in the task of forecasting equipment utilization processes and monitoring its maintenance.

The IARMS "Ecoflex" [78–79] created within the framework of the research solves the tasks of resource consumption monitoring and equipment usage control. It enables automated collection, accounting, storage, and processing of relevant information for both the entire enterprise and its individual units. This system is currently operating for dozens of clients in Ukraine and Eastern Europe.

IARMS "Ecoflex" represents a distributed multi-level automated platform. Cloud servers are used for storing input information as well as resource consumption data.

IARMS "Ecoflex" has a modular structure that allows for future upgrades and expansions without changing the software products and overall system structure.

This platform integrates resource meters, equipment operating hours, humidity and temperature control into a single network. Connected meters transmit data through controllers installed at the enterprise to a cloud service, providing technical accounting for the entire enterprise, its specific sections, and equipment units.

IARMS reports deviations from specified limits, the need for equipment maintenance control (for example, pump stations at water distribution points), maintenance control, and maintenance logkeeping, humidity and temperature control (workshops, refrigerators, boilers), etc (Figure 3). All of this is integrated into a single environment and a unified cloud service, eliminating the need to use 3–5 different systems. The system has a unified data format and provides management and control capabilities from a single center, as well as forecasting expenses for future periods.

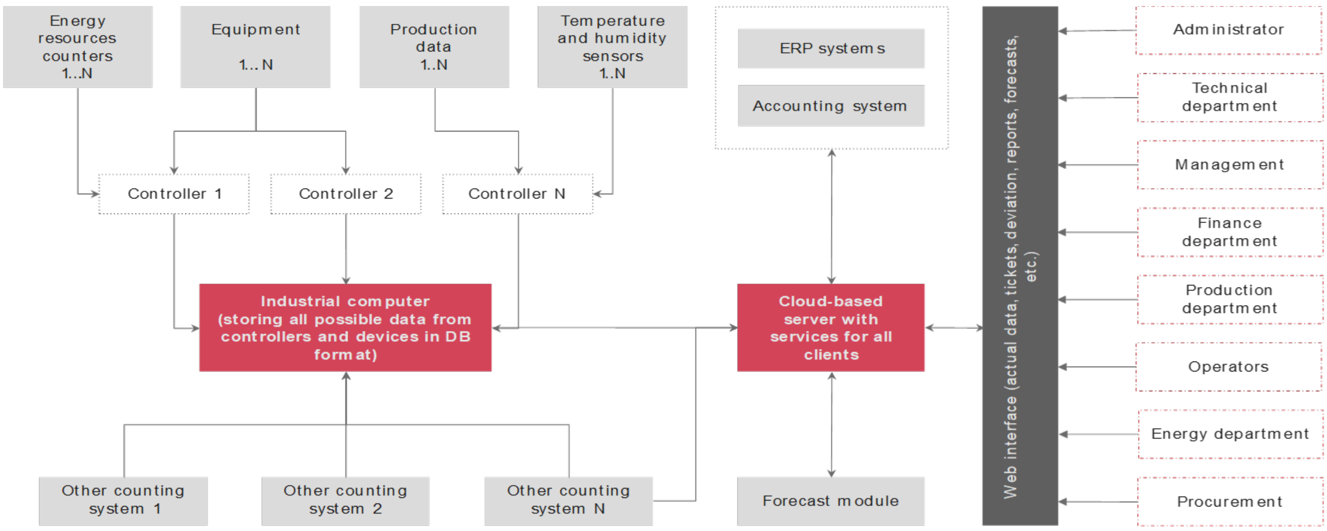

Figure 3 – Key devices of the IARMS system

Data from all meters and sensors of the system are collected in a single repository – a database installed on a server. The system continuously collects and processes data. Average and current readings are available to users for viewing through the Internet at any time of the day.

The server serves as a notification function when deviations from established threshold parameters occur. In such situations, the designated users in the system will receive an email notification, as well as a message within the system itself in a dedicated module that processes events. No manual actions are required from the maintenance personnel during normal operation.

The integrated subsystem for tracking engine hours and other operating parameters of industrial equipment is an extension of the functionality of the standard EcoFlex system [79]. It includes a module that allows:

- maintaining an equipment operating database;
- creating equipment load charts;
- providing automated control of equipment maintenance (maintenance) and maintenance logkeeping;
- notifying about the need for maintenance and informing about any deviations in operation;
- granting access to maintenance archives.

IARMS ensures the integration of all enterprise resource meters into a unified digital network for centralized data collection and processing.

By means of a cloud web interface and a mobile interface, the ability to monitor resource consumption at the enterprise is provided from any device, anywhere in the world, as long as there is an internet connection and the user is registered in the system with appropriate access rights to the resource expenditure data archive, with varying degrees of granularity.

It is possible to add additional data collection devices that work with different parameters. The system allows generating reports according to specific criteria and enables automatic sending to responsible individuals.

IARMS has geoinformation referencing with the ability to view the enterprise plan with equipment and meters installed at installation locations, providing additional information for various enterprise services about measurement points, communications, and facilitating more efficient determination of the energy balance for workshops, areas, equipment units, which are displayed on the map. It is also possible to perform a real-time search for objects on the map, solving direct and reverse GIS-system tasks. Additionally, IARMS provides the capability for real-time control and further analysis of resource consumption for various production operations (both regular and irregular), the ability to obtain different types of reports for analysis, and identification of the most resource-intensive production areas and/or technological operations for further optimization.

Special pulse counting devices are used for data collection. Up to 8 flow meters can be connected to one such collection device, and the collection devices will be connected in a serial RS-485 bus.

Data collection devices are connected to the server through the same serial line. A specially developed program constantly operates on the server, querying all collection devices and storing data in the repository. The collection device itself does not store data but transmits it to the server for processing.

The controller is a microprocessor-based circuit that performs two main functions: pulse counting from the meters and communication over the digital line [79].

IARMS "Ecoflex" allows:

– real-time formation of the enterprise resource balance;

– analysis of specific resource consumption per unit of production in individual structural subdivisions of the enterprise (workshops, areas, equipment units, etc.);

– maintenance of constant data on specific resources in critical production areas (e.g., humidity and temperature in refrigeration chambers);

– analysis of equipment depreciation (e.g., engine hours) and notification about the need for its modernization and replacement;

– creation and integration of local monitoring systems into a unified "cloud" information space for resource consumption and distribution accounting (e.g., electrical resources, steam, gas, temperature, humidity, equipment operating hours, etc.);

– provision of real-time access to information on resource consumption to different user categories and instant notification of deviations from established resource consumption limits and external parameter values (temperature, humidity, etc.), as well as the need for maintenance of connected equipment.

In further research, it is planned to involve AI methods and tools, in particular the Deep Learning method described above, to improve the information system.

To implement the Deep Learning approach for integrating AI into the Ecoflex monitoring system, the following steps need to be taken:

- Data collection: It is necessary to gather data on resource consumption, aging processes, and equipment wear at the industrial facility. This data can be obtained using sensors, meters, and other devices, including those integrated into the Ecoflex system.
- Data preparation: After collecting the data, it needs to be prepared for utilization in the Deep Learning model. This may involve data cleaning and normalization.
- Model development: The next step is to develop a Deep Learning model

for predicting resource consumption, aging processes, and equipment wear. The model can be developed using algorithms such as Long Short-Term Memory (LSTM) or Convolutional Neural Network (CNN).

- Model training: After developing the model, it needs to be trained on the collected and prepared data. Deep Learning libraries such as TensorFlow, Keras, or PyTorch can be used for model training.
- Testing and optimization: Once the model is trained, it needs to be tested on new data to evaluate its accuracy. Subsequently, the model can be edited and optimized if necessary.
- Model implementation: The final step is to implement the model for use in the industrial facility's monitoring system. The model can be integrated into the equipment monitoring system and operate automatically [79].

Conclusions

The results of the systematic analysis of proactive management in an industrial enterprise under conditions of risk and uncertainty lead to the following conclusions:

1. Proactive management of an industrial enterprise defines the main direction of robotization and automation of production processes, quality improvement, expansion of product lines and services, personalization of products, and enhancing financial stability and competitiveness in the product market.
2. Forecasting the indicators of the industrial enterprise's state and the product market is based on the utilization of virtual models of technological processes, products, and services (digital twins), allowing for timely and adequate assessment of the onset of stochastic and deterministic trends in their development.
3. Passive proactive management of an industrial enterprise involves timely evaluation of all deterministic and stochastic trends in the product market and aligning them with the enterprise's development trends with minimal delay.
4. Active proactive management of an industrial enterprise entails active participation in shaping product market trends by offering new consumer goods, production means, and services.
5. The analysis of the challenges in creating instrumental tools for proactive management of an industrial enterprise within the framework of the Industry 5.0

concept revealed that the main development direction for production tools is the utilization of intelligent industrial robots, while control tools involve the production of intelligent sensors with embedded analytics.

6. Instrumental tools for proactive management of an industrial enterprise within the framework of the Industry 5.0 concept consist of software and hardware platforms that enable real-time monitoring of enterprise activities by polling a vast number of intelligent sensors, intelligent data processing, analysis, trend recognition, provision of obtained results to other platforms, and ensuring their security.

7. Software and hardware platforms are created for almost all areas of industrial enterprise activities, including market and enterprise state monitoring and forecasting, planning and optimization of technological processes, logistics management, quality control, inventory management, decision support, supply chain management, customer interaction management, personnel management, project management, intellectual property management, and electronic document flow.

Industry 5.0 is the result of proactive management through the continuous development of industrial enterprises and a strategic direction for realizing Ukraine's industrial potential.