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SUSTAINABLE ECONOMIC DEVELOPMENT: DIGITAL TRANSFORMATION, ENTERPRISE DEVELOPMENT MANAGEMENT, WAYS OF RENEWAL AND MODERNIZATION

Collective monograph

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2.2 Tools of mathematical modelling in strategic enterprise management

The development of Ukraine's market economy is a highly complex and protracted process. The unpredictable dynamics of the market hinder the successful operation and development of modern enterprises. In such conditions, strategic management within the enterprise plays a key role. It is becoming increasingly important for Ukrainian enterprises, which are facing fierce competition, both amongst themselves and with foreign corporations.

Strategic management is the set of actions and decisions taken by senior management that lead to the development of specific strategies designed to ensure the fulfilment of the organisation's mission and the achievement of its long-term goals.

Strategic management provides a methodological framework for developing management decisions focused on taking proactive measures to address the challenges facing the organisation.

The development of strategic management requires the design and implementation of appropriate tools that enable, firstly, the translation of objectives and strategies into specific tasks for the company's departments and employees; and secondly, the introduction of monitoring and adjustment tools into departmental operations that are linked to the company's strategic objectives.

The unpredictability of environmental factors, as well as subjective factors affecting the operation of industrial enterprises, are driving the emergence of new methods of strategic management that enable the internal potential of an enterprise to be aligned as closely as possible with the opportunities and threats of the external environment.

In this regard, the process-based approach to strategic planning–which views an organization's activities as a set of business processes – is of particular interest. Moreover, modelling business processes as closely as possible to reality allows one to identify and test ways of improving the organisation's performance without the need for actual experiments, thereby incorporating the results into the strategic plan. This interest is also driven by the fact that business processes can be represented by economic and mathematical models, and their development can be forecast taking into account the influence of factors within the organisation's internal and external environments.

Various aspects of the theory and practice of strategic management have been examined in the works of O. Yermakov [58], O. Fedirts [59, 60], V. M. Porokhni [61], Z. E. Shershnovaya [62], V. G. Fedorenko [63] and others. The theoretical and methodological foundations of business process modelling in an enterprise have been developed in the works of A. Azarov [64], N. M. Volosova [65], S. V. Zelenko [66], O. V. Stavitsky [67], A. L. Litvinov [68], A. V. Sidorov [69] and others.

In a market economy, manufacturing enterprises gain greater autonomy and are freed from constant state control; however, at the same time, their responsibility for the results of their financial and economic activities increases. The enterprise's profit becomes the main foundation for the productive and social development of work collectives. Business entities have financial autonomy: they independently distribute income from product sales, make decisions on the use of profits, establish production and social funds, and raise funds for investment by utilising the opportunities of the financial market – bank loans, bond issues, certificates of deposit and other financial instruments. All these processes fall within the sphere of management activities [70].

The concept of management is inherent in virtually all forms of human activity, but it plays a particularly significant role in the economic sphere. In the international context, the term 'management' is widely used to denote this concept, derived from the English word 'management'. The primary purpose of management is to enhance the efficiency of socio-economic systems through the application of modern management principles and methods.

The essence of management activity can be summarised in the form of a conceptual diagram covering several key elements:

1. Goal setting, which includes forecasting, formulating, agreeing upon and setting goals with the possibility of their subsequent adjustment.

2. Information support, which involves identifying information needs, obtaining, processing, accumulating and transmitting information.

3. Analytical activities aimed at selecting the necessary data, calculating analytical indicators and evaluating them.

4. Management decision-making, i.e. selecting the optimal course of action from among possible alternatives based on the analysis and comparison carried out.

5. Implementation of decisions, which involves communicating assigned tasks to staff, organising and coordinating their work, monitoring implementation, and ensuring feedback for the timely adjustment of managers' actions.

Management can also be interpreted as a system of interrelated functions. Regardless of the level of management or the specifics of production, managerial activity is characterised by the presence of a certain set of functions. A diagram of the main interrelationships between management functions is shown in Figure 1 [63].

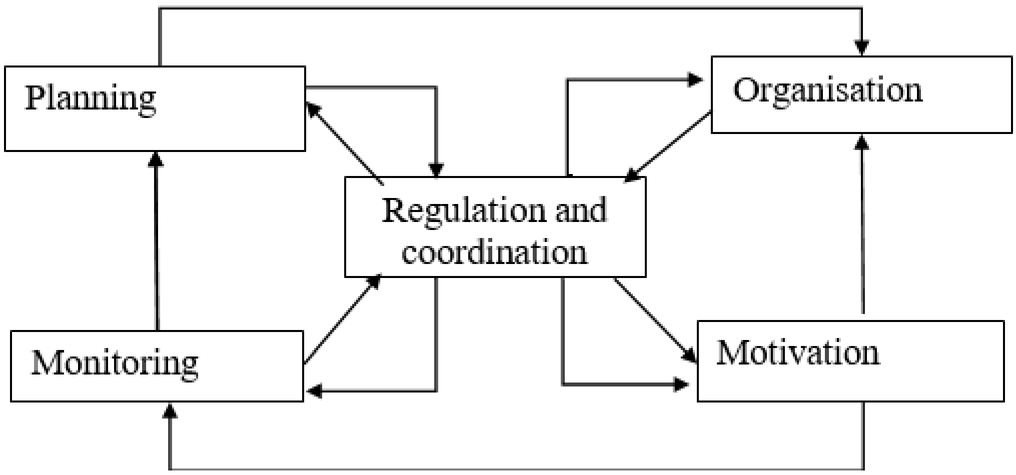

Figure 1. Interrelationship of management functions

Source of the figure: author's development or [63]

Planning occupies a special place among the main functions of management. It represents the process of defining the objectives of the enterprise's activities and the means of achieving them.

Directly linked to planning are the functions of regulation and coordination, which are carried out by management bodies during the implementation of approved plans. Regulation is aimed at maintaining the necessary parameters of the production management system's operation under dynamic conditions. Coordination, in turn, ensures the coherence of actions between structural units, officials and the external environment in both temporal and spatial aspects. Its main task is to establish effective links and information exchange between all levels of the organisation.

The function of organisation can be viewed from two perspectives: as the process of forming a management system and as an activity aimed at its streamlining and improvement.

An important condition for achieving the set goals is the interest of those involved in the management process in the results of their work. This is the essence of the motivation function. Motivation is the process of encouraging employees to engage in active and productive work. An insufficient level of motivation can negatively affect the performance of other management functions and the overall efficiency of the enterprise.

No less important is the control function, which involves comparing actual performance results with planned targets and established standards. Recently, controlling has become widely adopted. Its distinction from traditional control lies in the fact that it encompasses all types of control activities, including administrative control, audit, inspection and technological control [61, 62, 71].

The management process and its structure are interrelated elements, and management functions are implemented through interaction via the management apparatus.

As already noted, the primary function of management is planning, the essence of which lies in defining the objectives of the enterprise's operation and development, as well as in identifying ways to achieve them.

Development planning is one of the most important areas of activity for any entity in a market economy, particularly an enterprise engaged in production and commercial activities. A thorough approach to planning creates the conditions for the stable operation and improved efficiency of the enterprise.

It is customary to distinguish three main types of planning: strategic – covering a period of two to five years, operational – for one year, and short-term – for a shorter period. The management process begins precisely with strategic planning, as it forms the basis for all subsequent management decisions [72, 73].

Strategic planning is considered a promising area of development in management theory. In the 1960s, it was predominantly associated with long-term goals. The main difference between strategic and long-term planning lies in the approach to assessing the future. Long-term planning is based on the assumption that future development can be predicted by extrapolating past trends.

The concept of strategic planning should be viewed as a continuous process of shaping an organisation's strategy in the face of an uncertain external environment, which requires constant adjustment of objectives and the means of achieving them. Strategic planning provides a methodological framework for managerial decision-making, establishes a system for monitoring their implementation, and takes into account the specific characteristics of the organisation's operations.

Developing a strategic plan offers a number of important benefits for an organisation. It helps to improve operational efficiency, clearly define the future direction of development, and resolve key issues in a timely manner. Furthermore, strategic planning promotes better use of resources, the accumulation of professional experience within the team, and the formation of a cohesive team. It also helps meet the requirements of financial institutions and encourages a proactive approach to management, rather than waiting for problems to resolve themselves.

Despite all these advantages, many Ukrainian companies still do not pay sufficient attention to strategic planning. This is due to both external and internal factors. External factors include the instability of the economic and political environment, a low level of financial literacy among enterprises, and a strong dependence on government policy.

Among the internal reasons, one can highlight a lack of time due to pressing daily tasks, the belief that planning does not affect results, the insufficient qualifications of managers and employees, and the lack of methodological materials for effective work.

The concept of strategic planning for an industrial enterprise is based on a number of principles [74]. These form a coherent system that ensures the effective development of the enterprise.

The principle of reflection holds that the effectiveness of strategic decisions depends not only on the analysis of objective factors, but also on taking into account the interests of all participants in the process. It is important to consider how subordinates perceive the values and actions of management, as well as the interests of external stakeholders. Since the enterprise is managed by people with their own beliefs, experience and goals, the principle of reflection is of significant importance when preparing strategic decisions. It is applied not only in the modelling process, but also during strategic monitoring, analysis of the external environment and the development of management measures.

The principle of self-organisation implies that the enterprise, as a system, is capable not only of minimising undesirable deviations but also of reinforcing positive processes through the use of feedback mechanisms. A system is considered self-organising if its elements can make decisions independently and form stable interrelationships. This approach is widely used in systems theory and can be applied in the development of strategic planning methods.

The principle of bounded rationality is based on the fact that a decision-maker is unable to process all available information. Furthermore, the information required for strategic decisions is often incomplete and insufficiently reliable. Even a rationally made decision does not guarantee its successful implementation. Therefore, strategic planning must be based on forecast data, trend analysis and the ability to continuously adjust decisions as new information becomes available. This approach limits the use of classical models of optimal management.

The principle of self-determination views the enterprise as an open system that interacts with the external environment. Highly organised systems can not only adapt

to changes but also actively influence the environment to achieve their own goals. This is the very essence of the principle of self-determination. Unlike the passive approach, this principle involves the enterprise’s active participation in shaping the external conditions of its operations. Therefore, strategic planning methods must be developed with active interaction with the external environment in mind.

The principle of diversification involves the development of various areas of activity and the combination of different types of production and services. Its essence lies in the fuller utilisation of the enterprise's resources and their effective reallocation among different types of activity. Diversification contributes to the expansion of production capabilities, increased employment levels, and the rational use of available resources. Furthermore, this principle is applied when selecting information sources, partners, technologies, forms of production organisation and other elements of strategic management. Consequently, when developing methods and mechanisms for strategic planning, it is necessary to ensure a variety of tools that will enable the enterprise to function effectively in an unstable external environment.

The principle of resource reserving lies in the need to create appropriate reserves of resources to ensure effective enterprise management.

The principle of continuous adaptation stems from the dynamic nature of the system's development. To maintain its stability, management must be carried out in real time. The adaptability of strategic planning makes it possible to respond in advance to unforeseen circumstances. In fact, this approach involves developing several variants of strategic plans depending on possible developments.

The principle of multi-scenario planning means that forecasting a company's activities should not be limited to a single scenario. In an unstable environment, management must take into account both optimistic and pessimistic scenarios, which helps to mitigate risks when implementing strategic plans.

Together, these principles form the theoretical basis for developing models, methods and tools for the strategic planning of an industrial enterprise's activities.

The theory of strategic planning is based on various methodological approaches: systemic, process-based, organisational and others [74].

The organisational approach focuses primarily on the human factor, the social aspects of operations, and the need for horizontal and vertical coordination of staff work.

The systems approach is based on viewing any economic entity as a holistic system consisting of interrelated elements or subsystems. Such a system has input resources, a specific output, interacts with the external environment and functions through direct and feedback loops. Within this approach, an economic entity is primarily viewed as a component of a broader external environment.

The process-based approach involves identifying individual stages, procedures and functions of strategic planning that are constantly repeated in management activities. Each of these stages culminates in a specific outcome:

– strategic environmental analysis provides an assessment of the enterprise's current state and its competitive position;

– forecasting makes it possible to determine the organisation's likely future state;

– the formulation of the mission, objectives and strategies leads to the creation of a strategic plan, a development programme and an adaptive strategy;

– the implementation of strategies, as well as monitoring and adjustment, are linked to the development of programmes, management mechanisms, motivation, financing, investment and organisational planning, as well as to coordination and regulatory processes.

The functions of strategic planning are implemented through a set of interrelated actions, which ultimately lead to the achievement of specific results. The main outcomes of strategic planning can be presented as a sequential logical chain: situation assessment – forecast – strategy – strategic plan – programme – project – evaluation of results.

Management decision-making is impossible without the use of a system of indicators. It is these indicators that ensure the implementation of the logic, principles and methodological approaches of strategic planning.

In modern statistics and accounting systems, an indicator is regarded as a quantitative and qualitative characteristic of socio-economic processes and phenomena. Its qualitative aspect reflects the content and essence of a particular phenomenon in specific circumstances of time and place, whilst its quantitative aspect determines its scope, absolute or relative value. In the field of strategic planning, an indicator serves as a measure of a planning target, giving it quantitative or qualitative certainty. At the same time, the system of indicators used in strategic planning must meet certain requirements. Key requirements typically placed on indicators in strategic planning include their consistency and mandatory nature for a specific level of planning. Indicators must be capable of aggregation and disaggregation, i.e. they must ensure the comparability of data across different levels and scopes. They must have clear and measurable parameters so that planning outcomes are specific and reliable. The system of indicators as a whole should provide a comprehensive assessment of all aspects of the functioning of the planning objects, whilst remaining flexible and adaptive, capable of reflecting any changes in the object's status. Indicators should encourage improvements in the productivity, efficiency and effectiveness of the planned processes. At the same time, their number in forecasts, strategic programmes and plans at various levels and time horizons should remain limited so that the system is convenient and practical to use.

At the same time, even the best-designed plan does not guarantee success on its own. It is not only its creation that is important, but also its effective implementation in practice. In other words, a manager must be able to manage all the enterprise's available resources rationally, taking into account market needs and operating conditions.

For any enterprise, risk means the probability of adverse events occurring, which may lead to the loss of some resources, a shortfall in profits, or the incurrence of additional costs [66]. This is precisely why conducting both qualitative and quantitative risk analysis is of great importance. Such analysis allows for the identification of risk factors and the determination of the stages of activity at which they may arise.

Quantitative risk analysis aims to determine the scale of potential losses and is a rather complex task, solved using various methods: statistical analysis, cost-benefit analysis, expert assessments, and the analogy method. To reduce the level of risk, a variety of analytical approaches are used, including methods of mathematical statistics, economic-mathematical modelling and other tools that help to improve the reliability of investment decisions. Based on the results of the risk analysis, measures are formulated to minimise these risks.

The effectiveness of a company's operations depends to a large extent on the extent to which strategic objectives align with the organisational tools used to achieve them. It is precisely this alignment that serves as an indicator of the company's viability and its capacity for long-term development.

Approaches to implementing a strategic management system cannot be the same for all companies. Developing strategic planning and management skills requires, first and foremost, the creation and application of appropriate tools.

When examining the tools of strategic management, it is worth highlighting two main planning systems: the classic MOS system (Mission, Objectives, Strategies) and the Balanced Scorecard system. It is within the framework of these approaches that various mechanisms for forecasting and planning a company's activities are used.

The traditional MOS system is based on a sequential transition from one stage of analysis to the next. Each level of planning relies on specific methods and analytical tools. The prioritisation of objectives plays a key role in the strategy formulation process.

The ability to specify objectives, determine the means of achieving them and establish interrelationships between them is ensured by the structuring method. Its essence lies in the step-by-step specification of objectives with the identification of corresponding management levels.

Based on this method, a so-called goal tree is formed – a hierarchical structure within which goals are distributed across management levels. In this process, the specification of goals becomes more detailed from top to bottom: the higher the level, the more general the nature of the set goal [75].

Various methods are used to assess trends in changes to the enterprise's external environment, among which PEST analysis plays a significant role. This methodology involves the study of four groups of factors influencing the enterprise's activities:

political, economic, social and technological [76].

Assessing a company's performance is impossible without analysing the structure and dynamics of the industry in which it operates. The main objective of industry analysis is to determine the attractiveness of the industry and individual markets within it. Furthermore, such analysis allows for the identification of existing opportunities, potential threats and key success factors.

One of the best-known methodologies in this field is the Five Forces Model, proposed by Harvard Business School professor Michael Porter. It enables the assessment of the industry's state through the analysis of the following factors: the level of competition between firms, the influence of suppliers, the bargaining power of buyers, the threat of new entrants, and the risk of product substitution. The significance of each of these factors varies depending on the market and influences the level of costs, pricing, investment and business profitability [61].

The results of analysing a company's internal environment and the external conditions of its operations allow for an assessment of how well the company's capabilities align with market needs. On this basis, enterprise development programmes are drawn up and its market behaviour is determined. One of the most common tools for such a comparison is SWOT analysis [75]. Its classical form involves identifying the enterprise's strengths and weaknesses, as well as the opportunities and threats of the external environment.

The Boston Consulting Group proposed a portfolio analysis method, which allows for the formation of an optimal set of the company's business areas and the assessment of the competitive positions of various enterprises. This method is based on the use of a business portfolio matrix, where the strategic positions of the structural divisions of a diversified company are compared.

The 'General Electric–McKinsey' method, also known as the ABC method, is used to assess a company's competitive position. In this model, the industry's growth rate is replaced by an indicator of its attractiveness, and relative market share is replaced by the company's competitive position [75].

The Arthur D. Little approach is based on the concept of the life cycle of an industry or business unit. According to this approach, every business goes through the stages of inception, growth, maturity and decline. An additional parameter of the analysis is the company's competitive position [75].

Igor Ansoff also proposed a methodology for assessing industry attractiveness and a company's competitive status. It involves evaluating the industry's growth prospects, its profitability and level of volatility, taking into account the impact of each factor on the overall attractiveness index.

Derek Abel made a significant contribution to the development of the matrix approach, proposing to consider the business sphere in three dimensions: consumer groups, their needs, and the technologies used to create products. In this way, he supplemented I. Ansoff's approach with another important element – the technological factor [75].

R. Cooper proposed using industry attractiveness and business strength as criteria for strategy selection. Based on this, a portfolio matrix was developed, demonstrating possible directions for the enterprise's strategic development.

One of the most informative sources of data on large industrial companies and an effective tool for strategic analysis is the PIMS project [75]. Its aim was to establish quantitative relationships between market and production factors and the level of long-term profitability of enterprises.

Business planning is also part of the strategic planning toolkit. In a market economy, a business plan serves as a vital working document in the field of entrepreneurship. It outlines the company's operations and demonstrates how management intends to achieve its objectives, primarily with regard to increasing the company's profitability [69, 70].

One of the key tools of strategic planning is economic and mathematical modelling, including simulation modelling, the scenario approach, network methods and programming-based tools [77-84].

The process of economic-mathematical modelling comprises several sequential stages: the formulation of an economic problem and its qualitative analysis, the creation of a mathematical model, its investigation, the preparation of input data, numerical solution and analysis of the results obtained, followed by practical application [85-96].

The Balanced Scorecard deserves special attention. In domestic practice, this approach is known as the balanced scorecard system or the system of performance indicators.

The Balanced Scorecard [96] was developed by David Norton and Robert Kaplan in 1992 with the aim of complementing traditional business performance evaluation, which was based exclusively on financial indicators. Within the framework of the BSC, it is proposed to assess the effectiveness of an organisation's performance not only by financial results, but also across three additional areas: customer relations, internal business processes, and staff training and development.

Assessing performance in these areas allows for a more comprehensive determination of the organisation's operational effectiveness. The BSC not only complements financial indicators but also helps to:

– identify sources of revenue growth and the customer groups that drive it;
– identify the key business processes on which the company needs to focus;
– direct investment, staff development, corporate culture and internal systems towards strategically important areas.

The Balanced Scorecard is used as a tool to set objectives for employees, individual business units and the organisation as a whole, and to communicate these to all levels of management.

Within this approach, strategy is viewed as a continuous process in which all organisational processes provide feedback and can influence the adjustment of strategic decisions.

Unlike traditional strategic planning systems, the Balanced Scorecard [97] examines the company's activities through four key perspectives: finance, customers, internal business processes, and learning and development. It is these perspectives that enable answers to be provided to key strategic management questions.

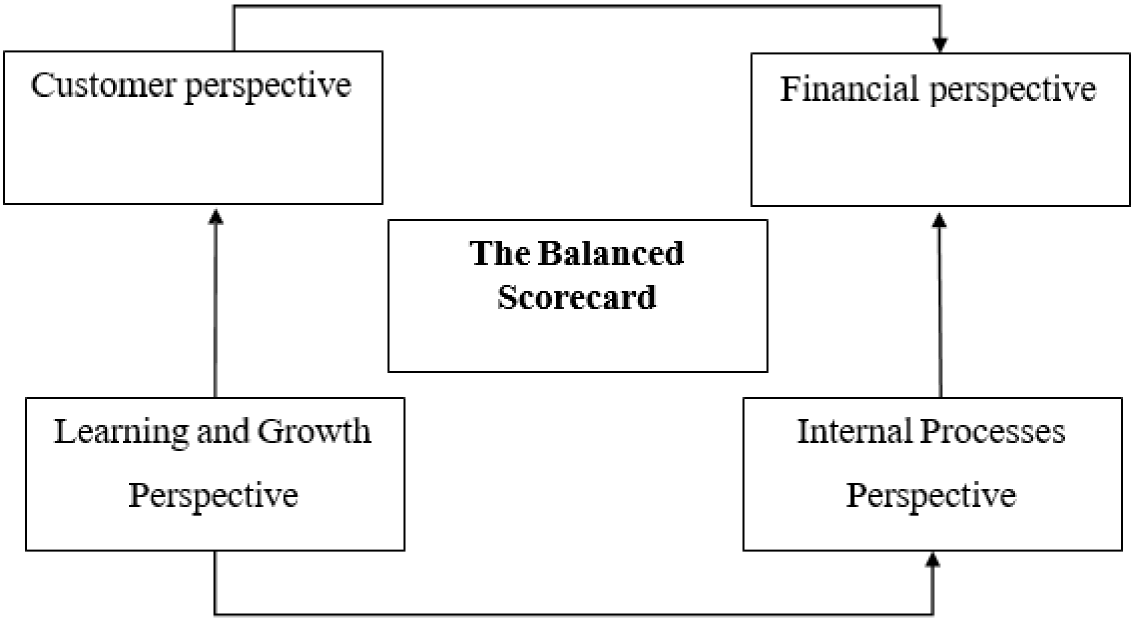

Figure 2. Balanced Scorecard

Source of the figure: author's development or [96]

The financial perspective is one of the most important, as profit generation remains the primary objective of a commercial enterprise. It encompasses all factors influencing the company's financial position.

The customer perspective enables the enterprise to develop a range of goods or services that best meets the needs of the chosen market segment.

The internal business processes perspective identifies the processes that ensure the achievement of financial goals and the satisfaction of stakeholders' needs. The main focus is on the key processes that influence strategy implementation and the creation of competitive advantages.

The learning and development perspective is of vital importance not only for the company's internal processes but also for ensuring its long-term development.

The main advantage of the Balanced Scorecard is that this system makes it relatively straightforward to implement the company's strategy in practice. It helps to identify the interrelationships between key parameters of the company's development and motivates employees to achieve set goals through encouragement rather than strict control.

Today, a wide range of strategic planning tools is in use. The company's manager independently selects the method of forecasting and strategic development that is most effective in terms of resource and time expenditure. At the same time, the advantages of the Balanced Scorecard compared to traditional management systems confirm its significant theoretical and practical importance.

The Balanced Scorecard system is based on the division of business processes into separate levels and their subsequent breakdown. For each of these levels, a specific system of indicators and evaluation criteria is established, reflecting the objectives and outcomes of the relevant processes. Therefore, the key concept in this system is the business process itself.

The history of the development of business process theory shows that the modern interpretation of this concept took shape approximately two decades ago. Initially, this concept did not attract significant interest among business leaders. However, over time it became clear that traditional functional management required ever-increasing material and labour resources without ensuring adequate efficiency.

A business process is defined as a set of interrelated activities which, within a specified timeframe, transform input resources into a specific output to achieve a particular objective. The main distinction between a business process and an ordinary process is its focus on the enterprise's economic activities and the attainment of an economic outcome, most often profit.

In terms of their nature, business processes are divided into four main groups: core, support, management and development processes.

This classification enables company management to present the company's activities in a more structured manner and to manage them more effectively. Each group of processes fulfils its own function within the organisation. For example, core business processes directly generate the company's current revenue and effectively act as profit centres.

Core business processes typically include production, supply and sales of products, i.e. those processes that create added value for the consumer. These include marketing, procurement of resources, production, storage, delivery and after-sales service.

Supporting business processes ensure the functioning of core processes and maintain the company's infrastructure. They are not directly related to product manufacturing but create the necessary conditions for the company's stable operation. Such processes include [97]:

1. Staff recruitment, training and assessment.

2. Document management, which defines the procedure for developing, approving and maintaining internal regulatory documents and ensures the coordinated operation of all processes.

3. Support processes, which create the conditions for the implementation of the enterprise's core functions and management functions. These include production supply, equipment maintenance and repair, occupational health and safety, environmental control, information and communication support, legal support, security systems, etc.

Of particular importance are development business processes, the main objective of which is to ensure the long-term functioning of the enterprise and the growth of its profitability in the future. This is precisely why they are often regarded as investment centres or venture areas of activity.

For most modern domestic enterprises, the issue of business process modelling has become particularly relevant due to the need to reform the management system and improve operations [79-83, 100].

Business process modelling is the representation of real processes existing within an organisation using graphical, textual or tabular methods of presenting information [69].

The model created allows for a comprehensive analysis of the enterprise's operations, an assessment from various perspectives, and the identification of problems that may remain unnoticed even by management.

The use of modelling tools also opens up the possibility of conducting a cost analysis of business processes. Such an analysis involves accounting for the costs associated with performing specific tasks, with the aim of determining the total cost of a particular business process.

In practice, difficulties often arise in identifying the causes of internal contradictions, inconsistencies in functions, or inefficient sequences of work. In this case, the constructed model allows not only to identify the problem but also to clearly demonstrate its sources.

When solving optimisation problems at manufacturing enterprises, three main aspects are usually identified: methodological, informational and technical [70, 85].

The methodological aspect of modelling lies in the use of a model description for the systematic planning of an enterprise's activities. It is precisely here that the important role of models in the theory and practice of production management is manifested. The formalisation of processes and the creation of structural-mathematical models open up new possibilities for analysing and verifying management decisions, and also allow us to use mathematical tools to move from formulated hypotheses to concrete conclusions [88].

A company's business process model reflects not a single situation at a specific point in time, but the overall picture of the enterprise's operations. However, it does not always cover non-standard or exceptional situations. Some areas of activity may be modelled in a generalised manner, whilst others require a more detailed description, particularly in cases of process automation [88].

A common misconception is the assumption that a business model created once can remain relevant for a long time. In reality, it must be constantly updated in line with changes in the enterprise's activities to ensure that actual processes align with the current model. It is effective business modelling, analysis and design that form the basis for organisational change and the improvement of business processes.

In the strategic planning system, business process modelling is carried out in stages. Schematically, this can be represented as follows:

Functional model of the enterprise (Supply → Production → Sales) → Process model of the enterprise (Supply business process → Enterprise business process →

Sales business process → External customer) → Quantitative model for calculating the enterprise's business processes → Strategic plan of the enterprise

The logic behind this approach is based on the sequential detailing of the enterprise's internal processes. First, a general functional model of the enterprise is formed, which reflects the organisation's main functions and the distribution of responsibility for their execution.

The functional model does not show the interrelationships between individual functions, yet it forms the basis for constructing the enterprise's business process system.

The next stage is the creation of a process model, which describes the flows of resources used during the performance of functions. At the same time, such a model does not include a cost assessment of the processes, so there is a need to build a quantitative model of business processes, which allows the costs of performing a specific process to be determined. It is the quantitative model that serves as the basis for formulating the enterprise's strategic development plan [97].

Modelling business processes that closely reflect the actual operating conditions of the enterprise makes it possible to identify and evaluate the most effective areas for improving the organisation's operations without the need for real-world experiments. The results obtained can be used when formulating a strategic plan as guidelines for the enterprise's further development.

The initial stage of any methodology for planning a company's activities is the identification of business processes, the definition of their boundaries, and the assignment of responsible persons for each of them. In this context, it is advisable to consider at least three main approaches to defining the boundaries of business processes. According to these, a business process can be defined as a sequence of actions grouped:

1. by type of activity or similar functions;
2. by the result of the activity or the end product;
3. by the creation of added value for the customer.

The first approach focuses on describing the actions performed by employees within a specific functional unit to achieve a particular result. The second approach allows tasks to be grouped according to the product and the specific customer. The third approach views business processes as a set of actions that create added value for the customer [88]. An approach based on grouping by functional similarity is most commonly used during the implementation of automation projects. In such cases, a brief description of current and future operations is usually provided, sometimes even without the creation of high-level models. If such models are created, they typically take the form of a functional hierarchy. Figure 3 shows the OBM (Oracle Business Model), which illustrates this approach.

The OBM (Oracle Business Model)						
	Planning	Resources	Production	Market	Sales	Support
Business Chain	Product of products	Supply	Management Production	Marketing management	Sales management	Customer relationship management
Business Chain	Planning and forecasting		Materials Management		Order fulfilment	Customer service management
Internal Support	Financial management					
Internal Support	Quality management					
Internal Support	IT management					
Internal Support	Project Management					
Internal Support	Human resources management					
Internal Support	Corporate Governance					
Cooperation	Work at trading venues					

Figure 3. OBM (Oracle Business Model)

Source of the figure: author's development or [86]

The main drawback of models of this type is that the enterprise is described primarily in terms of functional activities. During decomposition, business processes and operations are distributed among various functional departments and specialists, which contradicts the fundamental principle of re-engineering: 'one process – one department – one budget – one process owner'. It was precisely the principle of process management that formed the basis of the approaches of M. Hammer, J. Champy and other researchers in the field of re-engineering.

According to Hammer and Champy, re-engineering is a fundamental rethinking and radical redesign of business processes with the aim of achieving significant improvements in key performance indicators, such as costs, service levels and speed of execution [86]. The basis of this approach is the creation of new, more efficient processes effectively 'from scratch'.

Hammer and Champy's methodology has been in development for over a decade. At the same time, an analysis of international experience shows that a significant proportion of re-engineering projects have failed. However, the reasons for these outcomes are linked not so much to the methodology itself as to shortcomings in organisational management. Today, business process re-engineering can be interpreted as an activity based on viewing the enterprise as a system of interrelated processes and aimed at their continuous analysis and improvement.

The second approach is based on grouping business processes according to the results of activities rather than functional characteristics. The best-known examples of this approach are the thirteen-process model, the eight-process model and the Sheer model [88]. Their defining feature is the grouping of tasks according to the final outcome.

When process management is implemented and all process participants are subordinated to the process owner, such models allow for the formation of so-called 'flat' organisational structures. However, they place high demands on staff qualifications, are difficult for line managers to grasp, and require a significant level of abstraction during modelling.

At the same time, the implementation of such structures allows for a significant reduction in staff numbers, optimisation of the enterprise's operations, and ensures business transparency and manageability.

When applying this approach, it should be borne in mind that the concept of 'outcome' can be interpreted in different ways, and so there are several ways of implementing it [86, 88]. It is worth noting that these models were developed on the basis of data from the International Benchmarking Institute [98].

The 13-step model					
Market and consumer research	Development of vision and strategy	Product and service development	Marketing and sales	Production and supply of products and services (manufacturing companies) Production and supply of products and services (service companies)	Billing and customer service
Support processes					
Professional and career development of staff and human resources management					
Management of information resources and technologies					
Management of financial and material resources					
Implementation of environmental management programmes					
External relations management					

Figure 4. The APQC 13-process model (American Productivity and Quality Center)

Source of the figure: development by the author

The eight-process model was developed by specialists at the consulting firm BKG Profit Technology and has been successfully applied in practice.

The 8-process model			
Development of agreed operating conditions	Recruitment and training of staff	Logistical support	Development and modification of products
Reproduction of means of production	Marketing and sales	Production	Financing of operations and settlement of liabilities

Figure 5. The 8-process model of the BKG Profit Technology organisation

Source of the figure: developed by the author

The advantage of models of this type is that they allow the enterprise's activities to be viewed as a single system of interrelated business processes, each of which has a specific end result.

A. V. Sheyer proposed his own business process model (Fig. 6), in which he identified two main groups of processes: logistics and the processes of ordering and developing new products. Information, coordination, financial and management processes, as well as controlling and information management processes, are formed around them. A drawback of this model is that it does not clearly reflect the interrelationships between individual business processes.

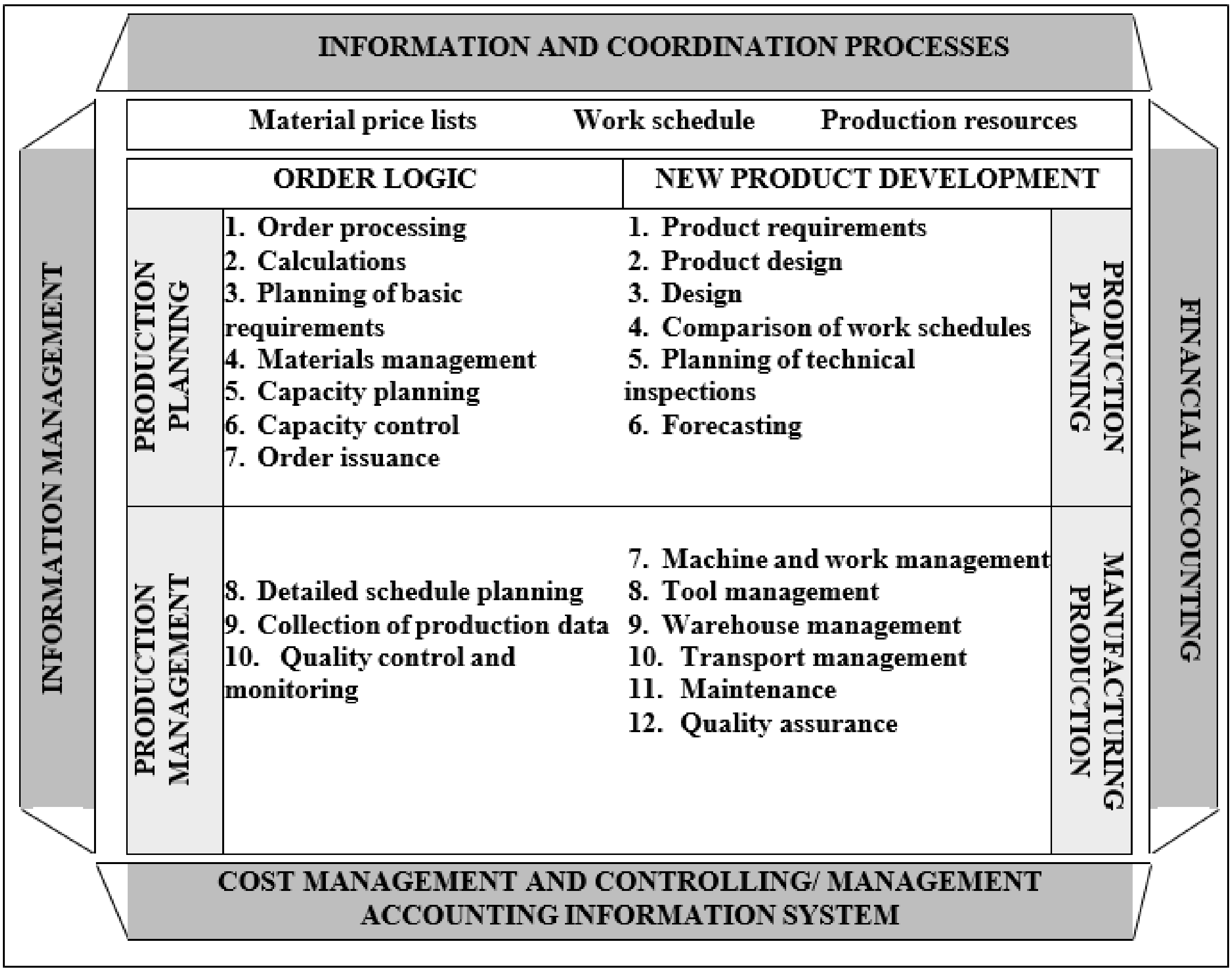

Figure 6. Sheer's model

Source of the figure: author's development or [88]

The third approach, focused on creating added value for the customer, is based on Michael Porter’s value chain concept. Within this approach, the key business processes that underpin the production cycle are identified, as well as the processes that support the functioning of the business system throughout the product’s life cycle [87].

M. Porter emphasised that the buyer does not actually purchase the product itself, but rather the value it creates for them. This is precisely why, in order to identify competitive advantages, a company must analyse the entire process of creating this value. Thus, the value chain acts as a kind of infrastructure that demonstrates the significance of individual business processes (Fig. 7).

Porter’s Model (Value Chain Model)				
Primary processes				
Internal logistics	**Production**	**External logistics**	**Marketing and sales**	**After-sales support and service**
Support processes				
Logistics **Company infrastructure support** **Human resources management** **Technology development** **External relations management**				

Figure 7. Porter’s model

Source of the figure: author's development or [87]

Primary business processes are those that directly create value for the customer. Secondary processes perform a supporting function, providing the necessary infrastructure and management system for the implementation of primary processes.

When considering the boundaries of business processes, M. Porter noted that they lie where each individual sub-process adds specific value to the product. An important conclusion follows from this: there is no universal list of business processes, as every enterprise creates a unique product and has its own system of processes.

Thus, the first approach to defining the boundaries of business processes is based on grouping processes by function or type of activity. Its main drawback is the lack of clearly defined persons responsible for each business process.

The second approach involves grouping processes by end result or product. This includes the thirteen-process and eight-process models, the advantage of which is that they view the company's activities as a holistic system of interrelated processes.

The third approach views business processes as a set of actions that create added value for the customer. It is precisely this approach that is implemented in M. Porter's model, according to which the boundaries of business processes are defined by the point at which added value is created for the product.

The approaches discussed reflect the key principles for identifying business processes in industrial enterprises.

At the current stage of management development, there is a trend towards describing business systems and business processes initially using symbolic modelling,

i.e. constructing various types of diagrams and charts, and subsequently using economic-mathematical methods and modern information technologies. Today, there are tools that, based on simulation modelling, allow the behaviour and development of systems over time to be predicted [86, 88].

At the same time, active work is underway to develop a unified approach to the description of business processes or their individual components [88, 89]. Various commercial entities, government agencies, research organisations and international consortia from the USA, Canada, Germany and other countries are working in this field. This has resulted in the creation of a significant number of methods and software tools that support the modelling process [86, 89, 95].

Among the best-known modelling methods are:

– SADT (IDEF0) functional modelling;
– the IDEF3 method;
– DFD data flow modelling;
– the ARIS methodology;
– the Ericsson-Penker method;

– the approach used in the Rational Unified Process.

The SADT (Structured Analysis and Design Technique) method [91, 92] is considered one of the classic tools of the process-based approach to management. Its main idea is that a company's activities are structured according to business processes, rather than according to the organisational structure or staffing table.

According to this concept, the business model is formed according to a specific logic:

The top level reflects the general context of the system, i.e. the enterprise's interaction with the external environment through a single contextual process.

The second level contains the main areas of the organisation's activities and the links between them. If there are many such areas, some of them can be detailed at the third level. At the same time, no more than two levels are usually used to describe the types of activities. Business processes are then detailed through business functions, which consist of specific operations grouped by common characteristics. Business operations are described by defining the algorithm for their execution.

The SADT method was developed by Douglas Ross in 1969 for modelling complex artificial systems. It was widely used in the US military, industry and business sectors to address issues of strategic planning, automated production, financial management and logistics. Subsequently, this method formed the basis of the IDEF0 standard, which was officially adopted as a US federal standard in 1993. The IDEF3 and IDEF1 standards are often used alongside IDEF0. SADT is a set of rules and procedures for constructing functional models of a specific object. Such models reflect the functions of the system and the interrelationships between actions, and are best suited for describing top-level management processes.

The advantages of this approach include [91]:

– a comprehensive description of business processes, including information, material and management flows;

– the possibility of deep decomposition;

– aggregation and detailing of information flows;

– standardisation of models;

– ease of process documentation.

However, the method also has certain drawbacks:

– complexity of comprehension due to the large number of connections in the diagrams;

– a significant number of levels of detail;

– difficulties in integrating several processes represented in different models within a single organisation.

The IDEF3 method [93], which is also part of the IDEF family, was developed in the late 1980s as part of a closed project at the BBC in the US. Its primary purpose is to model the sequence of operations and the interdependencies between them. Although IDEF3 has not been granted official standard status, it is widely used by systems analysts as a supplement to IDEF0.

The basis of the IDEF3 model is a process script, which describes the sequence of actions and sub-processes of the system. The relationships between operations are represented by arrows. As a rule, diagrams are drawn from left to right, which makes them easier to analyse.

Data Flow Diagrams (DFDs) [93] represent a hierarchical system of processes linked by data flows. Their main purpose is to show how input information is transformed into output, as well as to demonstrate the relationships between processes. To create DFDs, the Yordan-DeMarco and Gane-Serson notations are used, which differ mainly in their graphical presentation. The upper levels of DFDs show the main processes and interaction with the external environment. Further detailing is achieved by constructing lower-level diagrams until further division of processes becomes impractical.

Today, the trend towards integrating various methods of system modelling and analysis is becoming increasingly prominent. One example of such an integrated approach is the ARIS (Architecture of Integrated Information Systems) system, developed by the German company IDS [Scheer Ar]. ARIS is a comprehensive tool for analysing and modelling business activities [89]. Its methodology is based on a combination of different modelling techniques, which allow the system to be examined from multiple perspectives.

Within ARIS, the following are used:

– organisational models that reflect the structure of the enterprise;

– functional models, which show management objectives and functions;

– information models describing the data structure;

– management models that comprehensively demonstrate the implementation of business processes.

A key feature of ARIS is its ability to analyse each aspect of a company's operations separately, before combining them into a single integrated model. The advantage of ARIS is its comprehensiveness and the ability to establish links between models of different types. However, implementing this system often requires significant financial and human resources, as well as a considerable amount of time. Furthermore, the ARIS software environment is quite complex to use.

The Ericsson-Penker method [85] is interesting in that it uses the UML language for business process modelling. Thanks to UML extension mechanisms, the model can be adapted to the specific needs of the enterprise without changing the basic structure of the language.

The method provides for four types of business model representation:

– conceptual;

– process;

– structural;

– behavioural.

This approach makes extensive use of standard modelling templates, which help to find effective solutions for standard situations.

The UML language is also used in IBM Rational Software's Rational Unified Process. In this case, two basic models are created: a business process model and a business analysis model.

Economic and mathematical modelling of business processes is also of great importance. Various researchers have attempted to address the task of describing and optimising business processes using mathematical models [75-100].

One such tool is Petri nets [77]. They allow for the modelling of cause-and-effect relationships within a system and the representation of transitions between states. The main elements of Petri nets are places, transitions, arcs and labels. Despite their clarity and flexibility, this method has a drawback: if none of the transitions can be executed, the system enters a blocked state.

Another approach is modelling based on graph theory. In this case, business processes are represented as a system of vertices and edges, which allows the relationships between process elements to be clearly visualised and potential conflicts or deadlock situations to be identified.

In management practice, flow network models are frequently used, designed to analyse and optimise complex sets of interrelated tasks [69]. To study such systems, the tools of probability theory, graph theory and Markov chains are employed.

The main task of network planning is the graphical representation and optimisation of the sequence of tasks required to achieve defined objectives [76, 79, 81]. However, these models do not always account for the impact of the flow of orders from customers. This is why queuing theory plays a significant role [68].

A queuing system (QS) is a system that handles a flow of requests or orders. Such systems have an input flow of requests and service channels through which these requests are fulfilled [68].

In most cases, the arrival times of requests and the duration of their processing are random variables. This is why queuing theory is based on methods of mathematical statistics and probability theory. The main objective of this theory is to determine the optimal ratio between the number of requests and the number of service channels to minimise total costs [68, 81]. The SMO simulation model allows the behaviour of the system over time to be reproduced under given request flow parameters. The input parameters are the characteristics of the order flow, and the output parameters are the system's performance indicators. It is these economic characteristics that form the basis of business process indicators in the enterprise's strategic planning.

The shortcomings of models based on Petri nets, graph theory and flow network models have led to the more active application of queuing theory in business process modelling. Its advantages confirm the validity of this approach, particularly for enterprises in the furniture industry.

To calculate MRT characteristics, it is necessary to formally describe the order flow. The most accurate results are obtained when the order flow is simple or Poissonian. Such a flow is characterised by stationarity, regularity and the absence of after-effects [68].

Stationarity means that a stream of events is considered stationary when the number of events over a given time interval depends only on the duration of that interval, and not on the specific moment in time at which it occurs.

The ordinariness of the flow lies in the fact that the probability of two or more events occurring within a very short time interval is negligible compared to the probability of a single event occurring. In other words, service requests arrive individually, not in groups.

Table 1

A Comparative Analysis of Economic and Mathematical Methods for Modelling Business Processes

Method	Advantages	Disadvantages
Graph theory	1. Allows for the verification of the absence of negative situations in the process and the identification of relationships between its elements. 2. It is a component in the construction of other mathematical models, in particular Petri nets and flow network models.	1. Does not take into account the probabilistic nature of a specific event occurring; 2. The model is rather limited in its ability to describe a network of business processes within an organisation.
Petrie nets	1. They provide a detailed description of behaviour, including current, future and unattainable states.	1. Transitions from one state to another for each process are considered independently. If the conditions for any of the transitions are not met, the network enters a blocked state. 2. A general network modelling even fairly simple business processes is cumbersome.

Continuation of table 1

Method	Advantages	Disadvantages
Flow Network Models	1. A comprehensive representation of the entire set of tasks and activities; the ability to reallocate resources.	1. Require the specification of a large number of initial parameters. 2. Do not fully reflect the dependence of enterprises' performance on end consumers.
Queueing Theory	1. Takes into account the relationship between the input and output parameters of a business process 2. Allows business processes to be optimised according to specified indicators in real time. 3. Do not require a large amount of initial data.	

The absence of after-effects means that the arrival of requests is independent of one another. The time of arrival of a new request is not determined by the arrival of the previous one.

A characteristic feature of a Poisson flow is that the intervals between requests follow an exponential distribution. This indicates that the time intervals between requests can be either very short or quite long.

The number of requests in a Poisson flow arriving within a given time interval is described by the Poisson distribution. The probability of exactly a specified number of requests arriving in time t is calculated using the formula:

$$P_i = \frac{(\lambda t)^i}{i!} \times e^{-\lambda t} \quad (1)$$

where λ is the rate of arrival, i.e. the average number of requests arriving per unit of time.

The time intervals between the arrival of requests, as well as the duration of their processing in queuing systems, are usually random variables. The following distribution laws are most commonly used to describe them:

– the exponential distribution – used in cases where the time between requests or the duration of service may vary significantly;

– uniform distribution – applied when values fall within a specific range;

– normal (Gaussian) distribution – characteristic of situations where most values are close to the mean;

– Erlang's kth-order law – used when the quantity under investigation is the sum of several independent exponentially distributed quantities.

In some situations, the intervals between requests or their processing times may be known in advance, i.e. deterministic quantities.

A queue in which the time intervals between events follow a k-th-order Erlang distribution is called an Erlang queue. If these intervals are constant values, the queue is considered regular.

To determine the characteristics of queuing systems, the coefficients of variation of the time between requests and the time taken to serve them are used. The coefficient of variation of a random variable is calculated using the formula:

$$V = \frac{\sigma}{\bar{X}} \tag{2}$$

where σ is the standard deviation; $\bar{X}$ is the expected value of the random variable.

The higher the coefficient of variation, the greater the spread of values relative to the mean.

To denote queuing systems, the notation $A|B|m - d$ is used, where A is the distribution of the time between arrivals; B is the distribution of service times; m is the number of service channels; and d is the service discipline. The following notations are most commonly used: M – exponential distribution, G – random distribution, D – deterministic, Ek – Erlang distribution of the kth order, etc. [81].

The main parameter of the request flow is its intensity λ – the average number of requests arriving at the system per unit of time.

The main parameters of the SMO include: the number of service channels m and the average service time per request x. Often, the service rate is used instead of x: $\mu = 1/x$. This indicator characterises the number of requests that the system is capable of handling per unit of time, assuming continuous operation of the channels.

For queuing systems, another important parameter is the maximum permissible number of requests in the queue n [81].

The characteristics of a queuing system are understood to be indicators that allow the efficiency of the system's operation to be assessed and different options for its organisation to be compared [81]:

1. Idle probability P_0 – indicates the proportion of time when all system channels are free.
2. Probability of rejection P_{rej} – characterises the proportion of requests that were not accepted for service due to system overload. For systems without queue limits, $P_{rej} = 0$.
3. Probability of service P_{serv} – determines the proportion of requests that were successfully served: $P_{serv} = 1 - P_{reject}$.
4. The utilisation factor U reflects the proportion of time during which the system is occupied with serving requests.
5. Average queue length $\overline{q}$.
6. Average number of occupied channels $\bar{S}$.
7. Average number of requests in the system $\overline{k}$.
8. Average request waiting time in the queue $\overline{w}$.
9. Average time a request spends in the system $\bar{t}$.
10. Throughput – the average number of requests processed per unit of time γ.

The metrics *P0, U* and *S* the average number of occupied channels characterise the system's utilisation level. For the SMO to operate effectively, the recommended load factor is within the range of 0,75–0,85. If $U < 0{,}75$, the system is not being used efficiently, and if $U > 0{,}85$, it is overloaded [68, 81].

The indicators P_{reject}, P_{served} , average waiting time $\bar{t}$ and average queue length $\overline{w}$ characterise service quality. To improve efficiency, it is desirable to minimise the values of P_{reject} and waiting time and maximise P_{served} .

The system's throughput indicates the number of requests the system can process per unit of time. This indicator is particularly important for businesses where every completed order generates profit.

To calculate the characteristics of the SMO, the load value is used:

$$\rho = \frac{\lambda}{m\mu} \tag{3}$$

where ρ is the ratio of the request flow rate to the total service rate of the system.

A system without queueing constraints can operate stably only if $\rho < 1$. If, however, $\rho > 1$, the number of requests arriving per unit of time (λ) exceeds the system's capacity to handle them ($m\mu$), causing the queue to grow continuously [84, 93, 95]. For systems with queueing constraints and without queues, any value ofρ is possible, as in such systems some requests are rejected, i.e. not admitted into the MSS.

The advantages of queuing theory confirm the appropriateness of its application for modelling the business processes of furniture enterprises.

The main objective of queuing theory is to determine the optimal ratio between the number of requests and the number of service units, at which the total service costs and losses from downtime will be minimised. The resulting economic indicators are used in the formulation of the enterprise's strategic plan.

To develop models and methods for improving the efficiency of business process management, it is necessary to clearly define the key concepts both within the business process approach and from the perspective of queuing theory.

One of the main features of the model is that it provides a simplified representation of the real-world object, focusing only on those characteristics that are relevant to the study.

Taking into account the main provisions of queuing theory, a business process model can be defined as a system of interrelated activities that operates according to the principles of queuing theory and ensures the transformation of input resources into an output result in accordance with the set objective. The input to the business process, as an MSS, is the flow of orders for product manufacture, which is generated in accordance with consumer needs and the enterprise's production tasks (Fig. 8).

The service elements are the production equipment and personnel, which ensure that orders are fulfilled with the specified productivity and quality. The queue in the business process represents the permissible number of orders awaiting fulfilment in addition to those already in production. The system's output is finished products that meet the established quantitative and qualitative requirements.

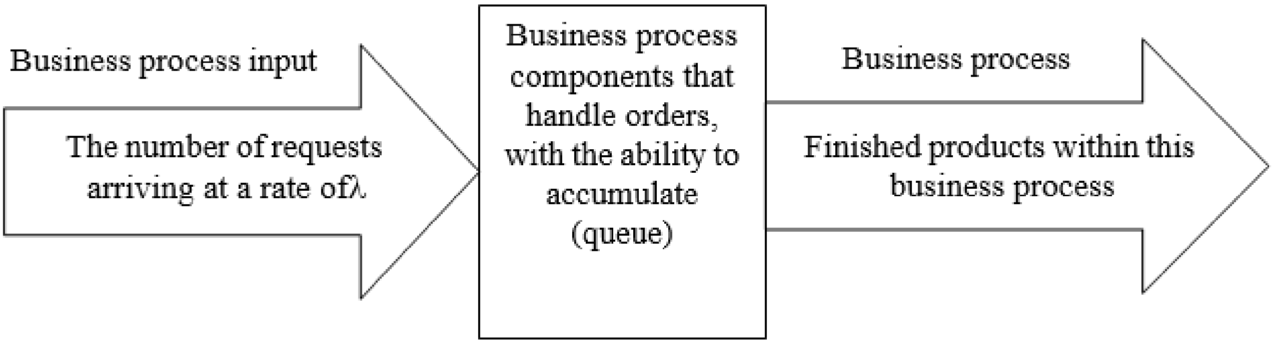

Figure 8. The business process as an SMO

Source of the figure: developed by the author

When constructing business process models, it is advisable to use the mathematical apparatus of queuing theory, as it allows for an adequate description of individual operations and business functions. When creating models, it is assumed that the order flow is Poissonian and that business processes have queue length constraints.

In such systems, the queue can hold no more than n requests. If a new order arrives when the queue is already full, it is not accepted for processing.

To analyse business processes, it is necessary to define three main groups of indicators: state probability indicators; quantitative indicators; economic indicators. State probability indicators characterise the probability of the system being in a certain state, i.e. serving a specific number (j) of orders P_j. For example, the value $P_2 = 0,15$ means that 15% of the time the system is simultaneously serving exactly two orders.

Such indicators form the basis for determining the quantitative characteristics of business processes, which depend on the intensity of incoming requests, the speed of their processing, and the number of service elements.

Based on these quantitative characteristics, economic indicators are calculated that reflect the efficiency of business processes, in particular the costs of order processing, revenue levels and other results of production activities.

The proposed economic-mathematical model is based on modern approaches to the analysis and practical application of mathematical methods for modelling business processes within the framework of strategic enterprise management.

The outcome of the business process, as a queuing system, is finished products that meet the established regulatory requirements in terms of their quantitative parameters.

To develop models of an enterprise's business processes and determine their economic characteristics, it is advisable to apply the mathematical apparatus of queuing theory. This approach allows for a sufficiently accurate description of individual operations or business functions of the process, which can be regarded as open queuing systems.

Certain assumptions are made when constructing business process models. In particular, it is assumed that the flow of orders at the input of the business process follows a Poisson distribution, as this type of flow imposes the most stringent demands on the service system. Furthermore, the operational model is treated as a business process with a finite queue length.

For such processes, it is assumed that the queue can contain no more than n orders. If a new order arrives at a time when the queue is already filled to its maximum capacity, it is not accepted for processing.

In this regard, it is necessary to identify three main groups of business process indicators: indicators of the probability of business process states; quantitative characteristics of business processes; economic indicators of business processes.

State probability indicators reflect the probability of a business process serving a certain number of orders. Typically, the values of P_j are determined – the probability that the system serves exactly j orders. For example, the value P_2 characterises the probability of two orders being processed simultaneously. If P_2 = 0,15, this means that for 15% of the business process's operating time, there are exactly two orders in the system. At other times, their number will be less than or greater than two.

The probabilistic states of business processes are described by corresponding mathematical relationships [68, 81].

Such indicators are mainly used as intermediate parameters for the subsequent calculation of other system characteristics [100], primarily quantitative indicators. Quantitative characteristics determine the operating parameters of the business process depending on the intensity of order inflow, the speed of their processing, and the number of service elements – production resources or personnel – within a specific time interval.

Economic indicators characterising the effectiveness of a business process can be determined on the basis of quantitative parameters.

Economic indicators of business processes are understood as characteristics that reflect the ratio of revenues to costs arising in the course of an enterprise's production activities, in particular the costs of order fulfilment, etc. The methodology for their calculation depends on the specific formulation of the problem. Accordingly, a system of economic indicators for business processes is proposed, which is described by corresponding mathematical expressions.

The proposed economic-mathematical model is based on an analysis of contemporary theoretical research and the practical application of mathematical methods for modelling business processes within a strategic management system.

The implementation of a Balanced Scorecard system within an organisation requires significant time and resource investment. The use of modelling in the formulation of indicators allows the design process to be made more efficient, the current situation to be clarified, changes to be tracked, and the development strategy to be adjusted simultaneously. Furthermore, it becomes possible to identify and refine the cause-and-effect relationships between strategic objectives, as well as to assess in advance the events, resources, timelines and responsible parties required to achieve the set objectives.

The cognitive modelling method enables the creation of a clear and logical algorithm for implementing strategic tasks, assessing the enterprise's capabilities and accounting for potential risks even before active measures are taken. This approach allows the enterprise's internal and external economic environments to be integrated into a single system and analysed both as a whole and in terms of individual components, taking into account interrelationships as well as quantitative and qualitative characteristics.

The development of the BSC involves formulating a strategy across several perspectives, defining strategic objectives and assessing the degree to which they are achieved using appropriate indicators. The Balanced Scorecard extends across the entire organisation through the setting of individual objectives within the corporate strategy and helps employees understand their own role in achieving overall results.

The application of the BSC has made it possible to formulate a long-term strategy for the activities of all the company's divisions, the management of which is carried out through planning, accounting, control, analysis of indicators and the motivation of staff to achieve the set goals.

When designing the BSC, a potential scenario for the realisation of strategic objectives is effectively modelled on strategic maps, reflecting the cause-and-effect relationships between them. At the same time, most tools that implement the BPM concept do not provide the capability to model the BSC for forecasting the development of the company's processes, which complicates the selection of the optimal scenario and the precise definition of strategic objectives.

Since the BSC system combines both quantitative and qualitative characteristics, assessing an enterprise's performance through modelling is a complex task. An analysis of existing methods shows that cognitive models are best suited to this task, as they allow internal and external factors to be integrated into a single system and take into account the interrelationships between them. Furthermore, such models can reflect both quantitative and qualitative process parameters.

As a rule, cognitive modelling is carried out in a specific sequence:

– determining the initial conditions and trends in the development of the situation to ensure the model corresponds to the actual state;

– establishing the desired directions and magnitude of changes in processes;

– selection of a set of measures and control factors, as well as determination of their impact on the situation;

– determining possible influences and the strength of their effect;

– selection of indicators characterising the development of the situation in accordance with the objectives of the analysis.

These stages of cognitive analysis are implemented using specialised software tools, including ‘Situation’, ‘Compass’, the ‘Igla’ decision support system, the CogMap software environment and others.

The simplest cognitive model is a directed graph – a cognitive map: $G=<V,E>$, where V is the set of vertices representing the elements of the system, i.e. strategic objectives, and E is the set of edges characterising the relationships between vertices. A positive relationship means that an increase in one indicator causes an increase in another, whilst a negative relationship means that a change in one indicator leads to an opposite change in another.

A cognitive map is formed as a result of structuring knowledge about the enterprise’s strategic objectives and external environmental factors. It allows for the systematisation of internal and external factors that have quantitative and qualitative expressions, as well as the identification of cause-and-effect relationships between them.

The constructed directed graph demonstrates the influence of factors, taking into account the arc weights w_{ij} established by experts, for example within the range from –10 to +10. The values of the weights can be determined on the basis of functional dependencies or using linear regression coefficients b_{ij} ($y_j = a + b_{ij}$).

This approach makes it possible to take into account both the direct quantitative and indirect qualitative impact of factors on performance indicators. As a result, the problem area is described more comprehensively, and the effectiveness of specific measures or projects can be assessed more accurately.

The development of a company’s strategy is a crucial stage in its development and demonstrates the organisation’s maturity and a sufficient level of achievement. The company under study faced the need to assess the effectiveness of its own actions, particularly given the cyclical nature of strategic management. In such circumstances, there is a need to determine whether changes are positive or negative and against what to compare them. In the absence of relevant data, this is difficult to do.

In this case, BSC modelling allows one to:

– clarify the situation and track changes whilst simultaneously adjusting the strategy;

– identify and clarify cause-and-effect relationships between strategic objectives;

– pre-assess the measures, resources, timelines and responsible parties required to implement the set tasks.

Implementing the BSC is a lengthy and resource-intensive process, yet modelling it significantly enhances the effectiveness of planning. Cognitive modelling enables the creation of a clear algorithm for achieving strategic goals, the formation of a vision for the enterprise’s future, and the assessment of opportunities and consideration of risks even before active measures are taken.

At the same time, it has been demonstrated that cognitive modelling of the BSC allows for the integration of elements of the internal and external economic environment into a single system and for its analysis without losing the interconnections between individual components, taking into account both quantitative and qualitative characteristics of processes.

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