System analysis of the problem of proactive management of an industrial enterprise

Kostarev D.B.1, Tevyashev A.D.2, Sizova N.D.3, Tkachenko V.P.4,

1 Kharkiv National University of Radioelectronics; Ukraine
2 Kharkiv National University of Radioelectronics; Ukraine
3 Beketov National University of Urban Economy in Kharkiv; Ukraine
4 Kharkiv National University of Radioelectronics; Ukraine

Abstract.
The results of a system analysis of the problem of proactive management of an industrial enterprise under conditions of risks and uncertainties are presented. It is shown that the main objective of proactive management of an industrial enterprise is to align the development trend of the commodity market with the enterprise's development trend. Mathematical models and methods for forecasting indicators of the state of an industrial enterprise and the commodity market are examined. The concepts of active and passive proactive management of an industrial enterprise are introduced. Proactive risk management of the enterprise is considered. It is demonstrated that Industry 5.0 is a consequence of proactive management by industrial enterprises and a strategic direction for the realization of industrial potential in the post-war period.

Keywords:
industrial enterprise
proactive management
commodity market
Internet of Things
digital twins
intelligent labor
cobots
convolutional neural networks
Industry 5.0
Introduction

Industrial enterprises are essential to a country's economy, providing diverse, high-quality goods, technologies, and services. To remain sustainable and efficient amidst rising production demands and stiff competition, these enterprises must adopt innovative management strategies. Each enterprise has a mission, resources, technologies, and strategies to achieve its varied goals, with dominant economic goals like income, profitability, and market share interlinked and affecting one another. A competitive enterprise's overall goal should align its growth with market trends while proactively managing its operations.

Proactive management involves either passively aligning with market trends or actively influencing them through introducing new products and services. The mismatch between an enterprise's growth and market trends can flag potential problems or crises, underscoring proactive management's role in preempting issues. This strategy, though simple, is vital for an enterprise's survival, sustainable operation, and efficient growth in a fiercely competitive environment with escalating production of quality goods and services.

Implementing proactive management encompasses all business activities and is executed in two stages: identifying and analyzing enterprise and market trends, then planning and executing preventative actions to align with these trends. Various methodologies such as Business Process Reengineering, Key Performance Indicators, Balanced Scorecard, budgeting, and modeling based on standards are employed for its implementation. The timely application of proactive management is key for an enterprise's survival and success amidst escalating competition and production demands.

1. Analysis of the problem

In today's post-industrial economy, enterprises are complex, dynamic systems, engaging in numerous activities such as economic operations, innovation, production, and legal adherence. Sustainable development and strategic management of resources, including labor, financial, material, intangible, and information assets, are vital for growth [1].

Effective management strategies tailored to each resource
enhance their utilization. For example, labor management includes workforce planning, motivation, and performance tracking. Financial resources, both internal and external, require careful management. Material resources like assets need efficient use in production, while intangible assets require timely acquisition and skilled use. Information resources need effective management for informed decision-making [2-3].

Enterprise management focuses on strategic directions for profitability and competitiveness. Tools used encompass economic, technological, legal, and socio-psychological mechanisms, alongside modern approaches like digitalization, which improves efficiency and competitiveness.

Enterprises are integrated systems, interacting with higher hierarchical levels and managing internal subsystems. As open, stochastic systems, they adapt to environmental changes. Management involves planning, organizing, motivating, controlling, and decision-making, with a mix of classical and innovative strategies employed for effective decision-making. Hence, the development and improvement of new management methods is crucial in the modern globalized landscape.

2. Problems of Industrial Enterprise Management

Industrial enterprise management entails coordinating activities to achieve goals, with modern industries requiring innovative approaches for efficiency and competitiveness. Key management strategies include [4-8]:

- Reactive approach: Response-based method for addressing immediate problems.
- Situational approach: Adaptable method that responds to unique circumstances.
- Proactive approach: Preventive method that anticipates and mitigates potential issues.

Proactive management, considered the most promising, involves anticipating potential problems and optimizing processes for maximum efficiency, over just responding to crises (situational management). This strategy forms a flexible organizational structure that responds to internal and external changes.

Applying the Pareto principle in proactive management
helps identify and prevent key threats. This approach, combined with modern data analytics and machine learning tools, supports informed decision-making and efficient operations. Proactive enterprises like Toyota and Boeing actively seek improvement opportunities, reduce risks, and enhance their product quality through methodologies such as Lean Manufacturing and Six Sigma [5-11].

The choice of management approach depends on various factors like company size, industry type, and customer needs. However, proactive approaches and new technologies like AI and big data are increasingly valuable in enhancing efficiency, minimizing costs, and providing new business development opportunities.

3. Problems of proactive risk management in an industrial enterprise

3.1 Risk assessment of an industrial enterprise

Enterprises constantly face uncertainties that lead to risks affecting performance outcomes. These risks are complex, emerging from various financial and economic activities, and linked to production processes, new products, services, and socio-economic projects. Essentially, risk is the probability of adverse events causing deviation from desired outcomes [12-14].

Risks in industrial enterprises can be associated with the probability of losses from investing in new products, services, or technologies that may not find expected market demand. They may also arise due to a failure to achieve profits from various investments.

Risk becomes a factor in any management decision made under uncertainty, which is a consistent part of economic activity. Identifying risks, understanding their nature, forecasting their consequences, and assessing their degree is vital for effective decision-making and risk reduction, especially in unstable economic conditions.

Enterprise activities are influenced by external and internal factors like changes in consumer demand, competition, price volatility, legislation and regulation changes, technological advancements, financial risks, macroeconomic instability, natural disasters, and unexpected events.
These risks can be categorized into financial, operational, market, reputation, external environment, and management risks. The goal of risk analysis is to establish the maximum acceptable risk, with various algorithms existing for risk assessment, aiding in selecting risk factors that need to be mitigated (figure 1).

![Risk Assessment Algorithms](image-url)
Risk analysis primarily includes quantitative and qualitative methods. Qualitative analysis identifies potential risks, risk factors, and sequences of risky activities, conducted during the task development stage. Conversely, quantitative analysis provides a numerical assessment of project risk factors' impact, basing on probability theory and mathematical statistics. It determines the magnitude of potential losses, identifies their causes, sources, and likely consequences [15-17].

Statistical risk assessment considers the company's record of losses and gains to determine the frequency and size of risk events. The main parameters of quantitative risk assessment are the probability of loss occurrence and the extent of damage from an adverse event. Managerial decisions are thus informed by the likelihood of various risks, aiding in performance forecasting.

Risk assessment approaches involve retrospective analysis based on actual data. This method includes statistical information processing, forecasting development indicators, and determining development trends (Figure 2).

![Risk Assessment Methods](Image)
Risk assessment utilizes retrospective and forecasted data to analyze uncertainties and mitigate potential risks, facilitating comprehensive risk management strategies. Tools for quantitative risk determination include game theory, statistical methods, mathematical programming, and cost-effectiveness analytics.

Risk management involves continuous risk monitoring, identification, forecasting, and evaluation of response operations. It considers internal and external factors in decision-making, with tactics, strategies, and preventive measures developed to minimize risk.

The risk management system involves risk analysis, monitoring, impact assessment, and system optimization. It employs approaches like risk insurance, diversification, and flexible technologies for risk minimization.

Modern management, recognizing operational uncertainty, focuses on flexibility, long-term performance, and cause examination. Risk management aims to reduce the adverse impact of factors and losses from random events. It includes creating risk strategies within the enterprise, making decisions based on risk analysis, and selecting the optimal decision to reduce risk.

3.2 Analysis of the Proactive Risk Management of an Industrial Enterprise

Risk management in an enterprise entails continuous monitoring and updating strategies to minimize potential losses. It includes loss reduction through preventive measures, resource optimization by prioritizing risks, and fostering enterprise resilience with contingency and recovery plans. It enhances competitiveness by enabling quick adaptation to changes.

The risk management process involves identifying and analyzing risks, developing and implementing risk management strategies, and constantly monitoring and adjusting these strategies.

Several benefits accrue from proactive risk management, such as reduced financial losses, improved product quality and safety, increased competitiveness, decreased legal risks, enhanced reputation, optimized management, and reduced employee stress.
Several mathematical models are available for risk management, each suited to specific types of risks, levels of uncertainty, available resources, and management preferences. Selection of a suitable model considers factors such as enterprise goals, operational activities, size, potential risks, budget, and employee competencies. In modern economic trends, there's a growing need for comprehensive, proactive risk management systems.

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

Industrial enterprises, classified as dynamic systems, operate in uncertain environments [18]. Optimal control depends on inputs such as market estimates, enterprise state, external parameters, and control vector. Passive proactive management requires timely assessment and alignment of market and enterprise trends. Active proactive management involves shaping market trends through new goods, facilities, and services. Effective forecasting tools are crucial for implementing proactive management in these enterprises. Let's consider these issues in more detail.

4.1 Forecasting Issues for Industrial Enterprise Performance Indicators

Industrial enterprises operate in dynamic environments, requiring real-time data on multiple aspects of their operations, such as product quality, energy use, equipment health, and finances. This data, gathered from IoT-based systems, must be processed efficiently to uncover correlations. BIG DATA and Data Mining technologies help in extracting independent indicators that represent the enterprise's state.

Historical data and external factor predictions feed into forecasting the enterprise's future state, informing proactive management strategies. This iterative process requires frequent updates based on emerging trends and new data.

Forecasting consists of selecting training samples, constructing models for changes in external factors and enterprise indicators, and calculating forecasts.

Predictive models, such as product, technological, supply chain, economic, and resource efficiency models, provide
insights for strategic decision-making.

Energy consumption forecasting involves analyzing current usage, predicting future consumption, creating reduction plans, and determining costs. Factors like time, weather, and technology affect predictions, requiring various models and methods for accuracy. The chosen model must be tailored to the enterprise's specifics, and its adequacy should be assessed for successful implementation.

4.2 Challenges in Forecasting Indicators of the State of the Commodity Market

The commodity market's condition, dictated by factors like goods assortment, demand and supply, prices, and production rates, is vital for understanding the economic environment. Its interpretation is complex due to the myriad of influencing factors.

To quantify the market state, indicators are used, often classified into production dynamics, demand and supply dynamics, international trade state, and price dynamics. These help identify emerging trends and provide market direction insights [18-19].

Forecasting these indicators is challenging due to the vast amount of data and the need to identify correlations between various factors. Advanced computational tools, such as BIG DATA, Data Mining, and neural networks, are utilized for this purpose.

Convolutional Neural Networks (CNNs), employing Deep Learning methods, are particularly effective for forecasting indicators. They learn quickly, work with hidden causal relationships, and handle significant noise in input data. CNNs have proven their ability to uncover complex data dependencies and make accurate forecasts in various fields.

Reviewing and understanding different forecasting methods' strengths and weaknesses can inform the modeling of enterprise activities, contributing to economic development and providing a strategic edge in the commodity market.

5. Proactive Management and Industry 5.0 – global trends, challenges and perspectives in Ukraine

Industry 5.0 revolutionizes industrial enterprises with technologies such as intelligent robots and cobots, reintegration of human factors, Industrial Internet of Things
(IIoT), continuous personnel training via virtual environments, and environmentally friendly production. This new era integrates robots into production for improved efficiency, cost reduction, and product quality. It reintroduces the human element, creating jobs and enhancing skills through 'digital twins'—virtual models used for data analysis, risk management, and production process management.

Industry 5.0 utilizes IIoT with smart sensors for real-time monitoring of enterprise aspects like equipment, energy, and personnel. The collected data undergoes processing and analysis for proactive management and is stored in the cloud for security. It also emphasizes continuous employee training in virtual environments, providing safe and cost-effective learning conditions.

However, the implementation of Industry 5.0 in Ukraine faces challenges like a low digital literacy rate, lack of necessary infrastructure, and inadequate funds. Despite these challenges, Ukraine's unique resources, manufacturing potential, educated workforce, and lower labor costs present a chance to lead in Industry 5.0. With expected investments, strategic utilization of funds for Industry 5.0, and a focus on producing high-quality, environmentally friendly products, Ukraine can realize its industrial potential in the post-war period.

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

Proactive management in industrial enterprises requires the integration of powerful information systems, significantly transforming all aspects of the company's activities. In the machining industry, for instance, Industry 5.0 leverages total automation to improve production efficiency and product quality [5-6].

Intelligent industrial robots with embedded smart sensors are used, providing real-time performance and work quality insights. They also facilitate real-time monitoring of enterprise activities through advanced IoT technology. These systems are often categorized into data collection and data analysis systems. Data collection systems gather information about production and enterprise activities, while
data analysis systems use intelligent techniques to process this data for informed decision-making and proactive management improvement.

Platforms serve as the technological foundation for developing system applications and modules. They provide tools, services, and infrastructure for system functionality, manage access rights, ensure scalability, and support all components' operation.

Creating these platforms and developing their functionalities across all industrial enterprise areas is crucial for proactive management. It involves producing intelligent sensors with built-in analytics and integrating systems globally within and across enterprises.

Various platform types are used to manage aspects like enterprise status monitoring and prediction, planning and optimization, market monitoring and prediction, logistics management, and more.

These systems significantly enhance modern enterprises' efficiency and align with Industry 5.0, including hardware and software components for data storage, processing, analysis, and prediction, often using advanced mathematical models and artificial intelligence.

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

Implementing a data collection and processing system in industrial enterprises facilitates monitoring of parameters like energy usage, equipment operation, and raw material consumption. Information modeling, based on analyzing a broad range of production and financial factors, supports forecasting in line with Industry 5.0.

An efficient information system allows for transparent accounting, optimized resource distribution, precise planning, and predictive forecasting of various operational aspects. The system reduces resource costs and controls equipment performance, maintenance frequency, environmental indicators, and product quality [20-22].

Key considerations include the development of an enterprise resource monitoring system's architecture and key elements, evaluation of forecasting models, and selection of numerical implementation methods. This system aims to control
equipment operation, maintenance schedules, and to alert about production parameter deviations [23-24].

The 'Ecoflex' Information-Analytical Resource Monitoring System (IARMS) is an example of such a system, operating for numerous clients in Ukraine and Eastern Europe. Its modular structure enables upgrades without altering overall system architecture. It integrates resource meters, equipment operation, humidity, and temperature control into one network, reporting deviations, and providing a unified data format. It collects and processes data continuously, with a server notifying of threshold deviations [25-27]. The system also includes an integrated subsystem to track engine hours and other equipment parameters (figure 3).

The Information-Analytical Resource Monitoring System (IARMS) "Ecoflex" provides comprehensive real-time monitoring and control of an enterprise’s resource consumption. This system is accessible globally via any device with internet connectivity and offers varying levels of data granularity.

Key features of IARMS include the ability to add additional data collection devices, generate custom reports, and map out the enterprise's equipment layout using a geoinformation module. This module can identify the most
resource-intensive areas for optimization and allows real-time search for objects.

Data is collected through pulse counting devices, connected to a server for processing. IARMS provides analysis of equipment depreciation, real-time formation of resource balance, and alerts for deviations from set consumption limits and the need for equipment maintenance.

Future research intends to incorporate Artificial Intelligence (AI) methods, specifically Deep Learning, for improved monitoring. This involves steps of data collection and preparation, model development and training, testing and optimization, and finally, model implementation in the monitoring system.

**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.

8. 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.

References:
[1] [http://www.klubok.net/article1487.html]
[6] Bill Gates, "Business @ The Speed Of Thought". 2nd edition, revised:
Eksmo; Moscow.


