BENCHMARKING

AS A FOUNDATION OF THE FUTURE

ECONOMY

Berezin Artiom Andreevich

Benchmarking as a Foundation of the Future Economy

Benchmarking as a Foundation of the Future Economy

By

Berezin Artiom Andreevich

Cambridge Scholars Publishing

Benchmarking as a Foundation of the Future Economy

By Berezin Artiom Andreevich

This book first published 2020

Cambridge Scholars Publishing

Lady Stephenson Library, Newcastle upon Tyne, NE6 2PA, UK

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

ISBN (10): 1-5275-5778-2
ISBN (13): 978-1-5275-5778-9

TABLE OF CONTENTS

SYMBOLS AND ABBREVIATIONS

AMF - Action Message Format

EBITDA - Earnings Before Interest, Taxes, Depreciation and Amortization

GUI - Graphical User Interface

EJB - Enterprise JavaBeans

HQL - Hibernate Query Language

JPA - Java Persistence API

J2EE - Java Enterprise Edition

JMS - Java Message Service

OLAP - Online Analytical Processing

OLTP - On-Line Transaction Processing

ORM - Object-Relational Mapping

UML - Unified Modeling Language

XML - eXtensible Markup Language

AISU - Automated Information Management System

DB – Database

KB - Knowledge base

SSDMC - Support System Decision-Making and Competitiveness

DM - Decision makers

DF - Decision former

IAD - Data Mining

IAS - Information and Analytical System

MIS - Management Information System

CIS - Corporate Information System

INTRODUCTION

The problem of managing the competitiveness of enterprises in various fields of activity has recently acquired national significance. To date, no company can give up its competitive positioning and use tools for analyzing and managing competitiveness. At the same time, companies are trying to develop a unique development strategy in order to apply competitive advantages to achieve high economic performance.

One of the mechanisms for managing the production and economic activities of enterprises is comparative research, modeling and forecasting based on the benchmarking principle. Benchmarking refers to the process of identifying and adapting examples of effective functioning of competitors in order to improve the company's own performance. Models and decision-making methods for managing competitiveness in the benchmarking process allow to explore the advantages and disadvantages of competitors in order to develop and implement an effective strategy for enterprise development.

Unfortunately, today, the problems of competitiveness are often considered only from the production point of view, without affecting other areas. Modern ideas assume that the main role in ensuring competitiveness is played by intangible assets and intellectual capital [1]. However, this statement is not entirely consistent with the Russian reality on the market: the information link between companies is still too weak, the introduction of innovations is weak, and the legal framework is not yet fully prepared [2]. On the other hand, the increasing pressure of various factors, especially crisis phenomena, on Russian companies leads to an aggravation of the competition for market share between them. At the same time, most companies pay little attention and do not conduct research in the field of decision-making to develop a strategy for their competitive development. One of the effective mechanisms for managing aspects of production and economic activity of enterprises in various sectors of the economy is a comparative study, modeling of determining, understanding and adapting existing examples of effective functioning of the nearest competitive company in order to improve their own performance [3]. Models and methods of decision-making for managing the competitiveness of your own

company in the process of comparative research allow exploring the competitive advantages and disadvantages of your nearest competitors in the market, developing and implementing your competitive strategy and manage it quickly, depending on the changing situation.

Competitiveness is a property of socio-economic systems [4], as well as the closest sphere to it - competition. The complexity of managing competitiveness is that the decision-making process cannot be based only on one or more factors that affect competitiveness. It should take them into account in total and separately, determining the significance of each of them by means of intellectual analysis or expert method, taking into account the requirement of updating data [5], since time and situational trends influence factors. Another problem of managing competitiveness is the need for forecasting, and the existing forecast models are not fully adequate and cannot guarantee the correctness of the chosen management strategy. This is because many competing companies react to the same market situations in different ways, which should be taken into account when making decisions. Therefore, when creating a methodology for supporting decision-making in this area, it is advisable to use scenario analysis methods [6]. These problems lead to the fact that the administration of enterprises makes mistakes in planning and implementing measures to improve the efficiency of competitiveness management processes. In this regard, the task of developing and implementing decision support methods for managing competitiveness using benchmarking principles is an urgent research task in modern market economic conditions.

The analysis showed that most researchers are working on general theoretical approaches to modeling the competitiveness management process and developing recommendations for the production of competitive products. At the same time, little attention is paid to the creation of software tools for automated decision support in this area of enterprise management. It is also worth noting the problems: the lack of adequate mathematical models for assessing and predicting competitiveness, the lack of consideration of hidden patterns of the competition process in existing models, the complexity of automation and the lack of efficiency in decision-making for managing competitiveness.

This confirms the relevance of research in the field of systematization of decision-making technologies and the development of new models and methods for automating benchmarking processes and managing competitiveness based on modern information, computing and telecommunications technologies. The book is aimed at describing models,

methods and software tools for analyzing and managing competitiveness based on the benchmarking principle in order to make decisions on optimizing the company's development strategy in market conditions and crisis phenomena.

CHAPTER 1

THEORETICAL ASPECTS OF ENTERPRISE MANAGEMENT TO IMPROVE ITS COMPETITIVENESS

1.1 The concept of enterprise competitiveness

Such a concept as competitiveness comes first in the management of production and economic activities of any enterprise in the market conditions. For all levels of management, it is relevant and affects each of its levels. The problem of effective management of enterprises in order to increase its competitiveness in dynamically changing market conditions requires an analytical study of existing different points of view of scientists and specialists in order to form a strategic approach to the effective solution of the tasks set in the book. Now, experts do not clearly define the concept of competitiveness, since there are different scientific approaches and ambiguity in relation to what the concept of competitiveness is applied to (in relation to an enterprise, group of companies, industry, region, sector, etc.).

First, we note a number of definitions of competitiveness from the position of well-known scientists. For example, specialists consider the characteristic of competitiveness Bernard I. and Collier J. K. through the concept of competition. Competition, by their definition, is a state when there is a complete, reliable and free relationship between economic entities, in terms of supply and demand for goods and services [7]. Competitiveness is the result of these relationships. Statistical analysis based on a comparison of market actors is very important. The disadvantages of this judgment include the fact that it does not describe how to improve the competitiveness of an individual firm.

Another point of view considers the competitiveness of a product or service as a multi-level concept that is formed at the level of an individual enterprise or company, and then flows to the level of the industry, region, or country. These levels are not identical, but closely related, and sometimes it is

difficult to determine what affects what. According to Andrianov [8], the company's competitiveness is determined primarily by the country's competitiveness. That is, from top to bottom, first comes the country's competitiveness, then goes regional, industry competitiveness, which rests on the product and the producer.

The modern economic dictionary reveals the concept of a country's competitiveness in this way: a country's competitiveness is the ability of the country's economy and the state to participate in international trade, retain and expand certain segments on world markets, and produce products that meet world standards. It depends on the technical and economic development of production in the country, the level of production costs, the quality of products produced, the development of infrastructure, and the presence of relative and absolute advantages [9].

Consideration of the competitiveness of a country, region, industry, and, in particular, a separate company in the domestic and foreign literature is given much attention. Some authors argue that there can be no single definition for such a complex concept as competitiveness. There are only various definitions that depend on the subject or subject to which they relate [10].

The European Management Forum (EMF), an international organization, suggested that the company's competitiveness should be considered as "its real and potential ability to design, manufacture and sell products that are more attractive to the consumer in terms of «price and non-price characteristics than those of competitors»" [11]. Another approach is based on determining competitiveness through the qualitative characteristics of its activities (market share, functional efficiency, managerial efficiency, etc.). In benchmarking concept, the company's advantages (organizational, economic, and technical) in comparison with its competitors are highlighted as key indicators of competitiveness. These advantages are used to reduce costs, increase product quality, upgrade opportunities, extensive production growth, maintain market share, and, as a result, increase profits.

Competitiveness is the main reason for the growth of profits and sales for any company, regardless of its size. The company's competitiveness is expressed through the potential and real ability of the company, taking into account its existing capabilities, to design, produce and sell products in specific conditions that are more attractive to consumers in terms of consumer and cost characteristics than the products of competing companies. Competitiveness can be defined through comparative and competitive advantages. Competitive advantages are scientific, technical and educational

potential, new technologies and innovations at all stages of production and product promotion [12]. For example, you can focus on competitive advantages in the scientific and technical field, which will determine the competitiveness of the entire country, and therefore the competitiveness of all its enterprises. The company's current and long-term competitive advantages are related to the market environment, which reflects and generates incentives, influences market factors, and interacts with social institutions that the company interacts with. Incentives are the signals emanating from the market external environment, for example, competitive pressures, rapid changes, redistribution of the market, etc. Each country and individual enterprise has its own set of incentives. For example, Russian companies have recently been influenced by such concepts as transaction costs, corporate responsibility, and mergers and acquisitions. In addition, competitiveness is influenced by factors of foreign and domestic policy, as well as the factor of globalization of the world economy [13], the processes of international division of labor, dependence on the international financial system, etc. [14]. It is generally recognized that only an innovative way of development can ensure the competitiveness of an enterprise. A characteristic feature is the transition to the era of post-industrial development, where information and the generation of ideas will play a key role. Thus, competitiveness can be determined through social factors, such as the availability of highly qualified employees, their ability to apply their experience in practice, the ability to self-study, etc. The use of new knowledge, skills and abilities will not only reduce the working cycle of the enterprise, labor, labor costs, resource saving, etc., but also, ultimately, will increase competitiveness. Thus, an important factor here is the availability of intangible information resources, which include knowledge, experience, new technologies, computer modeling [15], etc. At the same time, without having a huge capitalization and staff, a modern small enterprise is able to compete with large enterprises of the old model, and that emphasizes the great influence on the competitiveness the factor of innovation. Innovation is the introduction of new technologies in the manufacture of products or services. Innovations can be of an evolutionary nature (more useful product qualities, cheaper component parts of the product) or revolutionary (a new type of product, new characteristics, etc.). Innovations can also include new ways of management, warehousing, planning, logistics, etc. Incentives for innovation are the need to increase the market share of the enterprise, improve the competitive advantages of the product, improve forecasting, etc. It should be noted that competitiveness through innovation can be achieved where enterprises operate legally without the possibility of using corruption schemes, which is proved by the Coase theorem [16]. In addition,

the innovative approach is characterized by goodwill towards competitors [17] or the strategy of «friendly» competition, which is studied in game theory [18].

Often, authors approach the problem of competitiveness through achieving goals in a competitive environment, and the main criterion of competitiveness is understood as the «balance of power» between the company and its main market competitors. It is considered that competition should not be aggressive. In fact, this is the benchmarking strategy that is devoted to. The first step of the strategy is to partner with your competitors. For example, Russian economist Ilyin emphasizes that: «Modern competition of manufacturers is not the destruction of a partner, not the suppression of an opponent in any way. This is highly motivated cooperation and competition in using the best examples of experience and achievements of entrepreneurs» [19].

The transition from Soviet planning systems to market relations led to the emergence of competition and the concept of competitiveness for Russian enterprises. In market conditions, each company needs its own competitive strategy and action plan. It is impossible to create such a plan without evaluating the competitiveness of your company in relation to your nearest competitors and other industry players. Here it is necessary to use the concepts of benchmarking [3], strategic planning [13] and an instrumental model of scenario planning. These tools can provide an accurate forecast for the future for companies that want to compete not only within the borders of a country or region, but also around the world. The introduction of a benchmarking strategy in the process of managing competitiveness allows to combine the process of interaction between competing companies with the processes of modeling, forecasting and decision support to develop an effective mechanism for improving competitiveness. Thus, demonstrating the synthesis of mathematical and algorithmic descriptions of the competitiveness management mechanism with the implementation of the benchmarking strategy and its implementation as a decision-making support system represents the goal of the book.

1.2 System-synergetic approach to the analysis of complex socio-economic systems in the organizational field

Modeling of any processes, structures and communities refers to both universal and specific methods of scientific knowledge that apply objective laws of research in the framework of a system-synergetic approach.

Currently, research in the field of organizational theory is based on the analysis of the form and structure of companies, which, in turn, are considered as open systems. A complex system must have a multi-level and multi-element structure with nonlinear feedback. Corporations and banks that are clearly socio-economic systems have the same set of characteristics as any other open systems. To complex open systems can be attributed the state, the city, any civil and military institutions, unions and association. According to Jay Forrester [20], complex systems have ambiguous responses to external influences. From the point of view of synergetics, small impacts can lead the system to significant results and change the trajectory of its evolution.

Complex systems have specific properties. It should be noted that there is an interconnected structure of feedback circuits that determine the system's response to decision-making. Management decisions represent a sequence of actions that change the state of the system. At the same time, they create new information that must be analyzed to assess the consequences and justify new decisions. The multi-level management process is typical for all types of decisions: public, individual, conscious, unconscious, etc.

The next property is that complex systems have a hierarchical structure of a large order. The order of a complex system is determined by the number of equations that are necessary to describe its states at different levels of the hierarchy. For example, bank organizational structure on several hierarchical levels is represented by staff or employees, bank balance, customer service, banking system, banking operations, equipment, reputation of the bank, the system of relations with the bank, loan portfolio, system of relations with natural and juridical persons, etc.

Complex open systems are nonlinear, so the functions describing them must also be nonlinear. On the one hand, non-linearity ensures that a particular feedback loop dominates for some time. On the other hand, it may happen that the dominant is in a different part of the phase space, where the behavior of the system is so different from the first case that the two regions of the phase space may seem at first look unrelated to each other. In the aspect of synergy, even small changes in the system parameters lead to a considerable change in the system as a whole, which is due to the nonlinear nature of the relationship between the system elements. However, the same non-linearity can provide a system with conservative resistance to management decisions that are applied to change its behavior. In our case, non-linearity allows to model organizational systems with real dynamic characteristics. The interaction of complex systems with each other should be considered in the

organizational field, where the behavior of each individual system is very different from the behavior of simple systems, modeling and analysis of which are quite trivial procedures. The organizational field is a set of organizations that make up the sphere of institutional life [21]. Organizations that exist in the same organizational field, in the process of evolutionary development, become more homogeneous and unified due to their close information interaction with each other. Researchers explain the decrease in organizational diversity by the impact of the external environment (instructions, regulations, legislation), as well as the impact of the internal environment, in particular, from employees who require standardization of wages, labor, and career growth. Unified effective organization models are distributed by consulting services to other enterprises. An organization always has internal factors that stimulate its growth and development, regardless of external factors. Internal factors include the professional qualities of managers, the company's regulated production and business processes and accounting procedures, which allow the company to spread its experience and organizational structure to new regions and markets. However, in the process of evolutionary development of enterprises, the risks of loss of control and loss of feedback increase. This is because organizational structures, being complex systems, do not have time to adapt to dynamically changing market conditions.

The organizational field, like all complex socio–economic systems, includes many factors. In the process of modeling and analyzing the states and dynamics of the behavior of such a system, a comprehensive account of the social, economic, technical and information interactions of its components (enterprises) is required within the framework of the system-synergetic approach. All types of interactions can be considered as a broad aspect of different types of information interactions. At the same time, the possible synergy of types of information interactions, which causes an emergent effect when factors are combined, is often more important than the influence of each of them separately. Therefore, in the process of analysis and modeling, it is unacceptable to consider factors separately from each other, since in this case it is impossible to describe the dynamics of interaction of banking structures in the organizational field with sufficient completeness and reliability.

The system-synergetic nature of the evolution of a complex system means a high sensitivity to changes in only a small number of certain parameters of the order [20], as well as to some changes in the internal structure. Complex open systems are characterized by different internal structures and can have the following organization models: hard deterministic, stochastic,

nonlinear, and self-organizing. In a multidimensional phase space, the system is represented by a point and a coordinate vector of states. The behavior of a point is determined by moving along the phase path. To change the phase trajectory, control actions are used on the parameters of the system, to change which its behavior is particularly sensitive-order parameters. In the phase space, there are also special points of unstable equilibrium, in which even a minor administrative impact of an informational nature puts pressure on the entire system so that its behavior can change in any direction. The purpose of functioning of the socio-economic system is to achieve and maintain its sustainable state. Stability in this aspect means that the system retains its basic structure and the main functions performed for a certain time and under various external influences and internal disturbances.

The order parameters to which the system is sensitive, and the coordinates of special unstable equilibrium points where the system is sensitive, are usually not obvious. For example, in economic terms, there are two groups of indicators that are often used in solving strategic forecasting problems. Indicators from the first group include: dynamics of the company's market share, current market share, current sales volume, sales dynamics, and others that indirectly indicate customer satisfaction with the company's products. Indicators of the second group include labor productivity, profit margin, profit dynamics, operating costs, etc. and reflect the efficiency of the enterprise. To determine and select order parameters, you need to develop a model of the behavior of a particular system, perform modeling, and analyze the dynamics of the system to detect order parameters and special points. As an example, we note the Adizes model [22], which is based on the fundamental law that underlies the functioning of all organizations that go through similar stages of the life cycle and demonstrate predictable and repetitive behaviors. At each stage of its development, any organization is faced with a unique set of tasks that need to be solved. The success of an organization is determined by the ability of managers to manage the transition between these stages. At the same time, Adizes offers not to solve the organization's problems, but to teach the organization to solve its own problems. Then the process of managing an enterprise is the process of achieving results in the short and long term.

Developing Greiner's ideas, Ichak Adizes suggested that the dynamics of organizational development, like the functioning of most physical, biological and social systems, is cyclical. He based this idea on the theory of the organization's life cycles, which is characterized by two components: explaining and predicting. The first contributes to the formation of a sense

of trust, both in the theory itself and in the consultant who uses it. The second one makes you pay attention to issues that are not usually considered by the company's management as key ones. Thus, the theory of Adizes allows to analyze both possible scenarios for the development of the organization, and the prospects for attracting effective managers. We purpose to investigate the dynamics of the organization's behavior through changes in the phase trajectories of development in the phase space, where they can be described in the form of related nonlinear differential equations. This allows to study the dynamics of the enterprise structure, behavior over time, and find the most sensitive of the parameters. To model a complex system, the author proposes a mathematical model that includes a system of equations and inequalities to describe financial and economic processes and phenomena, in order to study and then manage competitiveness by changing the order parameters at special points in the phase space.

1.3 Analysis of methods for assessing and managing competitiveness

In the scientific community, there are different approaches to determining the factors that affect the competitiveness of the enterprise. One approach was suggested by Arthur Thompson and George Strickland [23]. To assess the competitiveness of the company, they proposed such factors as product quality, image (reputation), production capacity, use of technologies, innovative opportunities, financial resources, distribution opportunities (dealer network), customer service. Based on the analysis of the performance of individual enterprises, they also suggested using the relative market share occupied by the company, the ability to exert pressure on suppliers and consumers as criteria for competitiveness. In fact, it was stated that the size of the market share determines the competitive position of the enterprise. Other indicators proposed by David Krevens include competitive advantages, multifunctionality (competitive advantage in different situations), and complexity of duplication [24]. All factors Krevens smashed by three processes: first, the factors related to the internal process, the second to the outer third to two-way. Internal process factors must satisfy consumers, external ones form feedback and are related to the external environment. Two-way process factors provide a link between consumers and the external environment. This approach proves that the market is a complex system with multidirectional high-order processes. However, the absence of a minimum set of functions that describe these factors reduces the value of the model in terms of predicting changes in the company's competitiveness in the future. However, David Krevens also

noted [24] that the company's market share indicates not only its competitive position in the market, but also acts as an indicator of the forecast of future sales.

Jean–Jacques Lambert [26] gives the following indicators of competitiveness: market share, product properties, image, sales methodology, level of technology use.

A comparative analysis of other works on the subject allowed to conclude that competitiveness is mainly evaluated based on two criteria: consumer utility and price. [25]. It is also common to use a comprehensive assessment of product quality and, with some restrictions, the market share occupied by the product, which is functionally dependent on the profit received for the product and the quality of the product. Many authors consider the market share occupied by a product and / or organization and related indicators to be the main criterion for competitiveness [25, 26, 27].

Let's consider the main methods used by the authors to calculate a comprehensive assessment of the competitiveness of the enterprise and products:

1. In the first method, a comprehensive assessment of competitiveness (K) is represented by the sum of: $K = \sum_{i=1}^{N} K_i$

   (1.1),

where K_i is a single indicator of the competitiveness of the enterprise (product) with a total number of N.

As noted by Arthur A. Thompson and A. J. Strickland [25], the company's management should make up a set of key factors and competitive advantages or disadvantages of the company. Then an expert assessment of each indicator is carried out on a scale from 1 to 10 points, the points are added together, and a comprehensive assessment of competitiveness is obtained. A similar calculation is made for the company's strong competitors, which corresponds to the benchmarking strategy. Comparison of complex estimates of your own and competing enterprises can show the advantage or lag of your own enterprise. Next, we consider the criteria by which the company operates successfully, and by which it lags behind its competitors. Relative values that were obtained by dividing the current values of the company's indicators by the possible maximum values, or by the values of this indicator for the most successful competitor, can be used as competitiveness parameters. Then the complex indicator according to

formula (1.1) will illustrate the value of the level of competitiveness in comparison with competitors (benchmarking). The method is quite simple, but it can distort the idea of competitiveness, since the values of indicators may vary, have different effects on competitiveness depending on the time, players, and other indicators.

2. The following approach makes it possible to determine a more accurate complex indicator of competitiveness based on the weighted average of the arithmetic mean: $K = \sum_{i=1}^{N} W_i K_i$

(1.2)

where K_i - is a single indicator of competitiveness with a total number N; W_i is the weight of the i-th indicator of competitiveness.

In practice, the normalized values of the weights of competitiveness indicators are used, and their sum should be equal to one. Then the complex indicator will be measured on the same scale as the individual indicators of competitiveness. This approach is used by scientists Arthur A. Thompson, A. J. Strickland [25].

The method proposed in the works of A. A. Thompson and A. D. Strickland [25] and D. Krevens [24] considers the market share and its dynamic change as indicators of competitiveness. This approach is confirmed by research in the framework of a project of the Cambridge Institute of strategic planning, which showed the relationship between market share and sales volume and the company's profit volume [25]. At the same time, market share can serve as a measure of the accuracy of the above methods for determining complex indicators of competitiveness. Therefore, to assess competitiveness, it is proposed to study the dynamics of the market over time.

Analytical studies of existing approaches to assessing competitiveness allowed to draw the following conclusions. All evaluation methods have a common functional drawback, which is that they determine only individual points of the trajectory of changes in competitiveness in the phase space and do not allow to see the whole picture of the dynamics of changes in competitiveness over time, and therefore do not allow you to make forecasts for the future. The methods do not allow to synthesize and study the dynamic model of competitiveness for a particular enterprise in comparison with the dynamics of competitors ' competitiveness in the framework of the benchmarking process, which does not allow to find out the hidden reasons that affect competitiveness and trends of change under their influence.

1.4 Methods of enterprise management in terms of increasing its competitiveness

Entrepreneurs and owners are mainly interested in the long-term sustainable position of the company, determined by the potential competitiveness of goods and services. Competitiveness depends on the stage of the product's life cycle, i.e. the entrepreneur needs to know the function of changing competitiveness over time. Therefore, graphs of changes in sales or profits for managers are more informative than the numerical values of these indicators for the same period. Let us consider methods of managing competitiveness. In Fagerberg's research method of managing competitiveness [16], the investment mechanism was considered, namely: direct investment in r&d; indirect investment in r&d obtained through the purchase of innovative products and services from local and foreign suppliers; investment in production capital. Research has shown that direct investment is doubly effective in high-tech industries, while indirect investment and investment in production capital are crucial in low-tech industries. It is also found that the competitiveness of large countries is more dependent on internal innovation, while small countries are more dependent on external innovation. At the same time, investing in r&d is more effective than investing in production capital, and the size of the country and the technological level of the industry do not matter. We will call this method of management investment. It should be noted that at present, the interest in this method of management on the part of large corporations is somewhat reduced, since they reduce the intensity of innovative developments. The national science Foundation of the United States has shown that for every dollar invested in innovative development, small firms generate four times more revenue than medium-sized companies, and 24 times more than large firms [29].

Another method of managing competitiveness is the development and implementation of competitive strategies to oust foreign companies from the market and capture their market segments. There is an opinion that competitiveness depends, to a greater extent, on the new market niches that the company occupies. Competition for a small business in a narrow niche can be more effective than chasing the leaders of existing large market niches. This method is defined as niche marketing. One of the strategies of this approach is to bring new products to the market, literally, the next day after the patent protection period for competitive analogues ends. According to Sam Hill's calculations, 32,025 products are offered annually in the United States, 93.3 % of which are an absolute copy of what is already on

the shelves [28]. Although niche marketing is primarily of interest to small and medium-sized businesses, large corporations use their financial, technological, and manufacturing potential to oust weak competitors from promising market niches.

1.5 Benchmarking process as an enterprise management mechanism

In General, benchmarking is a process of identifying, studying and adapting the best practices and experience of other organizations to improve the performance of their own organization in terms of improving its competitiveness [30] (organizations with similar processes in their industry, regardless of industry affiliation, in their own country or abroad). The concept of benchmarking first appeared in the United States in 1972. PIMS, a research and consulting organization, found that in order to find an effective competitive solution, it is necessary to adopt the best practices of other companies that are successful in similar conditions. According to the American consulting company Bain&Co, in recent years, benchmarking is one of the three most common methods of business management in large corporations, along with strategic planning and mission of companies. However, simply identifying differences between your own business and your competitors does not explain how to overcome these differences and achieve a competitive advantage. In this regard, the need for benchmarking should be justified, and the goals of benchmarking should coincide with the strategic goals of the organization [48]. The American company Ernst & Young and The American Quality Foundation conducted a study that showed that benchmarking is effective for companies that are national and world-class leaders, but ineffective for weak companies.

It is natural that any enterprise should first implement a program to improve its activities in terms of reducing costs, increasing sales, gaining new markets, developing new products and services, creating new sales channels, improving efficiency and productivity, etc. before chasing the leader.

However, in order to implement this program, the company must know which areas and functions require changes and improvements. In addition, benchmarking serves for this purpose. Business processes in your own company are compared with the existing best methods of the competing company within the framework of benchmarking. The comparison identifies possible shortcomings that need to be addressed. After identifying

the shortcomings, the task is to develop ideas and find solutions that are adapted to the requirements of your own company so that, thanks to your own developments, you can surpass the best indicators of your competitors. In the future, you should constantly double-check the results of benchmarking in order to maintain and strengthen your superiority. The founder of the production management method, Robert Kemp, defines the benchmarking process [31]:

1. Identification of the benchmarking item.
2. Identification of the benchmarking partner.
3. Defining the method for collecting information and collecting data.
4. Identify discrepancies that are important for competitiveness.
5. Planning future performance indicators.
6. Communicating the results of benchmarking to interested parties and getting help in applying them in practice.
7. Setting specific goals and objectives for improving the company's performance.
8. Development of action plans for their achievement and solution.
9. Conducting planned events and tracking results.
10. Re-checking of benchmarking control points.

The algorithm for conducting benchmarking does not have strict regulations - usually each company develops and adapts the stages of strategy implementation to its needs and often offers its own method of benchmarking project.

The use of benchmarking has many directions. For example: benchmarking in logistics allows to quickly and cost-effectively identify problematic situations in logistics systems. Benchmarking is used in the working out of development strategies and management functions and is considered as a way to evaluate performance strategies in comparison with leading companies to ensure long-term presence in the market. Analysis of the content of the benchmarking process shows that it can be considered as a direction of marketing research. The advantage of benchmarking is that production and marketing functions become more manageable when the best methods and technologies of other enterprises or industries are researched and implemented in your company. Thus, today benchmarking becomes a management mechanism in any socio-economic systems, as it allows you to discover what others are doing better by studying, comparing, improving and applying their methods of work. The goal of benchmarking is to provide a high probability of success of the socio-economic system based on the research. Benchmarking is carried out within the framework of

competitive analysis and is a detailed and ordered function of managing the competitiveness of an enterprise.

According to the concept of benchmarking, any business process must be marked, i.e. it must have several recognizable points by which it is possible, first, to determine how successfully the business process is proceeding, and, accordingly, how successfully the company is working at a given time, and, secondly, to plan the implementation of changes that can track the company's achievements in the field of business processes.

The technology for collecting information for the benchmarking process is often insider activity and industrial espionage. In our case, industrial espionage should be considered as a form of unfair competition, in which the illegal receipt, use or disclosure of confidential information constituting a commercial, official or other secret protected by law is carried out in order to obtain competitive advantages or to obtain material benefits. There is another area of information gathering called competitive intelligence. The main difference between industrial espionage and competitive intelligence is in criminal methods of obtaining information, while competitive intelligence operates within the law. Businesses are more likely to opt for competitive intelligence.

Summing up, we can conclude that benchmarking is actually an exchange of experience between companies. Competitive benchmarking can be considered a driving force in business [31]. Many companies work on the basis of benchmarking, applying the experience of colleagues and considering it as a tool for improving business and achieving competitive advantages.

Well-known mathematical methods are often used to support the process of benchmarking enterprises. Note the method of pairwise comparisons developed by T. L. Saati [32], which belongs to the field of game theory. Game theory is one of the sections of optimization and is used in solving a wide range of problems that lie in the field of economics, sociology, technology, etc. The theory includes a set of mathematical methods for analyzing and evaluating the behavior in a conflict situation in order to ensure the maximum possible gain for one of the parties. The method of pairwise comparisons, as an element of game theory, makes it possible to rank enterprises. In the framework of the method for each factor, establish relevant evaluation. At the next stage, experts evaluate the significance of situations by pairwise comparison. The comparison technique consists of simultaneously presenting two situations to the expert, who must choose the

most significant one among them in terms of its impact on the final results of the activity. Pairs are compared with each other in every situation of every unit. The comparison results are used to calculate the significance coefficients for individual situations.

The law of competition dictates, at least, a pair (interconnected) consideration of economic entities when modeling the competitiveness of enterprises, since the consideration of the model of development of a single enterprise makes sense of the problem of analyzing competitiveness in its dynamic aspect. One of the first paired models of competition is the Bertrand model of price competition in the oligopolistic market [17]. The model describes the behavior of companies in the oligopolistic market by changing the prices of their products. The main conclusion is that the price of the product will be equal to the cost. The result of Bertrand's research is two models of market behavior:

- cooperative model, which implies an agreement in which companies charge a monopoly price and serve their part of consumers;
- competitive model in which firms do not act co-operatively and set the price at the level of their costs. However, in an asymmetric case where one of the firms has lower marginal costs, it can set the price below the competitor's costs and get the entire market.

It should be noted that the Bertrand model is one of the models of «paired» consideration of competing companies of firms and is a prototype of the benchmarking strategy. The disadvantage of the model is its static nature, since the decision-making process is considered at certain points in time.

1.6. Systematic approach to describing the interaction of competing enterprises in the benchmarking process

Organizational field [20], in which there is interaction between companies in the process of benchmarking allows to describe the enterprise as a complex dynamic system with the help of coupled differential equations. All systems are characterized by different internal organization and are divided into hard-deterministic, stochastic, nonlinear, self-organizing. For all systems, stability is an important property, i.e. the system maintains the basic structure and basic functions for a certain time, under external influences and internal disturbances. Stability is an internal property of systems. The mathematical model of a complex dynamic system includes a system of equations and inequalities for describing processes and phenomena that include a set of variables and parameters for the purpose of

its research and management [33, 34]. Norbert Wiener proposed to consider complex dynamic systems in Cybernetics as a set of interacting nonlinear oscillators [35]. Since companies in the organizational field are in constant evolutionary development, it is also possible to apply a similar approach to describing the dynamics of changes (fluctuations) in the technical and economic indicators of competing enterprises [36, 37, 38]

It should be noted that fluctuations in economic indicators are complex due to the large number of interacting factors in real market relations, as well as the presence of subjective factors such as archetypal features of owners and top managers. Despite this, there are certain prospects for using mathematical models to describe real fluctuations and model the dynamics of benchmarking processes [39].

Let's consider a block diagram of competitive interactions to assess the competitiveness of a product produced and sold by a leading company and its competitor in the process of their interaction in the market for the study of the benchmarking process [39] (Fig. 1.1).

For this scheme, assume that any company has the properties of an open self-supporting system. In particular, during the production or purchase of goods at wholesale prices, the product is accumulated for sale, and then the product is transformed into monetary form as a result of its sale. At the end of the cycle, because of feedback, money is transformed into production or product acquisition. As can be seen from the figure, the dynamics of competition depends on external and internal parameters. For example, the company is subject to external influences (investments, costs), as well as random market fluctuations. Fluctuations in economic indicators in the markets are subject to changes that are both regular and chaotic. The study of the nature of fluctuations is necessary for their use in order to predict the main trends in the company's economic activity, as well as to analyze the dynamics of indicators of individual enterprises. For a self-sustaining system model, it is possible to evaluate the dynamics of changes in competitiveness through the functions of influencing the model parameters. We formulate the tasks of enterprise management to improve its competitiveness in the process of benchmarking:

1. Forecasting the dynamics of changes in competitiveness.
2. Evaluation of the dependence of competitiveness on the volume of confidential and ordinary information about competitors received.
3. Increasing the company's competitiveness with the correct organization of the cost strategy.

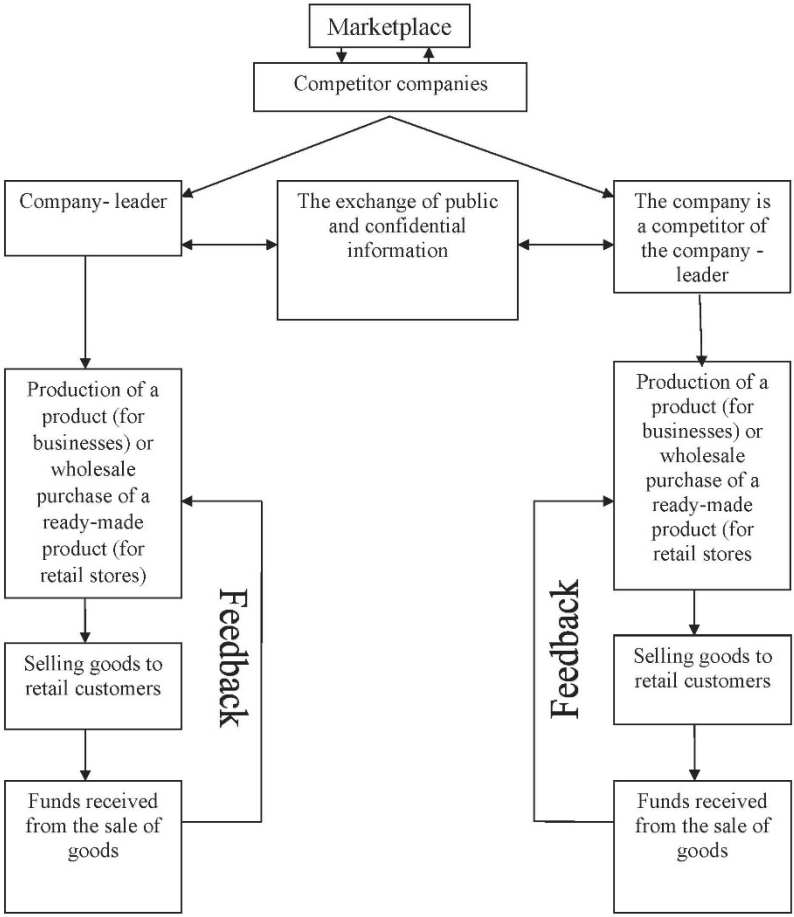


Figure.1.1. - Block diagram of competitive interactions

4. Determining the impact of the size and frequency of investments to improve the competitiveness of the enterprise.
5. Modeling and research of the impact of crisis events on competitiveness in order to develop procedures for improving it.
6. Managing competitiveness depending on market conditions and enterprise development strategies.

Any company that produces and sells products is part of the market, which is a socio-economic system that also has the properties of complex open

dynamic systems. There are random and regular fluctuations in the market, sharp changes in the state, long-term evolutionary trends, delays in implementation in relation to external influences, etc. Thus, the market itself is also a complex system of high order.

1.7. Decision support systems for enterprise management in terms of improving competitiveness

Decision support systems (DSS) are special interactive systems that use computing power, software, databases, and models to support various stages of decision-making in the process of analytical modeling and forecasting of enterprise activities (Fig. 1.2).

Decision support systems (DSS) emerged in the early 70-s of the last century as a result of the development of management information systems and artificial intelligence systems. Advances in information technology have influenced the development of the DSS. Systems of this class are based on artificial intelligence technologies and, as a rule, are not part of integrated enterprise management systems. DSS are systems designed for decision-making in complex, weakly structured situations. The main feature of the decision support technology is the method of organizing the interaction between the person and the system, which results in the development of a management decision. DSS can include situation centers, multidimensional data analysis tools, and other analytical tools. They allow to model business rules and strategies based on unstructured information.

Special mathematical models and methods allow to predict the dynamics of changes in various indicators of financial, economic and production activities, analyze costs for different types of activities, find out the detailed structure and form budgets. DSS can be considered as a powerful analytical system focused on Big Data analysis, performing complex queries, modeling domain processes, forecasting, finding dependencies between data, and performing what-if analysis. It is an interactive application system that provides Decision Making Person (DF) with convenient access to data and models for decision-making in weakly structured and unstructured situations in different areas of activity. The decision making process includes four stages:

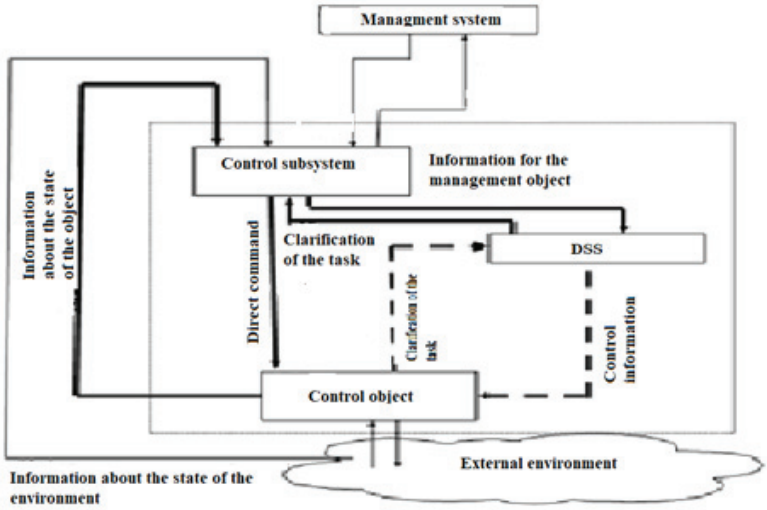


Figure. 1.2. Place of the DSS in the management structure

1. Problem recognition stage. At this stage, the tasks of identifying and understanding the problems facing the company are solved. Corporate information systems that are implemented and used in the enterprise generate a lot of detailed information and can help identify problems.
2. Design stage. At this stage, are synthesized possible solutions to problems using the tools of the DSS. For this stage, small-specialized DSS are most suitable, because they operate on simple models and can quickly develop and work with limited data.
3. Selection stage. It consists in selecting solutions among alternatives. Optimal selection requires processing arrays of data relative to a number of alternatives and the ability to work with complex analytical models to explain costs, causes, effects, and opportunities.
4. Stage of implementation. At this stage, managers can use reports with the results of forecasts for the application of solutions.

The following components are distinguished in the classical DSS:

- information storage of data,

- tools and methods for extracting, processing, and uploading data (ETL),
- operational data processing and analysis tools (OLAP),
- modeling and forecasting tools,
- means of data mining (Data Mining),
- means of visualization of the results,
- user's interface tools.

Decision-making on managing the competitiveness of an enterprise can take place in different conditions, which may differ in the authority of the DF, the area of responsibility, the ability to influence resources, and the ability to change or adjust goals. However, this process is subject to the principles of decision-making, which should include:

1. Analysis of the company's business activities to identify bottlenecks in competitive interactions in the organizational field.
2. Analysis and evaluation of the company's goals in terms of improving competitiveness and determining the need for adjustments.
3. Cause-and-effect analysis of the possibilities of solving the problems of the enterprise in the field of competition with the established restrictions on available resources for the purposes of the enterprise.
4. On the basis of the company's goal in terms of improving competitiveness, tasks for various areas of economic activity are formed.
5. Development of a set of measures by management and production departments for solving tasks and determining the possibility of effective use of financial, production, information and human resources.
6. Development of the enterprise plan for the period under review, taking into account the goals and objectives set by the company's management for the company's services and divisions, or adjustment of the existing plan.
7. Organization of monitoring the progress of planned measures to improve competitiveness, identification of emerging deviations from indicators, assessment of the causes and opportunities for eliminating deviations.

Taking into account the specified tasks, we will form the requirements for the DSS to manage the competitiveness of the enterprise:

- completeness and reliability of the information received;
- timeliness and efficiency of making management decisions;

- conducting analytical work aimed at improving the efficiency of various types of enterprise activities;
- automation of all types of accounting and control.

There are two types of systems that can be distinguished among the many DSSs:

1. Data-oriented systems, which include monitoring systems and data accumulation; data analysis systems; information and analytical systems.
2. Model-oriented systems, which include predictive modeling systems; representative systems; optimization systems; recommendation systems.

Decision support systems have been widely used in the economies of different countries, and their number is constantly growing. DSSs are used in marketing for forecasting and analyzing sales, market research and price dynamics, for project management and performing research and development work, for production management, etc. Most of the DSS functionality is focused on planning, management and development of enterprises, as well as operational management and resource allocation. Let us look at some implementations of the DSS.

1. «Simplan» is one of the first systems whose purpose is to organize support for decision-making stages in financial management, marketing and production procedures. The system makes it possible to study the relationships between different economic indicators of the enterprise. It has seven subsystems: data management, modeling, forecasting, econometric and statistical analysis, report generation, security control, and graphical display of results. The DF can choose the method of econometric or statistical analysis, data forecasting, and use the built-in language to form the modeling process.
2. «Pilot Software» has created a DSS-60 decision-making package that focuses on the areas of risk management and marketing. The system implements operational analytical data processing using multidimensional databases.
3. «Combi-PC» considers various types of products, options for enterprise development plans, events, and performers as objects of analysis. The system database is built as a set of tables. Comparative evaluation of objects and alternative selection procedures is supported by a variety of algorithms and procedures for multi-criteria optimization (the method of comparability thresholds, the

method of paired comparisons, expert and multidimensional classification procedures, etc.). The user can design an algorithm for solving their problem in the form of a sequence of stages or choose a ready-made standard algorithm from the library. DSS allows to solve the problems of assessing the capabilities of the enterprise, analyzing the system of product quality indicators, planning research and design work, and comparative analysis of the activities of enterprises in the process of benchmarking.

4. «DSS-UTES» is designed to find optimal solutions in complex problem models. It allows to connect to perform the individual steps of the solution of tasks of autonomous units and custom models. The system includes the system manager; the subsystem for building a multidimensional utility function; the subsystem for evaluating the results of the model; the subsystem for optimizing the parameters of the user algorithm, etc.
5. «ISDS ISPS» are used by innovation and finance managers to synthesize programs for developing and bringing new products and technologies to market in large companies. The system supports the following functions: pre-selection of proposals for innovative projects; comparative analysis of new proposals and projects that are already being developed; formation of investment projects, etc.
6. «Marketing Expert» provides decision support at all stages of developing strategic and tactical planning, marketing, and monitoring their implementation. The system performs two main tasks: audit of the marketing process and marketing planning using analytical methods (GAP analysis, segment analysis, SWOT analysis, Portfolio analysis, etc.). «Marketing Expert» allows to work through each element in the company's activities. In addition to quantitative methods, the system contains tools for qualitative analysis (expert lists and tools for editing them). The DSS comes in two versions: «Marketing Expert» and «Marketing Expert Professional». The professional version includes a forecasting module with the investment management program «Project Expert» and «Project Expert 6».
7. «Decision Grid» is a software tool for automating the process of matching discrete alternatives based on a number of criteria. Information for decision-making is entered in a comparison table whose columns correspond to alternatives and whose rows correspond to the criteria for evaluating them. At the intersection of rows and columns, an alternative score is placed based on a specific criterion. The system has many features, conditions for evaluating

and comparing alternatives, which improves the quality of decision-making. It is also possible to synthesize DF action scenarios and view the results graphically.

8. «Visual IFPS/Plus» is an interactive financial planning system. The system allows you to solve a wide range of tasks: selection of balance sheet totals, distribution of profits by income items, forecast of changes in exchange rates, risk analysis, development of a sales strategy, selection of research projects, and strategic planning. The system has applications in finance, statistics, and production management.
9. «Specialized» software packages are also widely used for analyzing decisions in the management process: «Aliah Think», «Best Choice3», «Criterium Decision Plus», «Decide Right», «Decision Maker», «Expert Choice», «Straad», etc.
10. «Analytica 20» is a quantitative modeling system. Its capabilities include scenario analysis, synthesis of impact diagrams, multi-dimensional modeling, and risk analysis. The system provides transparency and power of business modeling in terms of creating and analyzing quantitative business models. «Analytica 20» is widely used for the synthesis and research of models in various industries: finance; consulting, healthcare; energy, scientific and technical research, manufacturing; telecommunications; education, etc.
11. «Expert Choice» is focused on using influence diagrams. It is based on a multi-criteria approach to decision-making. The system provides the following features: definition and description of goals, identification of alternative solutions, evaluation of key relationships between goals and alternatives, etc. The System performs pairwise comparisons of enterprises in the benchmarking process to determine the priorities of goals.

CHAPTER 2

DEVELOPMENT OF MODELS AND METHODS OF ENTERPRISE MANAGEMENT TO IMPROVE ITS COMPETITIVENESS USING THE BENCHMARKING MODELING MECHANISM

Modeling of socio-economic systems acts as a special kind of activity that corresponds to the formation of ideas about the future of society, in which the simulated system is embedded and involves the implementation of professional qualities of specialists in solving management problems, taking into account a combination of objective conditions and subjective factors.

2.1 Development of a mathematical model of competitive interaction of enterprises in the process of benchmarking

Modeling of interconnected competing enterprises in the organizational field requires analysis of intra-system relationships and relationships, as well as external relationships. In addition, the modeling process involves selecting and taking into account the order parameters and dependencies that determine the life cycle of the system's evolutionary development, as well as accounting the parameters and dependencies that oppose its development and normal functioning [37, 38, 40]. Developing optimal control mechanisms for such systems is a complex research task. When developing a model, it is necessary to conduct large-scale studies of all components of the system (enterprises, organizational field, and market) in order to set and solve problems of forecasting and synthesis of enterprise development options.

Since competitive interaction between companies occurs in the organizational field, it is advisable to describe the dynamics of their interaction with a mathematical model in the form of nonlinear differential equations [20]. Consider the well - known predator-prey model for describing a biological system [41]. If we describe the system as two types of predators competing for one type of victim, then in fact this process corresponds to the process of

competition between two companies (predators) for market share (victim). From a mathematical point of view, such a system can be described as two related systems consisting of simple differential equations. According to Forrester [20], competing companies are described by equations with nonlinear feedback. Such equations include the Van der Pol system of differential equations [42].

A necessary element in modeling the process of pair competition (competitive benchmarking) is the consideration of a dynamic model with competing elements. The rationale for using the model to describe fluctuations in the indicators of competing companies is their oscillatory nature [35, 36, 43], which can only be described in the framework of second-order differential equations. As shown earlier, the organizational field in which competing companies interact can also be represented as a dynamic system consisting of competing elements. Due to the fact that companies competing in the benchmarking process are autonomous systems, it is advisable to use the concept of a self-sustaining system when going to describe the dynamics of the benchmarking process. For such systems, the system of coupled Van der Pol equations can serve as a formalized mathematical description. Coupled Van der Pol equations have been proposed in radio physics to describe the dynamics of interaction between two electronic generators. Subsequently, they were successfully used to describe and study the mechanism of oscillations in photosynthesis reactions, fluctuations in glycolysis, as well as in modeling the dynamics of chemical reactors [44,45]. It should be emphasized that the coupled Van der Pol equations represent the simplest Ginzburg – Landau chain proposed by the authors to describe the dynamics of nonlinear coupled dynamical systems [48], in which the order – disorder transition modes were first obtained. During the research, it is proved that the dynamics of indicators of competing companies in the process of benchmarking can be described using similar Van der Pol equations, since competing companies have a feedback system that ensures their autonomous functioning. The model of competitive interaction between two companies is shown in Fig. 2.1.

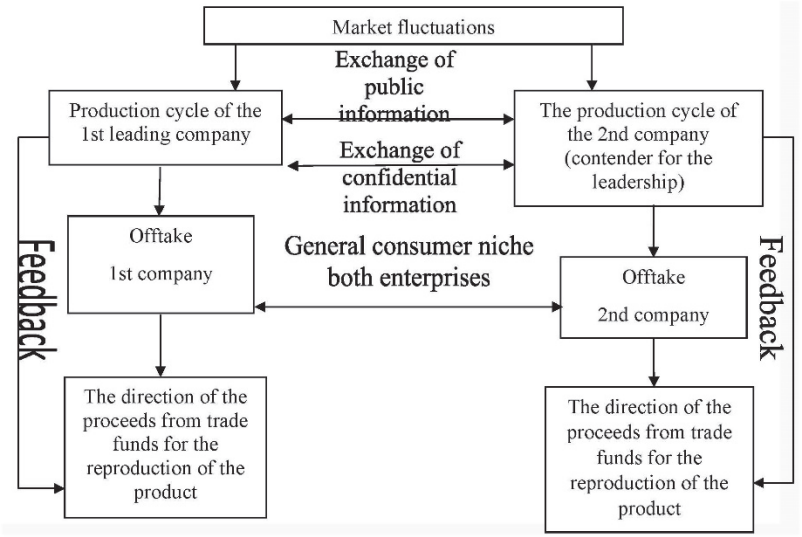


Fig.2.1. The model of competitive interaction between two companies

The process of competition between two enterprises in the process of benchmarking, by analogy with the interaction of two self-sustaining systems, is written in the form of two coupled Van der Pol equations with a time delay that is introduced to stabilize the systems when the parameters change randomly under the influence of fluctuations [50, 51]. Then the system of equations will be [50]:

$$\frac{d^2X_1}{dt^2} - a_1(1-Z_1)\frac{dX_1}{dt} + \omega_1^2(1+k_1X_2)X_1 = c_1\frac{d^2X_2}{dt^2} + r_1F_1 + d_1F_3,$$

$$b_1Z_1 + T_1\frac{dZ_1}{dt} = X_1^2,$$

$$\frac{d^2X_2}{dt^2} - a_2(1-Z_2)\frac{dX_2}{dt} + \omega_2^2(1+k_2X_1)X_2 = c_2\frac{d^2X_1}{dt^2} + r_2F_2 + d_1F_3,$$

$$b_2Z_2 + T_2\frac{dZ_2}{dt} = X_2^2,$$

(2.1)

Here X_1,X_2 are variables that reflect the economic indicators of companies ' development (dynamics of net profit, dynamics of gross profit, dynamics of EBITDA, sales volume per unit of time, etc.). a_1,a_2 are values proportional to the normalized specific number of employees per 100м^2 (average annual specific number of employees/100м^2. For example, if 100м^2 of the company's retail space is taken as a unit, and the change in the number of employees is 20%, then the coefficient values a_1,a_2 will be equal to 1.2). Variables Z_1,Z_2 reflect the efficiency of the distribution center of the enterprise over time. Efficiency is defined as a function proportional to the average value of the company's daily inventory. The equations containing the variables Z_1,Z_2 describe the function of the distribution center as a buffer (compensator for demand surges) of the main functions X_1,X_2. In various situations, the dependence of functions X_1,X_2 on functions Z_1,Z_2 is nonlinear. The values T_1,T_2 are constants proportional to the average rate of change in inventory, varying in the range from 0.1 to 2, which are determined when setting up the model for a particular company and depend on the intensity of its distribution center. They also depend on whether the described company is a leader in a competitive pair or a contender for leadership (the turnover of the leading company is higher than that of the applicant company). Values b_1,b_2 are indicators that are proportional to the normalized turnover per unit area of the first and second companies. The parameters ω_1,ω_2 are the inverse values of the turnover time equal to the annual or monthly periods. Coefficients r_1,r_2 are constants proportional to the companies ' capital expenditures. The average annual CAPEX (capital expenditure) for a particular company is taken as a unit, and its percentage change is taken as a fraction of the unit. For example, a change of 20% will be as + of the main value equal to one, the Functions F_1,F_2 represent the exponent in the degree of sine and display the resonant influence of the CAPEX value on the system solution. The d_1 coefficient is equal to one thousandth of the average annual net profit (or other final economic indicator) of the main competitor considered in the model of companies in other countries. The mathematical order of the coefficient data is defined in the work of Benzi and Vulpiani [51] as the minimum noise amplitude required for stochastic resonance in bistable systems. The economic rationale for the d_1 coefficient follows from the following considerations. Let the market share occupied by the main competitor be approximately 10% for a specific year, and the market share of the largest domestic retailer is 0.3%. Thus, the value of the coefficient d_1 for the function of stimulating noise F_1 in the market (chaotic fluctuations) will be about one thousandth due to the influence of damping market fluctuations. The random function F_1 represents an exponent in the degree of sine with a random phase and is

characterized by the awareness of competing companies about each other. Both companies in the market are linked by the availability of information about each other. Two types of information differ. The first type is informal information, which includes all confidential information of the company: its plans for the release of a new or modified product, credit and personnel policy, information about hidden state support, etc. The second type is formal or publicly available information that can be obtained from the media, from company websites, advertisements, opinions of ordinary customers, etc. the coefficients k_1,k_2 determine the degree of ownership of confidential information about each other. They can be normalized according to the company's store traffic, the maximum indicator is taken as one, and the indicators of other companies are taken as a percentage of it. The coefficients c_1,c_2 show the degree of daily awareness of companies about each other.

Thus, the model shows that the dynamics of indicators of an individual company in the dynamic structure of the market depends on similar parameters of competing companies that produce similar products. This fact allows to consider the model of each company within the framework of benchmarking – that is, in an integral relationship with the companies interacting with it. Under the proposed model, competitiveness can be defined as dynamic form changes of size, proportional to the amount of sales, net profit or other indicators received for a certain period of time by the company with a competitor, who is either a leader or a follower in terms of the benchmarking process. In addition to the competitiveness of companies, the model can take into account costs, investments, market fluctuations, and other external factors.

It should be noted that a similar system of equations was studied by Theodorchik K. F. [42], Ginzburg V. L. and Landau L. D. [48] and other researchers [52], but the lack of powerful computing tools and information technologies did not allow it to be investigated properly, in particular to investigate the influence of random fluctuations. At the same time, as a result of studies of the system of coupled Van der Pol equations with a time delay, carried out by Ginzburg V. L. and Landau L. D. [48] and Philip R. S. [53], it was possible to determine the boundary values of the coefficients of the system (2.1), within which it has stable solutions. At the same time, it should be noted the fundamental significance of the work of Yudovich V.I. [54], who proved the analogy between the Van der Pol equation with a time delay and the Lorentz system [55], proving the possibility of the influence of random functions on systems described in the framework of the Van der Pol equations with a time delay. The system of equations was implemented

in the «Mathematics 5.1» packet [56]. As a result of modeling an innovative and instrumental model of the mechanism for improving the competitiveness of enterprises associated with the benchmarking process, the following conclusions are made:

1. Within the model, the benchmarking process can be formalized using a system of two coupled Van der Pol equations.
2. The strategy of time-stretched periodic investments is more effective in influencing sales than the strategy of single big investments.
3. High costs (more risky) can lead to a drop in the level of competitiveness, while low costs can lead to a stabilization of its level.
4. Under the same initial conditions for a single (non-paired) company and paired companies, their potential market share will be different. The simulation showed that the share of the potential market occupied by a single company is less than that of paired competing companies interconnected through benchmarking. This is because a single company, especially a regional one, does not seek to enter other markets for fear of not sustaining expansion, since this requires additional costs. In turn, competitive companies have to combine organic growth with expansion into other markets, which makes it possible to take a much larger part of the market than companies that are afraid of competition.
5. In the initial period of the economic crisis, in order to increase the competitiveness of the product produced by the company, the most effective external assistance when it is provided periodically, in accordance with the internal production rhythm.
6. In times of crisis, when companies stop operating, the main factor affecting the resumption of commercial activity is the revival of the market, especially the activity of small and medium-sized enterprises in the presence of state support.

The study of the model confirmed the fact that chaotic fluctuations play a major role in the market system [39]. That means that chaos can be not only a destructive factor, but also an engine of restructuring for the appearance of a more complex form of order. Market chaos should be considered as one of the most important factors in the modernization of enterprises, when they are exposed to chaotic external fluctuations [57]. On the other hand, chaos is an essential feature of a market economy. It encourages the emergence of a variety of products on the market, services, ideas, innovations, information, cultural and social values. For example, there is a method for analyzing trends in the development of situations in the securities market, based on

the chaos theory. Its development was facilitated by the founder of the method, Bill Williams [57]. The method has a base in the form of a nonlinear approach, where the essential role is played by intuition, the experience of a trader using a method based on the chaos theory. It can be concluded that the influence of chaotic market fluctuations does not have a significant impact on competitiveness, since complex market dynamics always have chaotic fluctuations over time (Fig.2.2).

2.2. Methodology for modeling the benchmarking process for assessing the competitiveness of enterprises

The system of the organizational field, within which the competition process of these companies is studied, is considered from the point of view of the system-synergetic approach. It is known that the socio-economic systems that companies belong to are sensitive to changes in a small number of order parameters and to some changes in their organizational structure. So, the main tasks of decision support in managing competitiveness are:

1. Evaluating the strengths and weaknesses of companies in the framework of benchmarking;
2. Evaluating the dynamics of companies ' development using graph analytic methods in order to identify the causes of existing trends;
3. Forecasting the financial and economic situation of companies based on the identified trends in the behavior of companies in a competitive environment;
4. Synthesis of alternative scenarios, their evaluation based on simulation modeling within the scenario analysis method, and selection of suitable scenarios for making decisions about applying the most effective competitive strategy of the company in the market;
5. Formulation of recommendations for decision makers to improve the company's competitive position in the market.

Let us consider a methodology for modeling the benchmarking process for predicting the dynamics of changes in the competitiveness of companies based on the proposed mathematical nonlinear model in the form of a system of related Van der Pol equations with a time delay. The method is implemented in the predictive modeling module for various scenarios of companies ' behavior in the market, synthesized in the module for generating scenarios of the automated competitiveness management system. The method includes following stages [58]:

Stage 1. At the first stage of the developed method, the most significant order parameters are selected. For this purpose, the mechanism of expert assessments is used [35] based on the existing experience of similar studies [3, 49]. As a result, the following order parameters were selected as input data and the main factors influencing the modeling and forecasting process: capital expenditures, turnover per unit of retail space, and the number of employees per 100 square meters of retail space. The coefficients of the model are assigned to these factors, respectively $r_1, r_2\ b_1, b_2\ a_1 a_2$.

Stage 2. Synthesis of an instrumental mathematical model scheme with initial coefficients for modeling the benchmarking process and predicting competitiveness

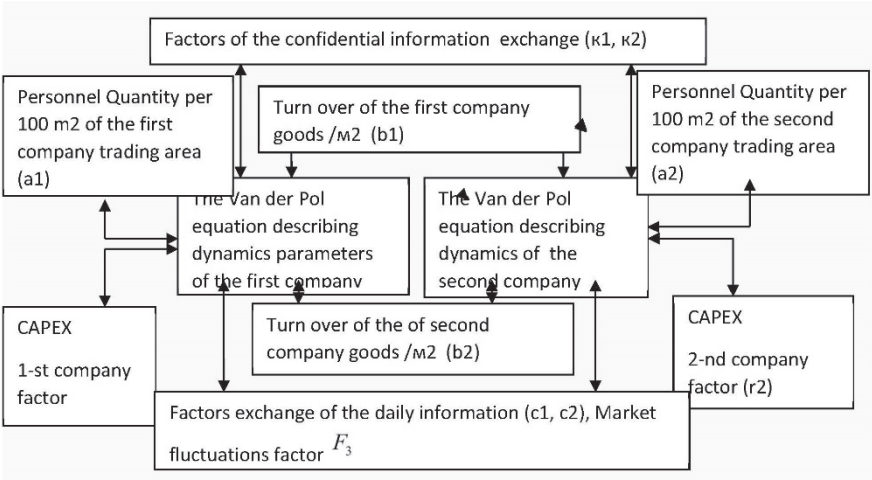


Fig.2.2. Model of competitive interaction between two companies

Stage 3. The next step in modeling and forecasting is to build graphs of the dynamics of indicators based on tabular data that reflect the competitiveness of companies. These parameters include the number of sales per unit of time, net profit and EBITDA per unit of time, revenue per unit of area, etc. Data is entered into the mathematical model in the form of initial conditions [59, 60].

Stage 4. Further, the mutual awareness of competing companies about each other is evaluated based on their daily information obtained from open sources and confidential information obtained through industrial espionage or insider activity. For modeling, assume that the mutual awareness

coefficient based on confidential information k is a constant. Let it be 0.7 for the leading company in the benchmarking pair, and 0.3 for the competing company. We will also set the coefficient of market fluctuations. It is known that for a normally functioning market, it is usually assumed to be equal to 0.01 – 0.001 [61].

Stage 5. The next stage is a computer study of the model and plotting the current and forecast dynamics of the company's competitiveness parameters depending on the initial data.

Stage 6. Comparative analysis of the obtained model graphs with graphs based on tabular data. If the graphs are very different, you can configure the source data and coefficients and run the simulation again.

Stage 7. The iterative process continues until the maximum approximation of the model and actual data is observed. The iterative process of setting up a model is the process of learning it. After the training procedure, the model was ready to synthesize predictive estimates for various time intervals and initial parameters.

Stage 8. At this stage, predictive modeling of the company's net profit dynamics is performed.

2.3. Managing the activities of scientific and technical enterprises to improve their competitiveness in the benchmarking process

Based on the results of mathematical modeling, a method of decision support for managing the competitiveness of enterprises was developed. The method allows to analyze and evaluate various scenarios for modeling competitive interactions for selected pairs of enterprises in the benchmarking process. Scenarios are defined by sets of values of input factors to assess their impact on the dynamics of changes in the company's competitiveness indicators. Based on the analysis of scenario decisions in the framework of the methodology, the decision-maker selects the optimal scenarios of the company's behavior in the market and the required values of production and economic activity indicators to achieve competitive advantages, which also allow synthesizing and storing expert recommendations in the future.

The method is implemented using the developed decision support tools and allows to:

a) Perform research and evaluation of the company's strengths and weaknesses as a part of the benchmarking process;
b) Conduct a comparative assessment of the dynamics of companies ' development using a graph-analytical method in order to identify the reasons for the divergence of existing trends;
c) Get a forecast of the financial and economic situation of companies based on the identified trends in the behavior of companies in a competitive environment;
d) Synthesize alternative modeling scenarios for different market situations;
e) Perform modeling of enterprise behavior in the benchmarking process of competitive interactions;
f) Get an assessment of the simulation results using the scenario analysis method;
g) Choose the best scenario for making decisions about applying or developing an effective competitive strategy;
h) Select or develop recommendations for improving the competitive advantages of the enterprise for DM in the expert tools;
i) Monitor the activities of enterprises after the implementation of control actions with modeling and evaluation of their competitiveness after the implementation of recommendations.

To support decision-making in managing the competitiveness of enterprises, experts propose well-known strategies and individual measures to improve competitiveness in order to achieve a steady and stable exponential growth of the company's financial and economic indicators in comparison with the selected competitor. The method allows to analyze and evaluate different scenarios with different sets of input parameters that affect the dynamics of changes in profits and other indicators based on obtaining forecasts in the short and medium term (up to 3 years), then comparing and selecting scenarios with the most optimal forecasts. On the basis of selected scenarios and existing standard templates with recommendations for changing the business strategy, which are accumulated in the knowledge base, experts create a set of measures to increase the competitive advantages of a particular enterprise and offer the DM (management and owners).

In the future, when implementing practical recommendations, data is periodically collected on the actual change in the main indicators for comparison with the forecast ones and the model is adjusted if there is too much discrepancy between them. The market situation is also monitored for timely detection of new competitors or changes in strategies of competing companies. New data about old competitors obtained as a result of

monitoring is entered into the model, and predictive modeling is repeated to modify and radically change the business strategy of the company. When a new competitor appears on the market, it is necessary to build a predictive model to assess the interaction between the enterprise and this competitor.

Consider an example of solving the problem of modeling and evaluating competitiveness for a small scientific and technical enterprise Spl-lab (Moscow), where the method was introduced and tested [39 ,62]. The average annual turnover of the company is about 4-5 million rubles. Prior to the implementation of the decision-making methodology, Spl-lab's sales volume was quite low (one or two devices per month), due to the presence of a competitor on the market-the American company Term – lab [63]. This competitor was selected as the leading benchmarking partner for comparison with Spl-lab, forecasting and analyzing this pair for synthesis and selection of recommendations for DM in order to increase competitiveness. Using the methodology and tools for decision support and competitiveness management, Spl-lab has developed a mechanism for increasing average monthly sales by [7, 39]:

1) increasing the level of ownership of confidential and everyday information about a competitor;
2) the organization of a subsidiary in order to model the process of paired internal benchmarking with the main company for the selection of the initial coefficients of the model of sustainable and stable increase in competitiveness.

Scenario analysis and predictive modeling tools based on the developed model were used to select competitive management mechanisms. As a result, forecasts for increasing the company's profit under various conditions and initial data were obtained. From a variety of alternative options with different sets of factors affecting the company's profit, two factors were selected that in this case had the maximum degree of influence on the dynamics of changes in net profit and, accordingly, could lead to profit maximization when selecting the correct values. Using experiments on a mathematical model with different values of these factors, the required values are determined, measures are selected and proposed for the DM to achieve these values by the enterprise in order to increase the level of average monthly sales. To estimate the increase in sales, a function is derived depending on the degree of information ownership [39]:

$$K_2 = K_1\{a_1, a_2, b\} \quad (2.2)$$

where - K_1 is the average monthly number of sales made by the company for the previous year K_2 is the projected average monthly number of sales of the enterprise for the next year a_1 is the utilization of daily information about a competitor, changing from 0 to 1; a_2 is the ratio of possession of confidential information about a competitor; varying from 0 to 2; b – coefficient of innovative knowledge company for the current period, varying from 0 to 1.

This feature allows to predict an increase in the number of average monthly sales by obtaining confidential information about innovative methods used by a competing firm. Table 2.1 shows the results of the company's work in 2013-2015. In order to improve competitiveness in 2014-2015, a method of decision support for managing competitiveness was introduced, which was used to select factors that affect sales and profit, and offer recommendations for improving competitiveness. The increase in sales volume in percentage for the initial year 2013 (this is the year of operation without using the methodology and tools and implementing the recommendations of the DM) was taken as a unit. Over the next two years, using the method, a stable increase of about 150% was obtained relative to each previous year.

As the first recommendation for improving the company's competitiveness, the company's management was asked to organize a spin-off subsidiary [10] from among its employees in the region and perform predictive modeling of the main and subsidiary company pair, comparing them in the framework of the benchmarking process [62, 63]. The subsidiary branch was proposed to be located in an area where there is an increased demand for devices manufactured by the company.

Table 2.1. Dynamics of sales volumes for 2013 -2015

Month/year	01/13	02/13	03/13	04/13	05/13	06/13	07/13	08/13	09/13	10/13	11/13	12/13	**% growths profits**
Sales volume (units)	1	1	2	4	13	26	7	6	25	4	14	14	**1%**
Month/year	01/14	02/14	03/14	04/14	05/14	06/14	07/14	08/14	09/14	10/14	11/14	12/14	**% growths profits**
Sales volume (units)	20	37	9	20	25	11	4	21	3	14	7	11	**156%**
Month/year	01/15	02/15	03/15	04/15	05/15	06/15	07/15	08/15	09/15	10/15	11/15	12/15	**% growths profits**
Sales volume (units)	11	67	35	14	50	8	26	35	36	18	19	50	**315%**

In the process of studying the mathematical model of competitiveness, a formula was developed for estimating the increase in the number of average monthly sales for an enterprise [39]:

$$K_2 = a_3 K_1 \quad (2.3)$$

where – K_1 is the average monthly number of sales of the enterprise for the previous year, - K_2 is the projected average monthly number of sales of the enterprise for the next year; - a_3 is the coefficient of increase of sales due to realization of devices using the regional branch of the (changes in the range from 2 to 3 depending on the ratio of the number of employees of the branch to the number of employees of the main enterprise).

In particular, a forecast was made for an increase in the number of average monthly sales by Spl-lab in 2015 compared to 2014. The forecast value of the average number of sales was 29, which is 6% different from the actual value of actual sales in table 2.1. Thus, the event to create a branch allowed to increase the number of sales by 2 times.

The next recommendation to increase sales for the company was to organize a strategy for reserving devices with determining the optimal amount of the necessary reserve. This is necessary, because according to expert estimates, due to the lack of goods in stock, any company can lose up to 10% of annual revenue on average [64].

Another event developed for the company in terms of sales promotion was the formation of closer information interaction with the main partner in benchmarking.

In order to obtain forecast estimates, the developed mathematical model introduced coefficients that characterize these events and made a forecast of the competitiveness dynamics of the devices manufactured by the enterprise for 2014 and 2015. The results of predictive modeling of the enterprise, which demonstrate a steady increase in the competitiveness of devices manufactured by the enterprise in the future, are shown in Fig 2.3.

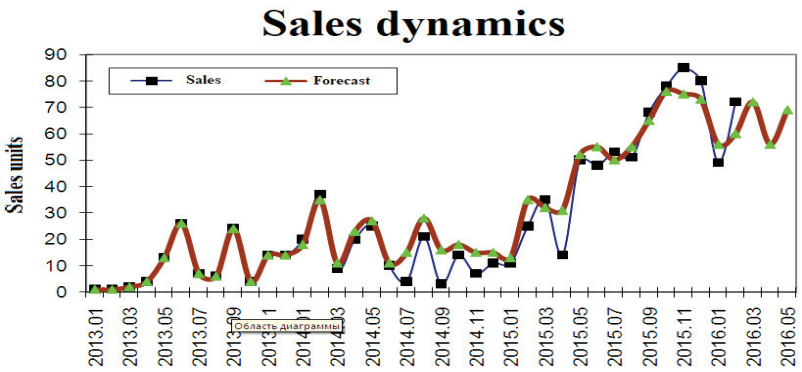


Fig. 2.3. The real and forecast dynamics of the sales of Spl-lab

As a result of research conducted on the predictive model and decisions on the implementation of the recommendations proposed by experts, sales at the end of 2015 actually increased by 3 times, and the average monthly profit increased from 100,000 rubles (2013) to 5,20000 rubles (2015). Recommendations and measures for managing production and economic activities to improve its competitiveness can be applied to other similar enterprises.

Let us take a closer look at the event aimed at improving information interaction between a pair of enterprises united in the model through benchmarking. At the initial time, the leading competitor in the domestic market-the American company Term - lab, which produces similar products, was selected as a pair for the Spl-lab enterprise. In the original mathematical model, only one-way information communication was taken into account between them through everyday information in the open access (on websites and in advertising brochures) about products. At the same time, the American company (due to the fact that it considered itself a monopolist in the market) was almost not interested in competitors and, of course, the Spl-lab company. Therefore, in the model, the corresponding coefficient for the Term-lab company was close to zero (equal to 0.05), while for the Spl-lab company it was set to 0.8. As one of the recommendations, it was proposed to strengthen the information link with the Term-lab competitor by placing ads for the Spl-lab company in English and creating an English-language version of the site. It was also recommended to introduce the practice of constantly informing the Term-lab company about the details of its products with some false information polls showing its non-

competitiveness. For this purpose, we used address - based spam mailing and delivery of advertising products to the competitor's offices.

The first period of an information attack on a competitor falls in the first half of 2014, which is reflected in the Fig. 2.3, as a period of fluctuations in sales with a gradual swing in the amplitude of fluctuations in the value of sales. As a result of the implementation of recommendations and information attacks, in the winter of 2014-2015 there was a sharp increase in the average sales level of the company Spl-lab. The results of predictive modeling, confirmed by actual sales, proved that increasing information exchange through managing information impacts on a competing company allows increasing the sales dynamics of a weaker firm, which confirms the correctness of the benchmarking strategy and implemented recommendations. In the mathematical model, this is reflected by increasing the corresponding coefficient to the same level (0.8) for both companies. Thus, predictive modeling shows that the policy of aggressive information interaction with a competitor through information attacks is necessary to increase the competitiveness of an enterprise [39].

Next, consider another event. The management of Spl-lab was recommended to create a regional branch in the region where the demand for the products was greatest for the competitor. Moreover, the branch had to be modeled as an artificially created competitor during the research process, which is linked through the benchmarking process to the main company. The method of predictive modeling is applied at the first stage to the benchmarking pair "enterprise – regional branch" for various scenarios of behavior of the head enterprise and the branch. Since all information about the branch is known a priori, setting up a mathematical model and selecting the optimal values of the coefficients is not difficult compared to a real competing company, which has only an open information. This makes it possible, under certain market conditions, to make a forecast for various scenarios of the branch's behavior in the regional market in order to determine the necessary indicators that the branch must have for its most successful entry into the market. In the future, to correct the input indicators of the enterprise, the competitive pair is changed to the branch-competitor pair, a new mathematical model is created and performs predictive modeling within the real benchmarking process in order to correct the model and select the input indicators of the branch that will allow real competition.

Predictive modeling of the first pair showed that for a successful first entry into the regional market and displacement of the main competitor, it is necessary to apply a discounted business strategy at the first stage. For this

purpose, devices manufactured by a branch of the Spl–lab enterprise must use inexpensive cases made of cheap plastic, which allows selling products cheaper than similar equipment produced by a competitor. The results of predictive modeling showed that the competitiveness of Spl-lab using such a strategy will grow exponentially over four years, which was confirmed by actual indicators.

2.4. Algorithm for predicting enterprise competitiveness indicators in the benchmarking process

Tested in practice mathematical models and a method for managing competitiveness allow to make an assumption about the universal nature of the proposed innovative tools. For this purpose, the following sections of the book present the results of synthesis of mathematical models, experimental studies of practical approbation of the method using a software and tool complex for financial and credit organizations, industrial enterprises and large retail retailers of the domestic market. The universal nature of the standard mathematical model makes it possible to use it in the educational sphere for training specialists in the field of management and decision-making.

However, before conducting experimental studies, it is necessary to develop an algorithm for predicting the dynamics of changes in the competitiveness of enterprises based on mathematical modeling and analysis to synthesize the recommendations of the DM, which is part of a comprehensive decision support methodology for managing the competitiveness of the enterprise. The algorithm has a universal character and is used for various companies that may differ from each other by type of activity, property, and economic status [65]. The algorithm includes the following steps:

Step 1. Select pairs of companies that can be compared within the benchmarking process by comparing their performance and current market position based on data collection and monitoring of companies ' performance over the previous time period. Benchmarking should be established between companies that compete most closely with each other in the market. Although the accuracy of the forecast increases when the monitoring period increases, the practical application of the model has shown that it is sufficient to use the previous doubled period of operation of companies compared to the forecast period.

Step 2. The choice of at least three factors for the compared companies, which, according to experts, have the strongest impact on changing its

competitiveness. Competitive comparison must first take into account the factors that make one of the companies the leader, as well as the factors that make the other company (the applicant for leadership) can catch up and overtake the competitor.

Step 3. Define the business parameters that will be compared in the model and for which the forecast will be performed. First, these should be the final indicators of the company's core business. They can be expressed both in absolute values and in normalized (percentage) values. Using the method of expert assessments, it is necessary to rank these parameters, where the coefficients of amplification/attenuation of the influence of each parameter on the simulation results are selected and the parameter's place in the system of equations is determined.

Step 4. Plotting the dynamics of actual indicators before predictive modeling, based on the selected parameters that will be used as initial conditions in the future.

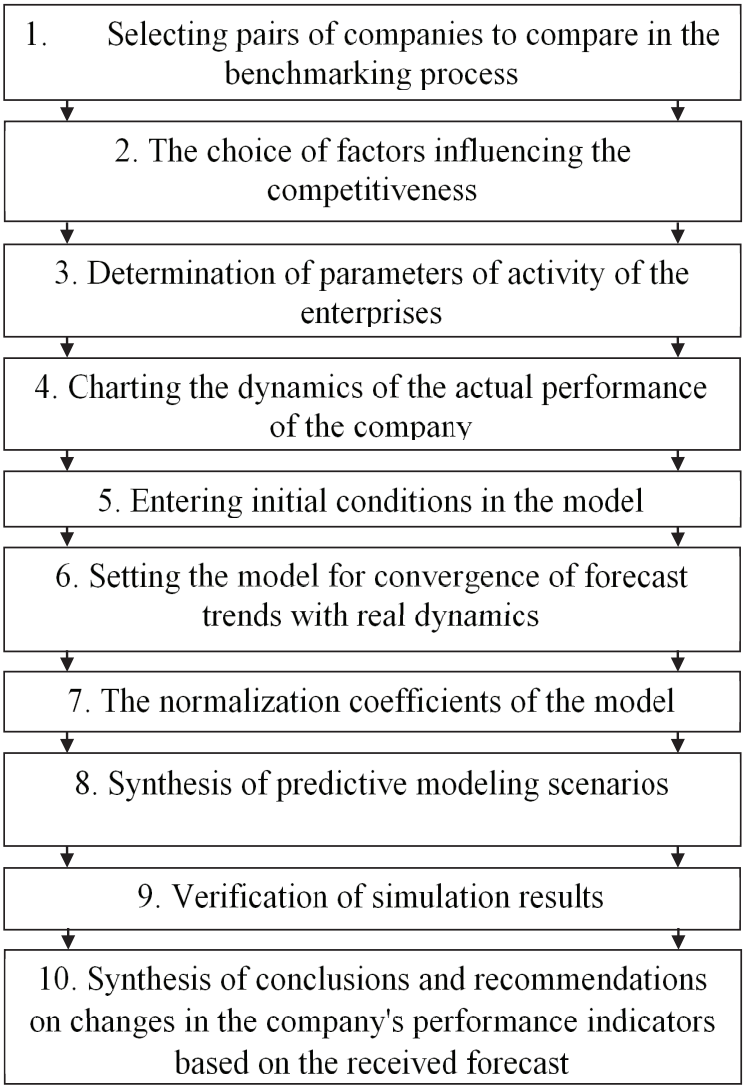


Fig. 2.4. - Block diagram of the predictive modeling algorithm

Step 5. Enter initial conditions in the model as nominal values of the same dimension as in the actual graphs. To determine a complex trend, it is advisable to enter initial data that corresponds to the data in the actual charts.

However, if the purpose of the simulation is only to determine the position of a point on the graph at a specific time (the forecast value of the indicator), then you can enter data for the last actual year as initial conditions. Experience with the model has shown that fairly accurate results (with an average error of 6.5%) can be obtained in the short term with a forecast horizon of up to two years.

Step 6. Fine-tuning the model to ensure that forecast trends converge with an existing actual trend in the retrospective part. Since the method of expert assessments has an error and not all parameters of influence can be taken into account (for example, not including a political influence factor in modeling the development of banking structures), then several modeling procedures are required to correct the model parameters. The experience of experimental and practical application for 87% of pairs showed that in general, at least 5 (in general, from 3 to 8) iterations of modeling are necessary, from which you can choose the most optimal variant of setting the coefficients. A more accurate setting will show the best predictive result at the output, regardless of the forecast horizon (short-term up to 2 years, medium-term-2-5 years, or long-term-over 5 years). For fine-tuning, the model coefficients are selected empirically. The task of coefficients is to increase or decrease the degree of influence of various parameters and factors on the results of modeling. For example, in the right part of the equations, there are coefficients that are responsible for random and non-random external conditions. Their task is not to let the strong nominal values of these functions destroy the model, but their effect must be artificially weakened, showing that the effects of external factors, although important for the model, do not have a direct impact on it. For example, a reduction factor of 0.01 in the model for the parameters on the right side of the equation shows a weakened market impact on companies. This is due to the fact that the market cannot influence companies with the same force and its influence in general will be weaker than the influence of a direct competitor. In addition, there are coefficients that are on the left side of the equation. For example, the coefficients of parameters that are responsible for the impact of the number of employees on the company's turnover. Parameters from the left side of the equation affect the system more than from the right side. Thus, by changing the coefficients, you can rank parameters by the degree of influence on the results, which allows to formalize the influence of factors on the management of the competitiveness process.

Step 7. The normalization coefficients of the model. It should be noted that the parameters differ from each other and are responsible for the formation of different processes. Therefore, the researcher faces a complex problem

of evaluating the compatibility of different indicators. Let us say we are faced with the task of forecasting net profit for a particular company, but in order to make a relatively accurate forecast, we need to insert only those factors that most strongly affect the dynamics of profit into the model. For example, net income is strongly influenced by the company's debt obligations, loan repayments, the company's capital investments based on borrowed funds, rebranding expenses, and so on. As already mentioned above, the initial conditions are taken in nominal values, that is, in such terms as they are expressed in official reports, for example, in rubles. However, factors may not always be expressed in actual units. For modeling, it is more correct to take the normalized value of indicators rather than the nominal value, since the nominal values of the parameters (especially from the right part) may be quite small compared to the initial data. For example, if the company's revenue is measured in hundreds of billions of rubles for a large company, then capital expenditures or other factors may be much lower, but the extent of their impact on profits can be huge. Consider an example of normalizing the model coefficients for capital expenditures. To normalize the actual schedule, the average annual growth value of the CAPEX indicator is calculated, and then the value is normalized for each of the companies and entered into the model. Further, the values are consistent with other variables and coefficients, and through several modeling procedures (an average of five), the model is adjusted to the optimal response with respect to this parameter. Then similar procedures are performed for other parameters.

Step 8. The next stage of forecasting is the synthesis of predictive modeling scenarios based on actual data. In the previous stages, the model is configured for a specific company and its dynamics under certain set parameters and initial conditions. After selecting the coefficients and setting them for a specific pair of enterprises, you can consider forecasting scenarios. The forecast scenarios are divided into 4 groups: optimistic, pessimistic, optimal, and hypothetical. Let us look at the scenario. The optimistic scenario is to model the company's activities in the best possible light for it. It is assumed that the company has already found the most optimal strategy that fully corresponds to its current position, and is developing organically according to an exponential development scenario without hesitation. It is also assumed that its competitors do not exert significant influence, do not conduct aggressive policies, and do not have their own successful strategy. This «ideal» model is needed to show the company's potential, if it does not make strategic mistakes and the competition process itself is almost leveled.

The opposite pessimistic forecast is characterized by the concept of «everything is bad». There is the most aggressive strategy of the competitor, and the company does not actually have a strategy that corresponds to its position in the market. The company's development schedules are clearly fluctuating. A pessimistic forecast may correspond to the actual performance of the company, if the company does not change a clearly unsuccessful strategy.

The optimal forecast should represent the real behavior of the company in the market as much as possible, taking into account both the existing dynamics and the planned ones. In fact, the optimal forecast is the forecast that should coincide as much as possible with the actual dynamics of changes in the company's indicators. It is the most complex, and the most problematic part is forecasting the behavior of the external environment (market). If the growth rate, development algorithm, and company plans can be obtained by collecting data and monitoring, it is impossible to predict the impact of the external environment. However, it can be represented as a sum of random functions with coefficients.

A hypothetical forecast allows to obtain simulation results for a set of indicators, external factors, and market fluctuations that should not be present in real market conditions, but that can hypothetically manifest under certain external conditions. An example is the current situation in the domestic market, which was significantly influenced by external political factors. The impact of these factors before 2014 could only be considered in hypothetical predictive modeling scenarios.

Step 9. Verification of predictive modeling results. This step is implemented after the actual data for the parameters under consideration is received. Depending on the parameter value, various errors are allowed. The most frequently considered parameters for retail companies are: net profit, EBITDA, trade turnover, etc. The margin of error for economic analysis is no more than 10%. The relatively large margin of error is due to the complexity of accounting for all factors, the sequence of their effects, and the strength of their impact on a specific company indicator. To improve the accuracy of forecasting, you must select the coefficients and parameters of the model as accurately as possible by repeatedly running the model and analyzing the simulation results.

Step 10. The final stage is the synthesis of recommendations for the necessary changes in the company's actual performance indicators based on the obtained optimal forecast of the company's development for the selected

set of model coefficient values. Recommendations are the basis of the company's strategy, which aims to achieve compliance of the actual indicators of economic activity with those that were selected for the optimal modeling scenario. Recommendations are generated only after verification of the model, as a result of which a trend is detected and parameters with an acceptable error are predicted.

2.5 Mathematical model and methodology for predicting the dynamics of indicators of competitiveness of financial and credit organizations

In this section, we consider the process of predictive modeling and comparative analysis of the dynamics of development indicators of two competing banks. In this case, the developed nonlinear mathematical model is used as an instrumental mechanism for improving the competitiveness of financial and credit institutions. Such institutions belong to complex socio-economic systems, are hierarchical structures of a large order, and include many factors that affect the final results of evolutionary development. In the process of analysis and modeling, it is unacceptable to consider factors separately from each other, since in this case it is impossible to describe the dynamics of interaction of banking structures in the organizational field with sufficient completeness and reliability. The order of a complex banking structure is determined by the number of differential equations that are necessary to describe its states at different levels of the hierarchy. For example, the top hierarchical level of the banking structure is represented by state servants, bank balance, customer service, banking system, banking operations, equipment, reputation of the bank, the system of relations with the bank, loan portfolio, system of relations with physical and legal persons, etc.

Despite the multi-factor approach to solving the target problem, the system-synergetic approach means that the final financial and economic indicators are highly sensitive to changes in a small number of parameters of the order [20] and to changes in the system structure. Moreover, a small control effect of an informational nature can change the behavior of the system in the phase space.

As it was shown earlier, the interaction of complex socio-economic systems should be considered in the organizational field, where the behavior of each individual system is very different from the behavior of simple systems, modeling and analysis of which are quite trivial procedures. The

organizational field in relation to financial and credit institutions includes a set of organizations that make up the sphere of banking institutional life. All financial structures that exist in a single organizational field are usually homogeneous and unified due to close interaction.

For modeling, predictive evaluation and managing the competitiveness of banking structures that are in close information interactions within the framework of the benchmarking process, the book offers an instrumental mathematical model. It is a system of equations and inequalities for describing financial and economic processes and phenomena in the banking organizational field with a selected set of variables [33, 34] for changing the order parameters at special points in the phase space.

Modeling banking systems in the context of globalization acts as a special kind of activity that corresponds to the formation of ideas about the future of each type of society in which they operate. This involves updating the professional qualities of banking specialists, taking into account a combination of objective and subjective factors that determine the process of evolutionary development of the system. Modeling allows to study the global processes occurring in the banking system, to structure the logic and methodology of the study of credit and financial processes in the dynamics of the development of the organizational banking field.

The simulation method of banks as complex systems, as well as other socio-economic systems requires an analysis of the internal relationships and external relationships required to achieve the functional goals of the subject simulation. The modeling process itself requires taking into account the maximum number of parameters and dependencies that determine the phase space of the simulated system. It is necessary to take into account parameters and dependencies that contribute to the activity or have positive effects, as well as parameters and dependencies that hinder the activity or have negative destructive effects on the functioning of the simulated banking system [37, 38, 40]. The search for optimal mechanisms for managing open banking systems is a rather complex scientific task. When developing a specific model, it is necessary to perform a number of large-scale studies of the system and existing crisis trends in order to ensure sustainable evolutionary development in the right direction in the market conditions and expanding globalization. An important research task here is to set and solve the problem of forecasting, analyzing and selecting alternative options for the development of banking structures in modes as close to real time as possible, which requires the introduction and use of Big Data technologies. Competitive interaction between banks also occurs in the

organizational market field [65], so it is advisable to describe their dynamics using differential equations [20]. As an analogue, it is advisable to choose the interaction in a well-known model of biological systems – the «predator-prey» scheme [41]. For example, if we consider a system of two types of predators (banks) competing for one type of victim (depositors), this corresponds to the process of competitive relationships. From a mathematical point of view, a system (two predators and one victim) can be represented as two related predator – prey subsystems. Then, according to Forester [20], competing banking structures can be considered as equations with nonlinear feedback. The rationale for using such models to describe the dynamics of changes in financial and economic parameters of banks is the oscillatory nature of fluctuations [34, 35, 66]. In this case, the Van der Pol system of second-order differential equations is suitable for formalizing the dynamics of banking structures ' indicators [42]. This system was considered earlier with the feedback mechanism that ensures the autonomous functioning of competing banks [65]. The process of competition in the framework of benchmarking is represented as the following system of related equations with a time delay [65]:

$$\frac{d^2X_1}{dt^2} - a_1(R_1 - Z_1)\frac{dX_1}{dt} + \omega_1^2(1 + k_1X_2)X_1 = c_2\frac{d^2X_2}{dt^2} + r_1F_1 + d_1F_3,$$

$$b_1Z_1 + T_1\frac{dZ_1}{dt} = \sum_{n=1} g_n \sin^2(nX_1 + \phi_n),$$

$$\frac{d^2X_2}{dt^2} - a_2(R_2 - Z_2)\frac{dX_2}{dt} + \omega_2^2(1 + k_2X_1)X_2 = c_1\frac{d^2X_1}{dt^2} + r_2F_2 + d_1F_3,$$

$$b_2Z_2 + T_2\frac{dZ_2}{dt} = \sum_{n=1} g_n \sin^2(nX_2 + \phi_n),$$

Here X_1,X_2 are variables that reflect the dynamics of the net profit of banks,

a_1,a_2 correspond to the level of rhythm of the bank's work and can vary from 0.1 to 2, R_1,R_2 the normalized amount of the bank's reserve for depreciation, Z_1,Z_2 -variables that reflect the degree of delay in the return time on loans issued (the dependence of functions X_1,X_2 on functions Z_1,Z_2 are nonlinear for banks), b_1,b_2 are the coefficients proportional to the time of return of loans, T_1,T_2 are the coefficients proportional to the time of payment of interest on deposits, ω1,ω2 - values, reverse-time turnover of credit funds of the bank, g_n is the proportion of money participating in each additional

transaction contribution (n is the number of operations), φ_n is a value proportional to the time delay cycle run additional operations compared with the time required for their execution,$\sum g_n \, sin^2(nX_{1,2} + \phi_n)$ function, which reflects the cycles of additional banking operations contribution, r_1, r_2 - constant coefficients proportional to third - party assistance to banks (for example, recapitalization), F_1, F_2 periodic functions representing the exponent in the degree of sine (displaying the resonant effect of the amount of recapitalization on the system's decision), d_1 – coefficient equal to 0.001 - 0.1, A_1- random function representing the exponent in the degree of sine with a random phase, reflecting the influence of the world exchange rate on the bank's activities, k_1, k_2– coefficients of banks ' possession of confidential information about each other's illegal banking activities, as a rule, it is equal to 0.1-0.2, c_1, c_2 - coefficients that reflect the level of interbank mutual support and can vary from 0 to 1.

The proposed model, methods of modeling and forecasting the development strategy of banks are considered on the example of two competing banks – «OTP Bank» (Russia) [66] and «Russian Standard Bank» (Russia) [67]. «OTP Bank» is a Russian commercial bank that is part of the «OTP Group», which is one of the leaders in the financial services market in Central and Eastern Europe. It is a universal credit organization that provides a wide range of banking services and products for corporate clients and individuals. «OTP Bank» is one of the 50 largest banks in Russia, and in a number of areas is among the market leaders. In particular, «OTP Bank» ranks 15th among retail banks and 2nd in the pos (point of sale)-lending market, 4th in the credit card market, and 13th in terms of profit for the first 9 months of 2011.

Standard Bank's priority areas of activity are consumer lending and credit card issuance. The bank is also engaged in acquiring, Internet acquiring, attracting deposits, settlement and cash services for individuals and legal entities, providing overdrafts, renewable and non-renewable credit lines, conducting international settlements (bank guarantees and letters of credit), trade finance, conducting conversion operations, etc. He is an agent of Russian Standard Insurance CJSC and Bank Insurance Company LLC.

The model settings were based on the performance indicators of these banks for 2010-2013, as well as the actual dynamics of their profits (Fig. 2.5). In the process of predictive modeling, forecasts of bank profit dynamics for 2014-2015 were obtained (Fig. 2.6) [65].

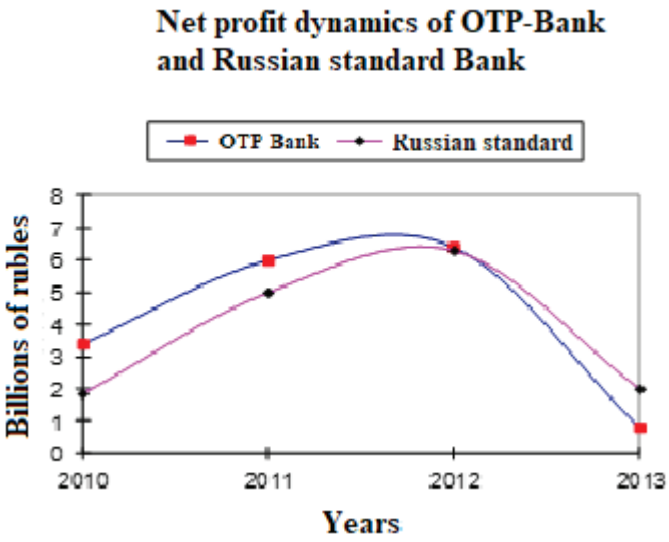
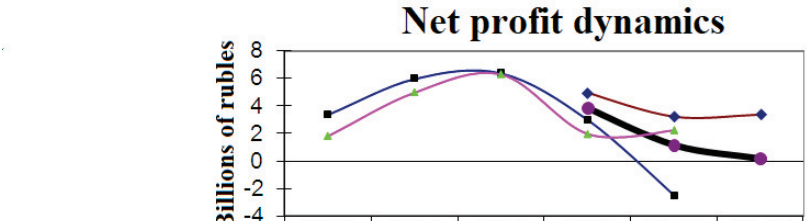


Fig. 2.5. – Dynamics bank's profits graph before 2013



	2010	2011	2012	2013	2014	2015
OTP-Bank	3,4	6	6,4	3	-2,5	
OTP-Bank forecast				3,84	1,152	0,17
Russian standard Bank	1,85	5	6,3	2	2,276	
Forecast for Russian Standard Bank				4,93	3,25	3,41

Fig. 2.6. - Predictive graph for both bank's net profit

Based on the results of the simulation, it is concluded that the credit policy of OTP Bank, as well as Russian Standard Bank, is experiencing saturation mode in terms of stopping the increase in the number of customers. Comparison with the actual situation on the banking market confirmed this conclusion, since the main direction of credit expansion has already taken place in Central Russia and reached its maximum in 2012. From the point of view of the model function of the dynamics of changes in net profit of OTP Bank and Russian Standard Bank represent fluctuations and without changing the financial strategy, they cannot go to the zone of stable increase in profit.

Analysis of the banks ' performance showed that in 2015, both banks sharply lose their net profit due to an increase in deductions for the formation of reserves for depreciation of assets on which interest is accrued. There are also higher operating costs. All this added up to a decrease in net profit, which could not be accurately predicted at the beginning of 2013 due to the impact of changes in the political sphere on the economic situation. The results in the first half of 2014 showed a worse picture than predicted. The results of the forecast for 2015 also did not give a clear picture, due to the emerging political circumstances of an external nature, but showed trends to zero or negative values. In general, the results obtained are typical of the depressed situation in the Russian banking sector in recent years. For example, Sberbank of the Russian Federation lost its net profit growth rate from 10% to 4%. Although, it should be noted that the larger banks in 2015 came out of the situation with a small increase, in contrast to smaller ones, such as OTP Bank and Russian Standard Bank.

The system of coupled Van der Pol equations can be used to analyze the dynamics of changes in various financial indicators of the banking structure, both individually and in the process of comparative analysis of its work with the indicators of more successful banks (benchmarking). In particular, the model made it possible to predict the dynamics of changes in the net profit of two banks for further comparative analysis with more profitable financial structures. In general, the forecast trends correspond to actual data, but the results of the analysis of actual indicators showed a strong influence of external political factors on the dynamics of banks ' development. In addition, it should be noted that the financial and economic performance of smaller banks is more strongly affected by minor market fluctuations in contrast to large-scale banks. The results of modeling and forecasting the net profit of two competing financial services companies (OTP Bank and Russian Standard Bank) prove the universality of the model [65], which can be successfully used as an instrumental mechanism for improving the

competitiveness of financial and credit organizations.

As promising areas of research, we note the need to add functions to the model that describe the effects of the Central regulator represented by the Central Bank of the Russian Federation. For example, the actions of the Central regulator (CBR) aimed at reworking licenses threaten to monopolize the banking sector and withdraw from competition banks that do not have administrative support. In the mathematical model, actions by the Central controller can be represented as an external influence in the form of a «negative» function F, which is not considered in the model because of the complexity of forecasting the time and nature of its impact.

CHAPTER 3

DEVELOPMENT OF MODELING TOOLS AND DECISION SUPPORT FOR IMPROVING THE COMPETITIVENESS OF ENTERPRISES

This Chapter discusses the methodological and practical aspects of the development and application of decision-making tools to improve the competitiveness of enterprises, which together constitute a system of decision support and competitiveness management (SSDMC).

3.1 Basic technologies for creating a decision support system and managing competitiveness

Registered users (experts and DM) interact with the server part of the system through the user Web interface, through applications and application packages installed on the client side, which include a number of tools for convenient and visual work with models of the studied enterprises and other data. SSDMC the server part handles requests from clients and performs operations on models and data. Server logic is created on the Java Enterprise Edition (J2EE) platform [75], which uses the object-oriented Java programming language [76]. Java applications are compiled into bytecode and can run on any Java virtual machine [78] regardless of the hardware platform. This determines one of the advantages of SSDMC – interoperability, i.e. the independence of the executable code from the operating system and hardware. The disadvantage of this technology is that the execution of bytecode by a virtual machine reduces the performance of algorithms, so caching is used as a compensation mechanism. Hibernate is a library for the Java language that solves object-relational projection problems for linking Java classes to information storage database tables and Java data types to SQL data types. It also provides tools for generating and updating a set of tables, building queries, and processing data. This technology is intended for solving object-relational mapping problems and provides a framework for displaying an object-oriented model of Java objects in relational databases. The library uses the Hibernate Query

Language (HQL) [68], which allows to build queries with objects and non-relational data. In order to reduce the load on information storage and improve performance, Hibernate uses a cache. The cache works while processing requests to the information store. If multiple requests are made during a session that return the same objects, these objects are stored in the RAM cache and can be reused within the session.

JBoss Application server, which is an open source application server and is a competitor to similar solutions such as IBM WebSphere or Oracle WebLogic, was chosen as the server platform. The Java Message Service (JMS) technology for network messaging between Java applications is used to interact with External software packages and application servers [78]. Interaction between components that use JMS is asynchronous (the procedure does not wait for a response to a message) and independent. JMS technology is aimed at transmitting data and notifications about any events. Another type of interaction between the JBoss application server, clients, and external programs is calling remote procedures and functions using the Enterprise JavaBeans (EJB) shared Java Beans. Using EJB, applications running on different JVMs and even on different physical servers can receive and use shared, shared objects. When calling a method of a remote EJB object, the calling program sends the method parameters to the server that provides the software component for public access and receives the result after execution. All of these Java EE standards and protocols are implemented by the JBoss application server.

The client application (browser) communicates with the server over the HTTPS Protocol and the AMF Protocol (Adobe Media Format), which is used to exchange data and call remote server procedures from the client application. ActionScript 3 technology is used to develop the business logic of client tool applications. The system that is being developed also includes many other technologies and protocols that are not yet used at this stage of creating SSDMC (Fig. 3.1).

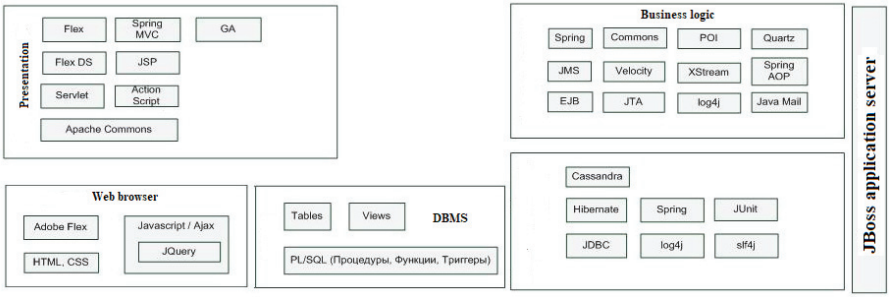


Fig. 3.1. Technology used in the creation of SSDMC

We will briefly describe some of the technologies and tools that were used to create

SSDMC:

1. The Spring Framework technology [70] is a universal open source application development framework for the Java platform. The Central part of the Spring Framework is the Inversion of Control container, which provides tools for configuring and managing Java objects. The container is responsible for managing the object's lifecycle. Container configuration is performed by loading XML files that provide information necessary for creating objects. Spring provides convenient interfaces for accessing data, working with HTTP, FTP, SFTP, etc.
2. The XStream library is used for processing data in XML format (eXtensible Markup Language) [70]. It is an extensible markup and presentation language for storing structured data. The format is a standard for transferring objects between systems running on different platforms and written in different programming languages. Any object and data structure can be represented in XML format in the process of so-called «serialization», passed to another component of the system, and then performed the reverse recovery of the object – "deserialization". Object serialization is used to store unstructured information about competing businesses and products that are retrieved from open sources on the Internet during the search process. XStream is a Java library for serializing objects to and from XML.
3. The Velocity [70] template handler, based on Java, provides a language for preparing the variables model. Its purpose is to guarantee a separation between the data representation level and the

business logic level. In the developed system, the handler is used to generate SQL queries to the storage that have a specific structure and parameters depending on the fulfillment of specific conditions.

4. The Apache POI library [73] of the Java platform is used for reading and writing Microsoft Office documents (Excel, PowerPoint, and Word), which mainly store information about the financial and economic status of competing enterprises (balance sheets, summary tables of financial indicators, etc.). Use the library to process weakly structured information, create or modify documents, index text, extract nested objects from documents, and much more. In SSDMC version POI 3.8 supports the formats of Microsoft Office 2007/2010 and is used for exporting reports from the application. DM provides an opportunity to download a report in Microsoft Excel format for analysis, editing, and visualization while viewing tabular data.
5. The Log4j logging library [67] implements a logging mechanism with records of events with SSDMC in chronological order with registration of external events and user work with tools.
6. Adobe Flex technology [72] extends the basic capabilities of Flash technology and allows to implement the interface of web applications in XML. Application logic is written in ActionScript 3. The result of the compilation is a SWF file intended for execution on the Flash Player platform.
7. The data format used for client – server interaction is AMF (Action Message Format). This is a binary data exchange format used in applications written in Action Script. Currently, most server languages and platforms in the form of libraries or frameworks support the AMF format.
8. Apache Maven technology is used to build the system from source code and deploy it to servers. This technology provides declarative Assembly of the project.
9. To synthesize mathematical models and solve predictive modeling problems, it was decided to use a specialized mathematical package of applied programs «Mathematica 5.1».

3.2 Information support for decision-making tools for managing competitiveness

Information support for management decisions is aimed at synthesizing information that allows to eliminate the uncertainties that arise in the process of targeted administrative activities, as well as to form a set of possible measures to improve competitiveness. There are three groups of

uncertainties. The first group includes uncertainties about the state of the enterprise as an object of management in the organizational field of the external market environment. The second group is related to the selection of quality criteria for evaluating decisions. The third group consists of uncertainties related to forecasting the results of decisions [75].

In relation to the competitive activity of the enterprise, the purposeful activity of the DM is as follows. Before starting to solve the decision-making task, the DM must have an idea about the business activity of the enterprise, the financial and competitive state of the managed object, the organizational market field, partners and competitors, available resources and ways to influence them. Comparing information about the current competitive state of the company and its competitors in the process of benchmarking with its desired image as a leading company in the market, the DM evaluates the discrepancy between them, analyzes and selects ways of influence, from possible alternatives that eliminate this discrepancy. As a result, a management decision is made on the nature of the impact on the enterprise, which contains information about the state of the management object and how to change it [74, 76].

The main component of information support is a multidimensional information storage. The operation of the repository includes the process of collecting, cleaning and rationing data collected from various sources in the public domain on the Internet, as well as providing users with access to information. The concept of information storage involves the implementation of a single information resource for a variety of tools. The repository supports chronology: along with the current indicators, historical data is stored with the indication of the time to which it belongs. Thus, the necessary data about the management object is collected in one place, reduced to a single format, coordinated, and aggregated to the minimum required level of generalization. When describing the information storage filling technology, there are three interrelated tasks: data acquisition and extraction, transformation and data cleaning, and data aggregation and loading.

Data collection is the process of searching for and transferring data from external sources to the storage. Aggregation refers to the organization of the process of calculating various data aggregates (integral indicators) and integrating them into the storage. The process of clearing data during storage filling includes: eliminating duplicates, restoring missing data, bringing data to a single format, removing unwanted characters, unifying

data types, and checking for integrity. The main data that is uploaded to the information store includes data from external and internal sources (Fig. 3.2).

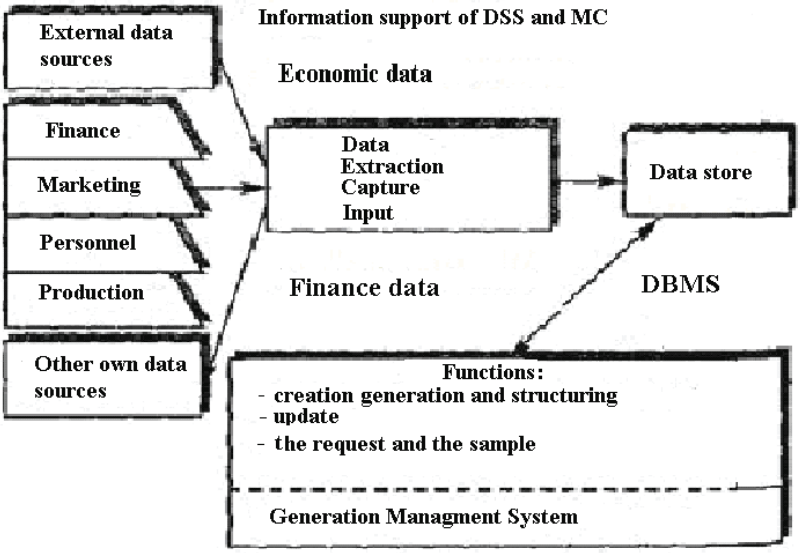


Fig. 3.2. - Basic information about the company's activities

A diagram of the formation and use of information storage in SSDMC shows how data is extracted from operational data sources using data integration tools (SIDS) (Fig. 3.3).

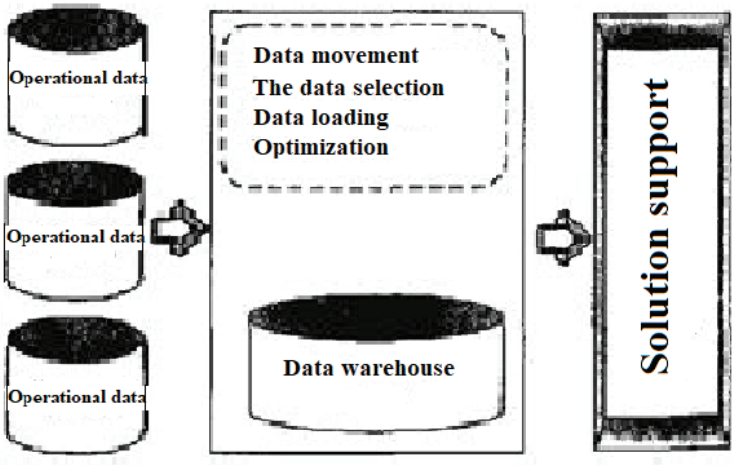


Fig. 3.3. - Data integration scheme for storage

As a model of the data warehouse it is proposed to use the industrial model. An industrial model is a set of pre-defined data models for describing business processes. Industrial models are created based on the experience of many organizations and try to describe the overall business process specific to a particular industry. On the market there are ready-made industrial models from IBM (financial sector, telecommunications industry, healthcare, etc.), from EWSolutions (healthcare, investment, law enforcement) and solutions from other manufacturers (Terradata, CSC). In the described in the book research, a storage model was implemented based on the IBM Banking Data Warehouse (BDW) industrial model based on tools provided by EC Leasing (Moscow). The IBM BDW industrial model consists of three data models: conceptual, logical, and physical-and rules for moving from one model to another. A conceptual data model is a ready-made set of business concepts that describe various aspects of a business activity. Business concepts are grouped in a hierarchy with 9 root concepts. When creating a repository, you select the concepts needed to describe the business process from the entire set, starting with the root concepts and going down the hierarchy. The initial data for the choice of concepts are the requirements for the composition of information. For each selected concept, the type of implementation is defined: a separate relational entity, an entity attribute, or an attribute value. Data models obtained using industrial models describe a typical business process that occurs in a particular industry. Thus, there is no need to study data source systems in detail to create a data model. However, the data integration subsystem has the additional burden of

converting and reconciling data from different sources for presentation according to a unified model.

To solve the problem of decision support for enterprise competitiveness management, the database structure was designed for solving OLAP mining problems. At the design stage of the database, it was determined what data will be stored in it. For informational support of the tools, information about the current and retrospective state of competing enterprises and their products is entered in the database from the repository. A fragment of the info logical database data model is shown in Fig. 3.4. Relational data tables are associated with model entities. Based on the logical relational model, a physical model is formed for implementing the storage structure in the corresponding DBMS.

To analyze and select the performance indicators of competing enterprises and transfer them to the mathematical predictive modeling tools, data is loaded into multi-dimensional storefronts, which are hyper tables that are used in the OLAP processing process. All organizations that work in business

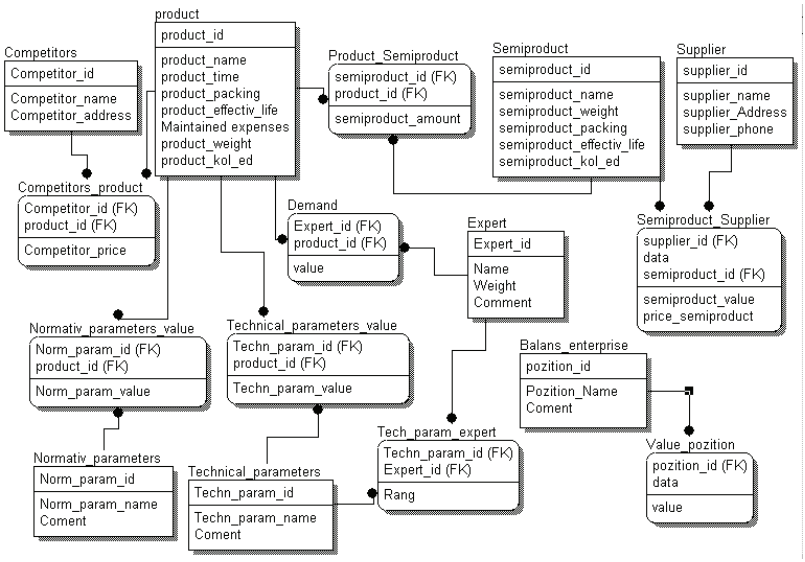


Fig. 3.4. – A fragment of the entity-relationship data model

Business face multidimensional data, and the complexity of the data does not necessarily depend on the size of the enterprise. The OLAP tool is used

as a tool for working with data tables. OLAP data organization is based on the concept of a multidimensional data cube that stores the analyzed data in its cells. Dimensions are aggregations of other data values, such as product names and month names of the year.

The OLAP Toolkit provides the ability to access, view, and analyze data related to competing businesses through data slices or storefronts, which are presented as dynamic hyper tables in the book. By viewing data and aggregated metrics in storefronts, users can analyze information extracted from storage. It is based on a conceptual view, as a natural view of the DM on the control object with the ability to view aggregates from several independent dimensions that integrate certain data sets.

A hyper table is both a data showcase, an OLAP tool, and a non-standard user interface element. Combines tabular analysis functionality with a tree structure and controls to view the dynamics of changes in competitiveness indicators displayed in cells over time. Hypertablism is a technology for visualizing a hypercube of data in which data is grouped by parameters and aggregation levels. It provides the ability to navigate a multi-level and multi-dimensional tree structure of data in real time. A screenshot of the data visualization module with a hypertablism fragment and a product pricing graph is shown in the figure (Figure 3.5).

The peculiarity of the hypertablism is that the number of rows in the table is not a static value, the rows themselves are not equal in nature and functionality, since some of them are aggregates. Aggregate rows are nodal and show summary information for the corresponding columns that belong to them in the rows of the lower levels of aggregation. Associated with aggregation rows is a button that works similarly to a node element in a tree list – it allows you to hide or show the contents of a group. The number of rows of the hyper table is dynamic and varies depending on the state. Another key feature of the hyper table is the ability to quickly view and analyze changes in values over time (position 10 in Fig. 3.5). When loading data into a table, the server receives information about the values of the selected data columns for all rows and for each enterprise activity indicator from the selected time range. The time range is defined when specifying a subset of data. The hyper table allows to view a real-time graph of changes in any selected value over the desired time period. By moving the slider on the timeline, you can see changes in the values of all other cells in the table, thus analyzing the areas of interest according to the graph.

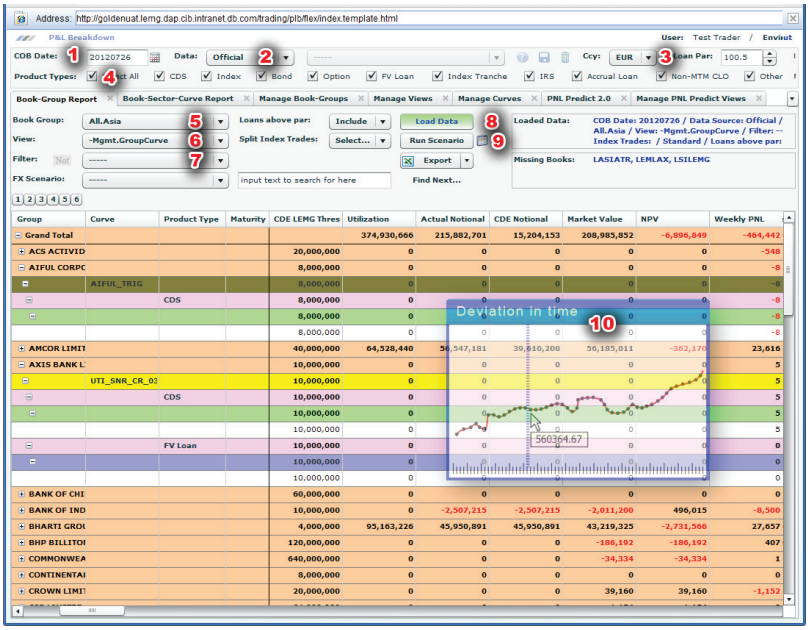


Fig. 3.5. A fragment of hyper stability to render a report on the work of banks in the benchmarking process

To extract data from open sources on the Internet, software intelligent agents are used, combined in a distributed ETL (Extract, Transform, Load) subsystem for integrating data into the storage. The distributed ETL subsystem extracts data from sources in the time domain and implements functions for processing them in terms of structuring, cleaning, and rationing. These functions can be implemented in the form of templates that are configured based on the target requirements for collecting data of a certain type and format in the sources. Most documents about the company's activities are placed in Microsoft Office formats (Word, Excel, Power Point), PDF format, and less often in HTML or XML formats. The presence of software templates for extracting data from documents of the same format allows to reduce the complexity of the work.

The ETL subsystem consists of a set of processes that process data and mechanisms for managing progress. ETL processes work with data that is initially structured as relational tables with data about concepts. A logical concept can be a description of a characteristic of a business object (enterprise) or an event that occurred in a business object. Table templates are also generated in advance for specific types of businesses.

3.3 Architecture of a set of decision support tools for managing competitiveness

The set of tools developed in the research is a kind of expert intellectual decision support system. Such systems use expert knowledge to provide highly effective solutions to problems in a particular subject area. In most cases, they are intended to provide consulting assistance to specialists (DM) in solving problems that arise in poorly structured and difficult to formalize areas. The information repositories of such systems store knowledge obtained from experts and are used when the need arises. A feature of the systems is that they have a mechanism for generating recommendations, which explains how solutions can be obtained that contribute to achieving the required performance and quality indicator for a particular enterprise.

Expert support for decisions is based on the concept of «standard template solutions», according to which the problem situations that arise can be reduced to some homogeneous classes of solutions, i.e. to a typical set of alternatives. To implement such expert support, an information Fund is created for storing and analyzing typical alternatives for specific market situations. If the problem situation that occurs is not associated with the existing classes of typical alternatives in the repository, then a mechanism is implemented for modeling the company's activities in atypical conditions with a search and evaluation of possible solutions. After implementing the iterative process of selecting the optimal solution, predictive modeling, and adjusting the parameters of the original mathematical model, the resulting solution is marked as a typical alternative, and the corresponding recommendations are entered in the information store. Thus, the mechanism of knowledge acquisition in the intellectual decision support system is implemented.

The mode of acquiring knowledge corresponds to the stages of synthesis of a mathematical model, algorithmization of the modeling process, programming in the environment of the application package «Mathematics 5.1», debugging the program, performing modeling and forecasting, and

verifying the results obtained. The knowledge acquisition stage requires certain qualifications and is therefore performed by the appropriate expert. To implement specific decisions to improve competitiveness, the DM may not be a programming specialist, since it works primarily with data tables and an expert component solver. The solver generates recommendations for achieving the goal based on data from the repository, General data about the problem area, and rules from the knowledge base.

The decision support tool set can be represented as a four-level architecture that includes: the representation level (user interface), the server level, the data warehouse level, and the data source level (Fig. 3.6).

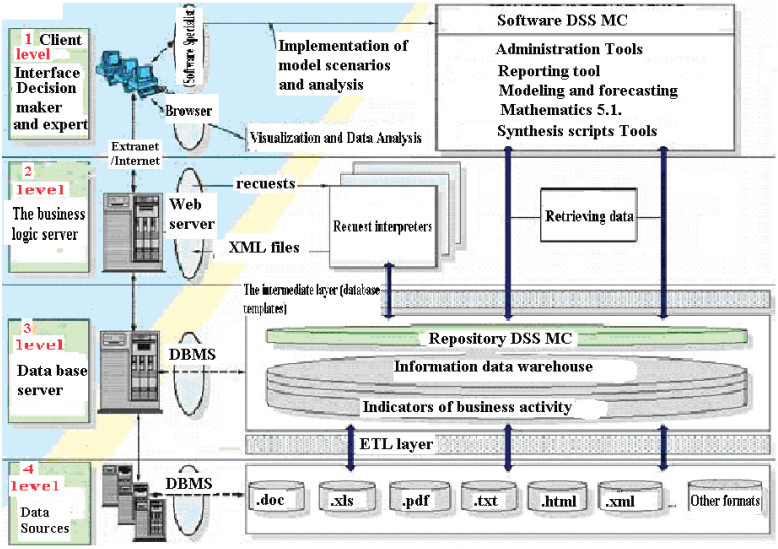


Fig. 3.6. – The main architecture tiers

Each level uses its own set of technologies and performs a specific set of functions. The architecture of the tool complex shows the inter-level information interaction of the main components. The data source level and database level were discussed earlier. At the presentation level, the main work is performed on scenario synthesis, analytical processing, predictive modeling, and presentation of the results of intellectual analysis to DM and experts.

The user works with a standard Web browser. After the user is authorized on the server, it is possible to select the necessary application to work with, depending on the user's requirements. In response to the request, the server sends an XML page with JavaScript inserts and a client application to Adobe Flex. Then the Flex client continues working with the server via the AMF Protocol and HTTPS Protocol.

At the server level, JBoss Application Server works, which processes client requests and passes the required analytical processing applications to the client. The server calls stored procedures and functions using the Java application and database communication technology JDBC (Java Data Base Connectivity). The server also performs the necessary actions with the data, interacting with the database layer, and transmits the necessary data for the applications to work as part of the serialization mechanism. Thus, the server performs both the role of a Web server and an application server, interacting with other servers through special API interfaces based on EJB technology. The server part performs calculations using complex algorithms that require high performance of calculations, such as aggregation and calculation of analytical values. The General architecture of the complex of decision support tools for managing the competitiveness of the enterprise with the main operations is shown in the figure (Fig. 3.7).

There are two categories of people who work with the final and intermediate results of the tools: decision formers (DF) and decision makers (DM). If the role of the DM is played by the administrative staff of the enterprise, qualified experts should be the DF. The DF can view the database with the collected information and solve modeling and research tasks.

The main tasks that are solved by the DF include the task of research and evaluation of the company's condition, the task of determining the order parameters for managing the competitiveness of the enterprise and products, the task of evaluating the effectiveness of measures to improve competitiveness, the task of parametric programming for selecting optimal strategies for improving competitiveness.

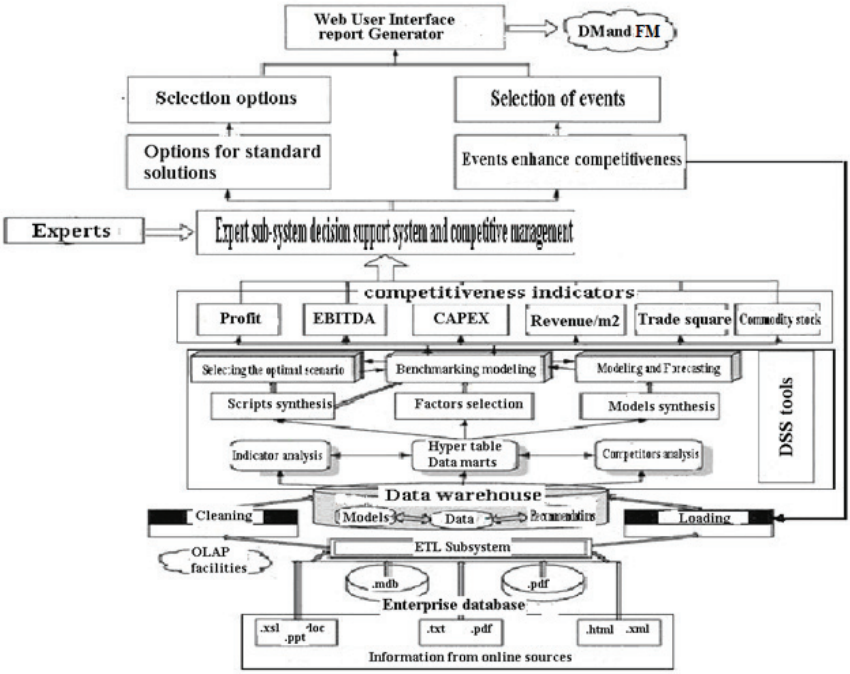


Fig. 3.7. - Architecture of a set of tools

3.4 Decision support methodology for managing enterprise competitiveness

Currently, the issues of solving the problems of managing the development of enterprises are put forward in the foreground. The solution of these problems is complicated by the uncertainty and instability of the dynamics of changes in the external market environment. Development of mathematical models for complex solution of strategic tasks of decision support and management requires significant expenditures of material and information and computing resources and highly qualified specialists. Consideration of certain aspects of management will not provide sufficient information for decision-making, so in order to obtain the most appropriate strategy for the company's development, corresponding to market conditions and competitive interactions, it is necessary to take into account the indicators and activities of the enterprise.

A modern tool for solving this class of problems is a decision support system with an expert component. As an interactive system, it gives DM access to real-time data, aggregates, and models to help make decisions in various situations based on analysis of weakly structured and unstructured data. The purpose of the system is to support the work of the company's management in the management of the enterprise, the synthesis and selection of necessary management solutions to ensure and improve its competitiveness in the market, which also determines the strategy for further development of the enterprise.

To implement a comprehensive decision support methodology for managing competitiveness, information and software in the form of software tools has been developed. Let us consider the main tasks that are solved in specific components of the SSDMC tool complex:

- analysis of the competitive situation on the market with the selection of competitors ' enterprises and collection of information about them (subsystem of information search and analysis of information about enterprises (audit data and accounting reports), goods and services on the Internet based on Big Data technology), comparison of indicators for selecting competitive pairs for benchmarking (comparative analysis subsystem);
- modeling and forecasting of enterprises ' performance before implementing a strategy to increase competitiveness (mathematical modeling tools based on a package of application programs),
- analysis, evaluation and selection of factors that have the strongest impact on the competitiveness of your own company (data Mining intellectual analysis tool for normalization, ranking, clustering and selection of financial and economic indicators of enterprises),
- synthesis of possible scenarios of enterprise development (subsystem of situational modeling and scenario analysis),
- predictive modeling of changes in the competitiveness indicators of benchmarking enterprises for different sets of values of influence factors in development scenarios (mathematical modeling tools based on a package of applied programs),
- analysis of simulation results, comparison of the obtained forecast graphs with real graphs of benchmarking enterprises and selection of alternative vectors of factor values that are characteristic of the optimal development strategy (Data Mining analysis tool),
- analysis and evaluation of alternative sets of indicators in order to select the most optimal one according to the minimax strategy (Data Mining tool),

- selection of existing recommendations from the knowledge base (KB) (the logical output module of the expert subsystem) or synthesis of new DM recommendations to achieve the required indicators from the optimal set with their integration into the information storage (subsystem for working with the information storage and knowledge base),
- synthesis of logical rules for selecting recommendations for new scenarios and vectors of factor values to add to the expert subsystem logical output module (expert subsystem training module),
- providing recommendations for decision-makers.

A comprehensive method of decision support includes:

1) set of mathematical models of competitive interaction adapted for enterprises of various types of activity;
2) method of mathematical modeling of the benchmarking process;
3) n algorithm for predicting indicators of competitiveness and financial position of companies in competitive conditions;
4) behavior scenarios for market situations;
5) method of scenario analysis;
6) criteria for evaluating the results of modeling to select an effective competitive strategy;
7) expert recommendations for improving competitive advantages and choosing a competitive development strategy;
8) procedures for monitoring the activities of enterprises to assess the effectiveness of implementing a competitive strategy.

The developed method of decision support for managing the competitiveness of enterprises includes the following steps (Fig. 3.8).

Step 1. Data collection and analysis of the competitive environment. This environment is an external market environment that includes a description of competitors and indicators of their financial and economic activities;

Step 2. Analysis of the internal environment of the company, which includes an assessment of its financial and competitive status and analysis of competitive products;

Step 3. Synthesis of a mathematical model for competitive pairs of enterprises in the process of benchmarking, based on the state of the external environment, characteristics and indicators of enterprises;

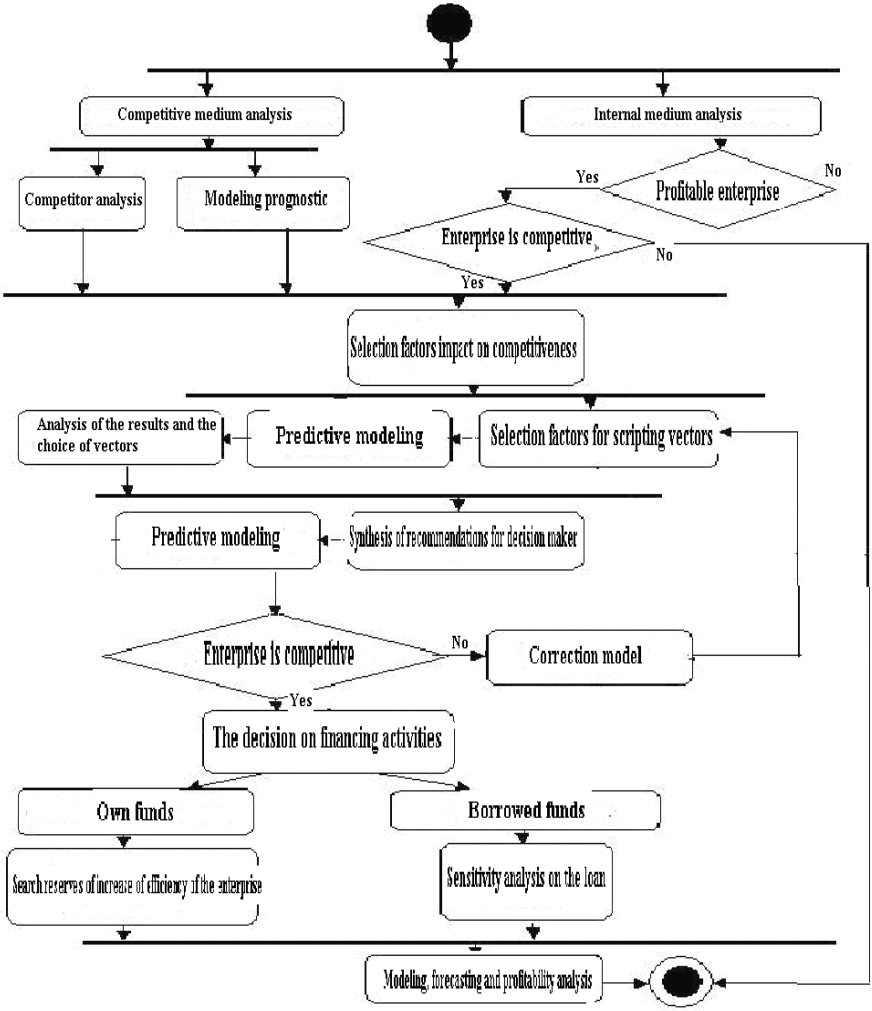


Fig. 3.8. - Decision support methodology

Step 4. Predictive modeling of enterprise activity to assess its competitiveness and setting up the model to achieve convergence of forecast schedules with actual ones,

Step 5. Selection of a number of factors that have the strongest impact on the competitiveness of the company and its products;

Step 6. Synthesis of possible development scenarios (scenario analysis) regarding factors affecting competitiveness for different scenarios,

Step 7. Predictive modeling of scenarios (scenario analysis) of the company's activity in the process of competitive interactions with a benchmarking partner for different market situations and sets of values of influence factors (development scenarios);

Step 8. Comparative analysis of the results of the actual operation of the enterprise and alternative forecast results of modeling for the selection of vectors of values of indicators that are characteristic of the optimal development strategy in terms of improving the competitiveness of the enterprise;

Step 9. Synthesis of DM recommendations for changing the strategy of market behavior and enterprise development with their preservation in the knowledge base storage for further training of the expert component;

Step 10. Predictive modeling of the enterprise activities in a benchmarking process of interaction with a competitor after achieving (or as close as possible) required values of indicators of financial-economic activity for comparison with actual performance, competitiveness, error estimates mathematical models are developed and adjusted;

Step 11. Providing recommendations of the DM and reports with the results of predictive modeling of the company's activities after the implementation of appropriate measures.

Step 12. Solving the problem of financing activities that should be taken on the basis of the recommendations received. Such financing can be carried out with your own funds, or if there is a lack of them, with the help of borrowed funds.

Step 13. Monitoring of the company's performance after the implementation of measures (modeling, forecasting and analysis of profitability and competitiveness).

3.5 Software tools for modeling competitive interactions of enterprises in the «Math 5.1 environment»

The main component of the complex of decision support tools is actually a software tool for modeling and forecasting the competitiveness of enterprises in the process of benchmarking, depending on different scenarios and vectors of influence factors. This is confirmed by the use of this tool for analyzing and predicting competitiveness indicators at various stages. As a mathematical support for the decision-making process and management of competitiveness, the thesis developed a nonlinear model in the form of a modified system of coupled Van der Pol equations (oscillators), which was considered and investigated in the previous Chapter. The main modeling packages include MathCAD, MathLAB, Mathematica, Maple, Maxima, etc. A set of programs for implementing modifications of the system of equations in relation to different market situations and competitive pairs of enterprises in different fields of activity is developed in the tool environment of the universal application package «Mathematics 5.1», since this environment is most suitable for implementing models of this class (Fig. 3.9). Before the practical application of the programs, experimental studies were performed in this environment.

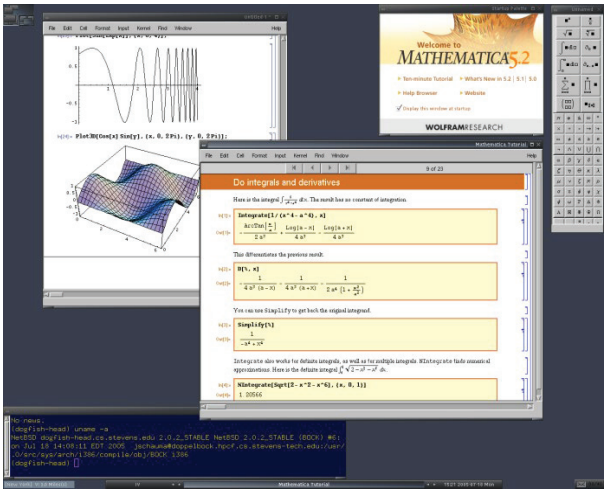


Fig. 3.9. – «Mathematica 5.1 simulation package»

The system allows to create programs in a high-level functional programming language to expand the functionality and describe new

mathematical models for solving problems in various fields. Wolfram research's Mathematica package is used for calculations in scientific research. The system has functional redundancy and is designed to automate the execution of mathematical calculations of any complexity with a high speed of symbolic transformations and numerical calculations.

The Mathematica system is the leader among computer systems of symbolic mathematics and provides the ability to perform complex numerical calculations with the output of results in graphical form, carrying out time-consuming analytical transformations and calculations. The central place in the Mathematica system is occupied by the machine-independent core of mathematical operations, which allows to transfer the system to different platforms using the Front End software interface processor. The system has the ability to expand the set of functions, which are used by the library and a set of add-on packages. New functionality and various programs can be developed in the Mathematica programming language. From this point of view, the package is a problem-oriented programming system based on a high-level functional programming language that is designed to solve various problems.

For the experimental study of mathematical models, a program is written in this language, which describes the system of coupled Van der Pol equations as a tool for modeling the processes of interaction between competing enterprises (benchmarking).

3.6 Research of a mathematical model of enterprise competitiveness using software tools

We will conduct research on the mathematical model using the developed software tools in the Mathematica environment for various scenarios of interaction between enterprises competing in the organizational market field. The main goal of our research is the synthesis and evaluation of mechanisms of competitiveness management for use in automated SSDMC.

3.6.1 Modeling the dynamics of competitiveness depending on the degree of mutual awareness of enterprises

This section presents the results of modeling and research of the competitiveness of commercial enterprises in the process of benchmarking when changing the level of awareness of enterprises about each other. As a criterion of competitiveness, we will consider the volume of sales.

In the process of modeling, we will consider two types of awareness. In the first case, companies receive information about each other from open sources in the process of conducting market research on market situations. In the second case, enterprises receive confidential information by spying, hacking of closed information sources through hacker actions or insider activity of employees of a competitor company. In the system of coupled Van der Pol equations (see Chapter 2), these two types of information are represented by two different coefficients expressed in percentage.

The model of the lack of mutual awareness of enterprises about each other leads to almost similar graphs of the dynamics of sales changes in time, under the same initial conditions (Fig. 3.10) [77].

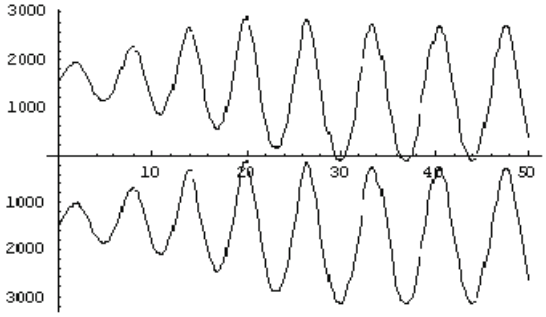


Fig. 3.10. - Schedules of sales of the enterprises without information about each other

The charts show the number of sales on the vertical axis, and the days on the horizontal axis. To visual assess the sales dynamics of the two companies being compared, the upper and lower charts are arranged symmetrically relative to the horizontal axis.

If the situation changes and the knowledge of the first company's open information about the second becomes 10%, and the second about the first 100%, this will lead to an increase in the level of sales of the informed company (Fig. 3.11) [77].

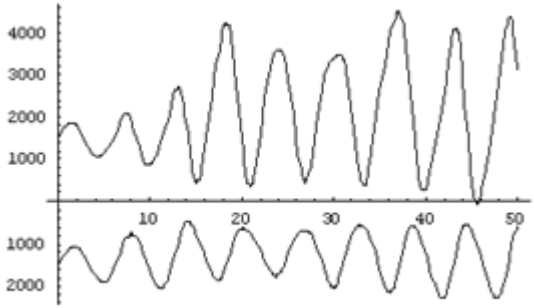


Fig. 3.11. Charts for increasing the sales level of a more informed company (top chart)

If, as a result of insider (or other) actions, one company receives 50% of confidential information, and the second does not have access to similar information, with an equal amount of daily information about each other, this will lead to a decrease in the level of sales of the enterprise that does not have such information (Fig. 3.12) [77].

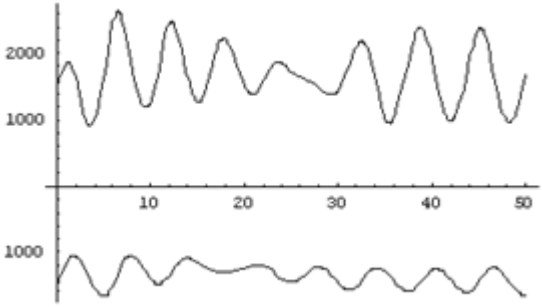


Fig. 3.12. - Decrease in the level of sales of an enterprise (lower graph) that does not have confidential information

Let us assume that both businesses have the same level of awareness (60%) in everyday and confidential terms. Then the sales schedules become sharply nonlinear, which at a certain point in time leads to disruption of the working cycle of one of them (Fig. 3.13) [77].

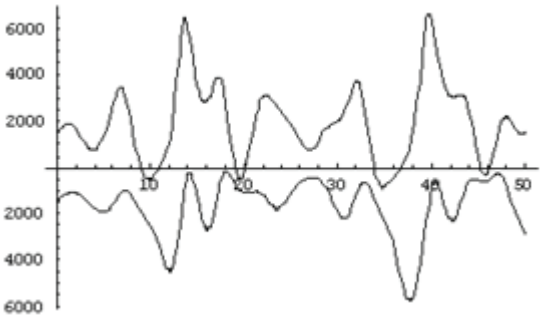


Fig.3.13. - Sharp fluctuating nature of sales schedules in case of violation of the limit of the degree of possession of confidential information

The search of coefficient values for the study of different variants of the degree of awareness of enterprises allowed to determine the optimal values of the indicator of awareness of enterprises for two types of information, in which the nature of sales fluctuations becomes more or less stable. At the same time, it turned out that for the majority of pairs of enterprises under consideration the stable nature of sales fluctuations is achieved with an asymmetric nature of the enterprises ' awareness of each other. In particular, it was found that for one enterprise, ownership should be daily information at the level of 100% and confidential information at the level of 40% about the enterprise. For another company, 50% of daily information and 30% of confidential information, respectively. With this ratio, the model obtained stable results of sales dynamics with a smaller sales amplitude for the second company (Fig. 3.14) [77].

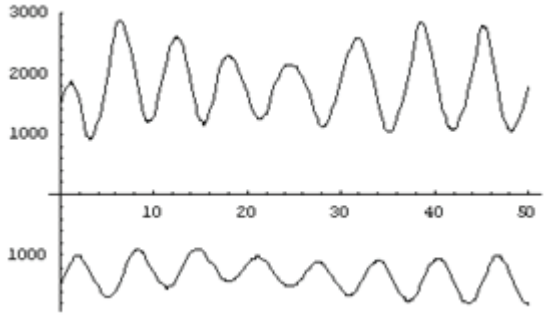


Fig. 3.14. - Achieving a stable nature of fluctuations in sales of competing enterprises

This study allowed to develop a number of recommendations for the decision-making subsystem for managing competitiveness by changing the degree of mutual awareness of enterprises.

3.6.2 Modeling the behavior of competing enterprises in crisis conditions

For the study, a program was developed to simulate the crisis situation in the market, which led to a complete drop in the level of sales.

In this state, the model ceases to be a self-supporting system. The crisis state was modeled by removing random functions interpreted by stochastic fluctuations of market indicators from the right side. The sales stop is displayed as the end of the oscillation process after one cycle (Fig. 3.15) [77].

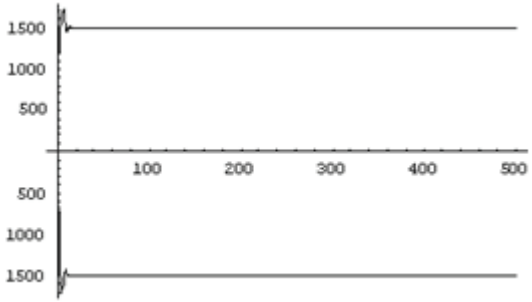


Fig. 3.15. - Termination of sales of competing companies in a crisis

After the end of the crisis, there is a revival of the market, which is modeled by returning to the system of equations the random functions. The level of sales of enterprises is restored (Fig. 3.16) [77].

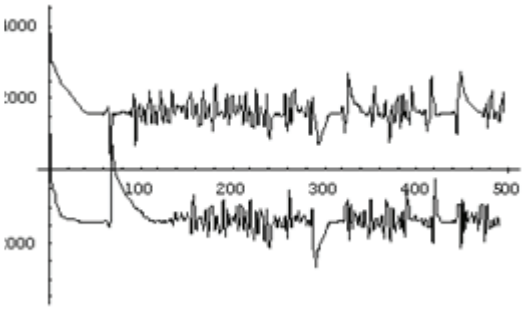


Fig. 3.16. - Recovery of sales after the end of the crisis

It should be noted that the process of restoring the normal functioning of enterprises after the inclusion of random market fluctuations corresponds to the physical phenomenon of stochastic electromagnetic resonance, when connected electronic generators operate in the presence of external fluctuations of a random nature [51].

The model shows how the market economy, as a mechanism with different activities, is capable of self-healing after crises, like the regeneration of biological systems after a violation of their physiological state.

3.6.3 Modeling and research of the impact of the investment mechanism on competitiveness

In order to model the investment decision-making process and assess the impact of investments on the competitiveness of enterprises, the model introduced variables that characterize the mechanism of investment placement. At the same time, several investment scenarios were studied and compared as part of the scenario analysis. As the first scenario, the strategy of single point investments was modeled. Such investments are made with a frequency of once in a few months. The sales chart shows a short-term burst of fluctuating processes, which proves that the investment strategy gives short-term effects of increasing sales (Fig. 3.17) [56].

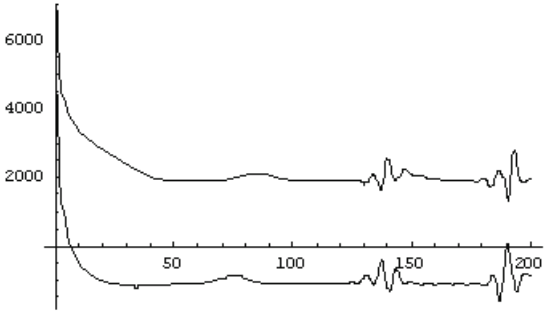


Fig. 3.17. - Short-term increase in sales with point investments by competing companies

In another simulation scenario, a model with investments stretched over time was studied (Fig. 3.18).

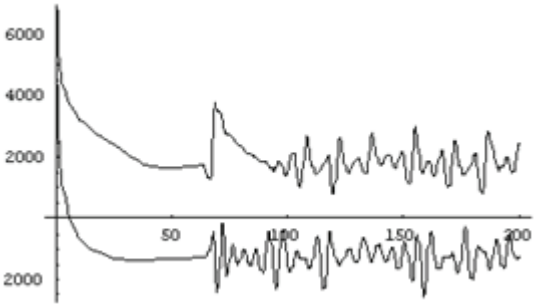


Fig. 3.18. - Sales schedules for businesses with stretched investments

Such investments are made within a certain period of time, for example, a number of investments within a month. As you can see from the graphs, the strategy of time-stretched investments is more effective in its impact on the level of sales than the strategy of point investments, which makes the first strategy a more effective mechanism for increasing competitiveness.

To model the study and evaluate the impact of the investment amount on the sales level and competitiveness of the enterprise, a module was synthesized and implemented to model the percentage increase in the volume of investments and the frequency of investments in order to develop recommendations for selecting their size and frequency.

As the results of the simulation, let's take the initial investment graph shown in figure 3.9 and increase its volume by 100% (Fig. 3.19).

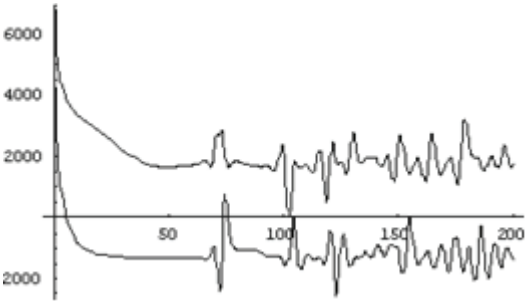


Fig. 3.19. - Model charts for increasing the level of sales while increasing investment by 100%

It should be noted that any investment, despite its size and length of time, always causes a negative reaction of enterprises at the first stage, which is characterized by a decrease in competitiveness. This is due to the fact that investments involve expanding the product range, introducing new sales technologies, implementing new logistics chains, attracting new personnel, etc. All this at the first stage leads to a decrease in the level of sales, since enterprises must adapt to new working conditions, and then the operation of the enterprise enters the normal oscillatory mode of operation.

The next stage is to model and evaluate the impact of the frequency of investments on the dynamics of competitiveness in relation to the company's own production cycle. The first simulation scenario was made for the frequency of investments, which is 2 to 5 times higher than the duration of the production cycle of the enterprise. In this case, we have received the graphs with the monotonous levels of sales for both companies in the long term (Fig. 3.20) [56].

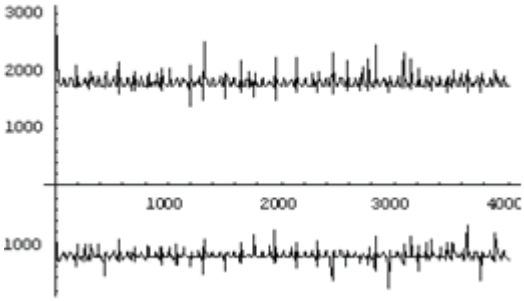


Fig. 3.20. - Monotonous level of sales with the frequency of investments equal to the reverse time of the production cycle

The second scenario involves setting the frequency of investments, which can vary from 0.1 to 0.01 percent of the reverse time of the production cycle of enterprises. In this case, the model gave a forecast of increased sales by enterprises in the long term (Fig. 3.21) [56]. Thus, it has been proved that the implementation of the strategy of frequent investments (2-5 times more often than the duration of the production cycle of the enterprise) has less efficiency than the strategy of rare and very rare investments (0.1-0.01 times less often than the duration of the production cycle of the enterprise).

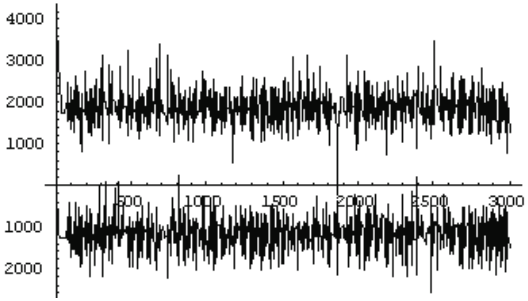


Fig. 3.21. - Increased sales at an investment frequency equal to one-hundredth of the return time of the production cycle

In addition, frequent investments require significant capital investments compared to rare ones, which, in the end, will lead not only to a decrease in competitiveness, but also to the possible bankruptcy of the company.

3.6.4 Modeling and research of the impact of different forms of costs on the competitiveness of enterprises in the benchmarking process

To assess the impact of costs on the competitiveness of enterprises in order to select the optimal strategy for managing competitiveness through cost optimization, a study was conducted of the behavior of the information-related enterprises model in the framework of benchmarking depending on different forms of costs. Various types of costs were modeled by introducing two types of periodic negative functions F_4, F_5 to the right side of the Van der Pol equation system. By changing the coefficients for functions, the value of costs was changed, and the frequency of the period of functions F_4, F_5 corresponded to their different types [59].

In the first scenario, the influence of cost values on the level of sales by enterprises was studied. To do this, the model was run for a large (100%) (Fig. 3.22) and small (10%) (Fig. 3.23) the level of costs [59]. The graphs in the first figure show that large costs can lead to a drop in sales, while small costs (the graphs in the second figure) lead to an increase and stabilization of their level.

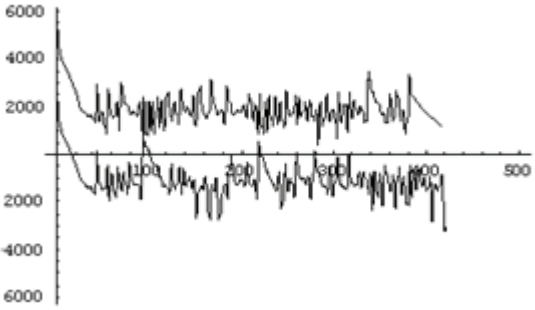


Fig. 3.22. - Sales dynamics at high costs

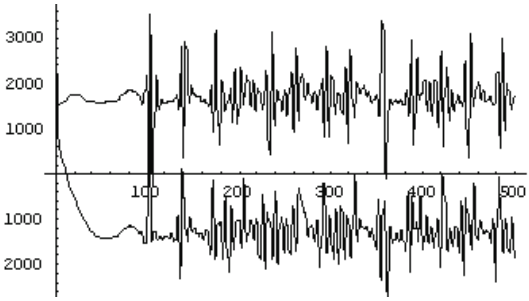


Fig. 3.23. –Sales dynamics at low costs

In the following scenario, we studied the effect of changes in the level of delay between the production and sales processes on the level of sales at average costs that simulate the cost of upgrading equipment in enterprises. The simulation showed an increase and stabilization of the sales level with a five-fold decrease in the level of delay between production and sales (Fig. 3.24) [59].

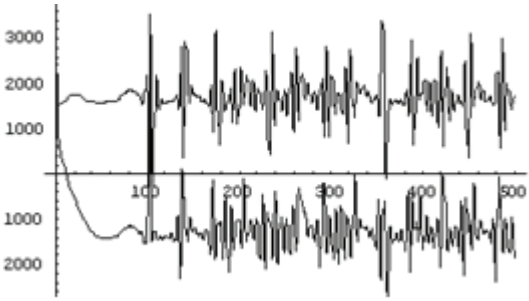


Fig. 3.24. - Charts for increasing and stabilizing sales levels

The graphs confirm the assumption that the impact of the cost strategy on the competitiveness of the enterprise is not trivial. For example, a rapid upgrade of the company's machine fleet (reducing the level of delay between the production and product sales processes) leads to a significant increase in the competitiveness of enterprises.

Predictive modeling and research of the results showed that the most correct strategy for increasing competitiveness by optimizing costs is to combine traditional costs with the costs of updating production. This leads to a high stable level of product competitiveness in the market (Fig. 3.25) [59].

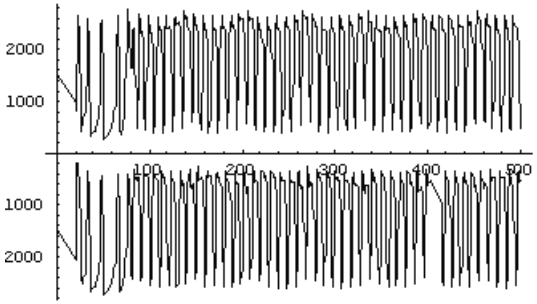


Fig. 3.25. - Charts of sales dynamics with the correct cost strategy

3.6.5 Influence of chaotic market fluctuations on enterprise competitiveness management

It is known that chaotic fluctuations play an important role in the market system. For dynamic systems, chaos should be considered as one of the factors of updating the system, through the influence of random external fluctuations. Chaos is an essential feature of the market economy and stimulates the emergence of a variety of products, services, innovations, etc.

Neoclassical models of market economy development and its separate spheres were intuitively based on a system-synergetic approach. In fact, the market economy is a synergistic self-organizing system. In such systems, along with fundamental and technical research methods, the method of analyzing trends in the development of situations based on the chaos theory is used [58]. This method has a solid basis in the form of a non-linear physical approach, in which intuition, experience and talent of market participants play a significant role.

The results of theoretical and experimental studies of real enterprises operating in the framework of competitive interactions, based on the proposed mathematical model, showed that the behavior of dynamic systems in the market organizational field is influenced by chaotic fluctuations, and this influence is not destructive. The random nature of fluctuations in market indicators can bring to life the modes of operation of enterprises, which lead to the optimization of its behavior in terms of increasing its competitiveness.

The results of modeling the process of managing the competitiveness of enterprises in the framework of information-related Van der Pol equations,

which are under the influence of random fluctuations in the market, proved the following [71]. Increasing random variability in the market environment leads to the structuring of the production process at competing enterprises with an increase in its competitiveness. The company's sales dynamics depend on similar parameters of competing companies that produce similar products. This circumstance makes it necessary to consider the model of sales dynamics of each enterprise in an integral connection with the enterprises interacting with it in the market. Thus, the competitiveness of an enterprise can be defined as a dynamic form of change in the amount proportional to the number of sales made over a certain period of time by an enterprise that has one or more competitors that produce similar products. In addition to the competitiveness of enterprises, the model can take into account costs, investments, innovations, awareness, market fluctuations, and other factors.

Taking into account the results of predictive modeling of the company's competitiveness dynamics, it can be concluded that the proposed mathematical model of the competitiveness management mechanism can be successfully used in the strategic planning of the service sector enterprises, as well as in any other enterprises.

3.7 Mathematical modeling and research of the competition process of many enterprises

Analysis of sources has shown that many scientists define the competitiveness of an enterprise as the market share [10] that an enterprise occupies. Therefore, the paper set a fundamental task of modeling and studying the competition process of a number of enterprises, which is based on two principles:

- identification of key indicators of enterprises ' activity,
- analysis of the dynamics of changes in the company's market share with fluctuations in key indicators of economic activity and environmental factors.

As key indicators, we will consider the profitability of the company's activities (assessment of operational efficiency) and the dynamics of market share changes (assessment of strategic positioning).

To assess the relative competitiveness of several companies in the benchmarking process, the thesis proposes a method of mathematical modeling of the competition process between two pairs of enterprises for

market share [60]. The previously proposed nonlinear model of competing companies in the benchmarking process in the form of coupled Van der Pol equations is also used for modeling [50].

In this aspect, the competition process of multiple enterprises is modeled through several pairs of enterprises that are combined according to the proximity of key indicators and are considered the main competing pairs. In the book, we will consider the process of modeling and studying competition for two pairs of competitors. Then the mathematical model is represented as two coupled pairs of Van der Pol equations with a time delay.

Let the market shares held by enterprises be proportional to the number of sales they made over a relatively long period (more than three months). Then the model for pairwise comparison of 4 enterprises looks like this [60]:

$$
\begin{aligned}
&\frac{d^2M_1}{dt^2} - a_1(1-Y_1)\frac{dM_1}{dt} + \omega_1^2(1+k_1M_2+k_2M_3+k_3M_4)M_1 = \\
&c_1\frac{d^2M_2}{dt^2} + c_2\frac{d^2M_3}{dt^2} + c_3\frac{d^2M_4}{dt^2} + d_1F_1 + d_2F_2 - d_3F_3, \\
&b_1Y_1 + T_1\frac{dY_1}{dt} = M_1^2, \\
&\frac{d^2M_2}{dt^2} - a_2(1-Y_2)\frac{dM_2}{dt} + \omega_2^2(1+k_4M_1+k_5M_3+k_6M_4)M_2 \\
&= c_4\frac{d^2M_1}{dt^2} + c_5\frac{d^2M_3}{dt^2} + c_6\frac{d^2M_4}{dt^2} + d_1F_1 + d_2F_2 - d_3F_3, \\
&b_2Y_2 + T_2\frac{dY_2}{dt} = M_2^2, \\
&\frac{d^2M_3}{dt^2} - a_3(1-Y_3)\frac{dM_3}{dt} + \omega_3^2(1+k_7M_1+k_8M_2+k_9M_4)M_3 = \\
&c_7\frac{d^2M_1}{dt^2} + c_8\frac{d^2M_2}{dt^2} + c_9\frac{d^2M_4}{dt^2} + d_1F_1 + d_2F_2 - d_3F_3, \\
&b_3Y_3 + T_3\frac{dY_3}{dt} = M_3^2, \\
&\frac{d^2M_4}{dt^2} - a_4(1-Y_4)\frac{dM_4}{dt} + \omega_4^2(1+k_{10}M_1+k_{11}M_2+k_{12}M_4)M_3 \\
&= c_{10}\frac{d^2M_1}{dt^2} + c_{11}\frac{d^2M_2}{dt^2} + c_{12}\frac{d^2M_4}{dt^2} + d_1F_1 + d_2F_2 - d_3F_3, \\
&b_4Y_4 + T_4\frac{dY_4}{dt} = M_4^2,
\end{aligned}
$$

(3.2)

where M_1, M_2, M_3, M_4 - are the market shares of four enterprises, proportional to the number of sales, a_1, a_2, a_3, a_4 - are the coefficients reflecting the degree of rhythm of the enterprises (from 0.1 to 2), $\kappa_1, \kappa_2, \kappa_3, \kappa_4, \kappa_5, \kappa_6, \kappa_7, \kappa_8, \kappa_9, \kappa_{10}, \kappa_{11}, \kappa_{12}$ - are the coefficients reflecting the degree of ownership of strategic information of one enterprise about another (from 0% to 100%), $c_1, c_2, c_3, c_4, c_5, c_6, c_7, c_8, c_9, c_{10}, c_{11}, c_{12}$ – are the coefficients that reflect the degree of ownership of the daily information of one company about another, $F_1, F_2,$ - are the random functions that reflect the impact of monthly and annual fluctuations in market indicators on the market share occupied by enterprises, F_3 – is a random function that reflects the impact on sales processes of force majeure from the external environment of a techno genic, natural and anthropogenic nature, T_1, T_2, T_3, T_4 – are the delay times in warehouses of enterprises,

b_1, b_2, b_3, b_4 , are the speeds of output of products from warehouses of enterprises to sales, $\omega_1, \omega_2, \omega_3, \omega_4$ - are the inverses of the times of production cycles.

A number of the following assumptions are made for modeling:

1. Let the duration of the production cycles of the second pair of enterprises be half as long as that of the first pair. At the same time, the duration of production cycles of enterprises within the second and first pair differs by one and a half times between themselves.
2. Let all businesses initially be equally informed about each other.
3. All initial market shares of the four enterprises (initial conditions) are equal, and it is also assumed that there are shares of other enterprises in the market.

To study the model in the Mathematics application package, a program was created, as a result of the simulation, the dynamics of changes in market shares for four enterprises was obtained, expressed in terms of the number of sales (vertical axis) that change over time (horizontal axis in days) (Fig. 3.27). The first pair of graphs reflects the results of modeling the activities of the first and second enterprises in a mirror image for visual analysis, the second pair-the results of modeling the activities of the third and fourth enterprises. As can be seen from the graphs, under the same initial conditions (market shares), over time they become different for different companies [60].

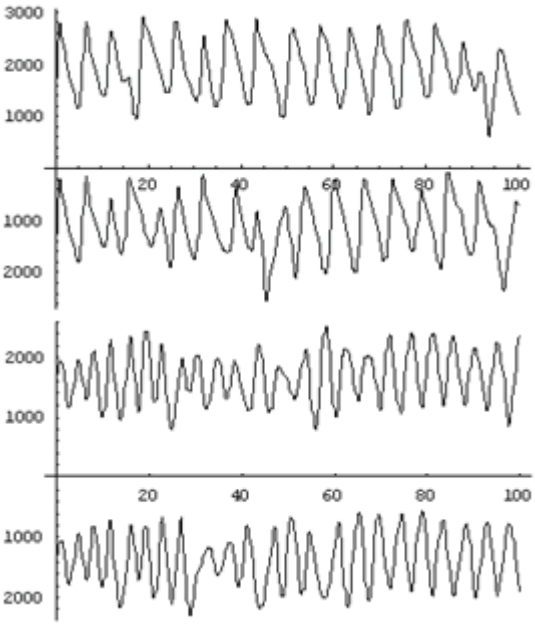


Fig. 3.27. - Dynamics of changes in market shares for two pairs of enterprises

3.7.1 Modeling and research of the competition process of enterprises subject to obtaining insider information

We will conduct a simulation of the competition process in the conditions when the first pair of enterprises receives insider confidential information about the second pair (within the range of 50 to 100%) (Fig. 3.28) [60].

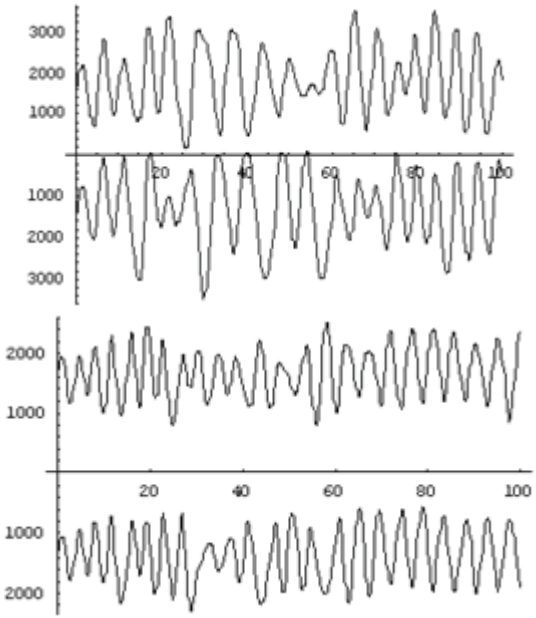


Fig. 3.28. - Increasing the market share over time for the first pair of companies by obtaining insider information

The first pair of graphs shows an increase in the market share, expressed in terms of the number of sales occupied by the first pair of businesses compared to the share of the second pair. Analysis of the simulation results shows that in a two-pair mathematical model, there is no constantly growing dependence of the number of sales on the ownership of insider information by enterprises in different volumes. During the simulation, experiments were performed when changing confidential information from 50 to 100 % in 5% increments.

The main result of the experiments was that the increase in the market share is manifested only when receiving 50% of confidential information and with a further increase in the share of this information does not grow any more. On the other hand, when the model is launched for only one pair of enterprises, the opposite results appear. The increase in the share of insider information dramatically increases the negative trends in the number of sales of the affected company. This fact suggests that in the case of a large number of enterprises that are in the process of competition in the market organizational field, insider facts have less and less influence on the

competitiveness of enterprises, since they are masked by the large influence of other indicators.

3.7.2 Modeling and research of the competition process of enterprises subject to changes in the rhythm of enterprises

The following experiment proves the dependence of the competitiveness of enterprises on the rhythm of work. At the first stage, results were obtained that showed instability of sales volumes for 1 and 4 enterprises with poor rhythm (coefficients) compared to the rhythmic work of 2 and 3 enterprises (Fig. 3.29) [60].

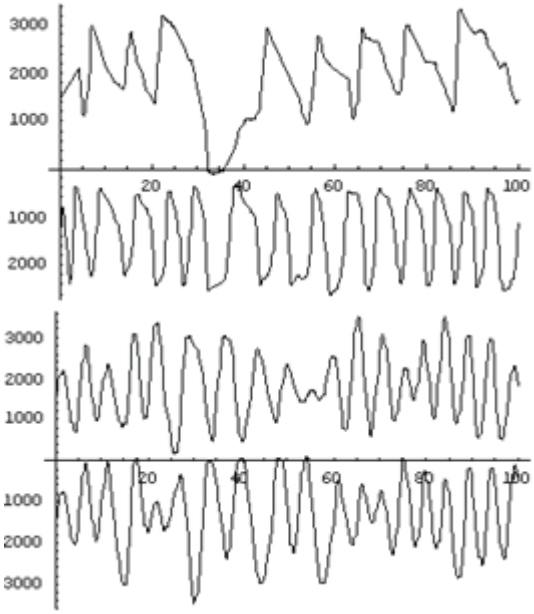


Fig. 3.29. Changes in market shares with a relatively poor rhythm of the first and fourth enterprises

Let us improve the rhythm of the first and fourth enterprises by changing the coefficients to the values of the other pair (3.30.). The results show a stabilization of sales volumes (Fig. 3.30) [60].

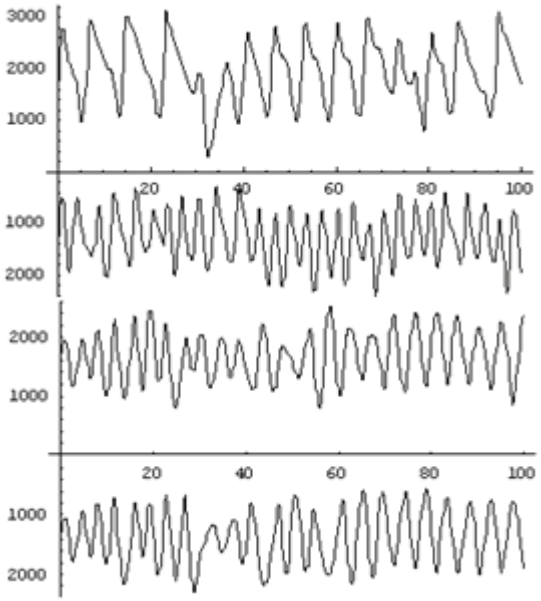


Fig. 3.30. - Stabilization of market shares while reducing the rhythm factor

The graphs show a relative stabilization of the market share dynamics for the first and fourth enterprises with a decrease in the factor of their irregular operation. On the other hand, there is a slight deterioration in the stable operation of the second and third enterprises, which is the result of increased competitive interactions that were not noticeable when competitors were not working rhythmically.

Thus, the modeling of two pairs of enterprises on the developed mathematical model allowed us to conclude that in order to increase the market share, and therefore increase competitiveness, it is necessary to organize the operation of the enterprise in a more rhythmic mode compared to the competitor. On the contrary, disruptions to the rhythm of competing enterprises will reduce their competitiveness.

3.7.3 Modeling and research of the competition process of enterprises in different modes of product output delay

The proposed model allows us to study the behavior of market shares of enterprises under different modes of product release delay (retention in

warehouses). To do this, we will conduct a simulation of the operation of enterprises with a decrease in the speed of product release from the warehouses of the first pair of enterprises by ten times at the initial stage and a subsequent gradual increase in the speed of release by five times. The second pair is in normal mode. We get the following results (Fig. 3.31) [60].

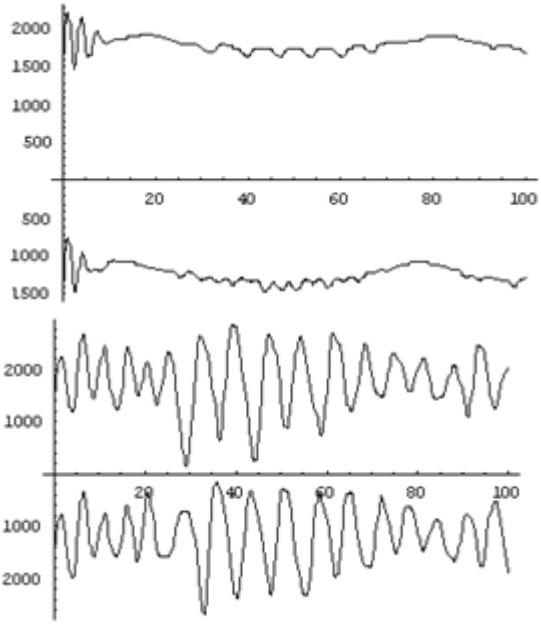


Fig. 3.31. - Changing the market share under the effect of the product release delay factor on the market

In the next experiment, we will reduce the speed of product release from warehouses by ten times, and then increase it by five times for the first enterprise of the first pair. At the same time, the second company and the other pair are working as usual. As a result, we get the characteristic dynamics of reducing the competitiveness of the first enterprise in comparison with the rest (Fig. 3.32) [60].

It can be seen that the market share occupied by enterprises increases at the highest rate of product release from warehouses. In the model of only two enterprises connected in the process of benchmarking, on the contrary, the greatest competitiveness is achieved when one of them artificially detains products in warehouses.

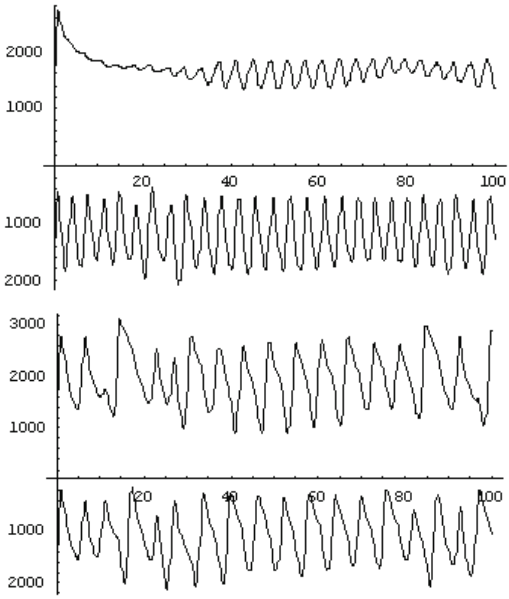


Fig. 3.32. - Decrease in the market share of the first enterprise while reducing the speed of product release

3.7.4 Modeling and research of the competition process of enterprises in the implementation of innovative solutions

For experimental research in this aspect, it is best to consider manufacturing companies rather than trading companies. Assume that four companies engaged in the Assembly of household appliances are selected for the simulation. At the same time, the first pair of companies uses a traditional manual Assembly line, and the second pair introduces an innovative robotic Assembly line with the possibility of readjustment for the production of new products.

Assume that when the market demand for household appliances changes, reconfiguring an automated Assembly line takes 10 times less time than a traditional conveyor. In the developed mathematical model, this circumstance is reflected through a change in the time value. At present, due to the moral aging of household appliances, market changes in demand occur regularly, so constant reconfiguration of equipment is required, which entails restrictions in the speed of bringing products to market. In fact, businesses

do not always keep up with changing market conditions. The results of the simulation show that when the product release rate is limited over time, the first pair goes into a stable uncompetitive state compared to the second pair, which captures a large market share (Fig. 3.33) [60].

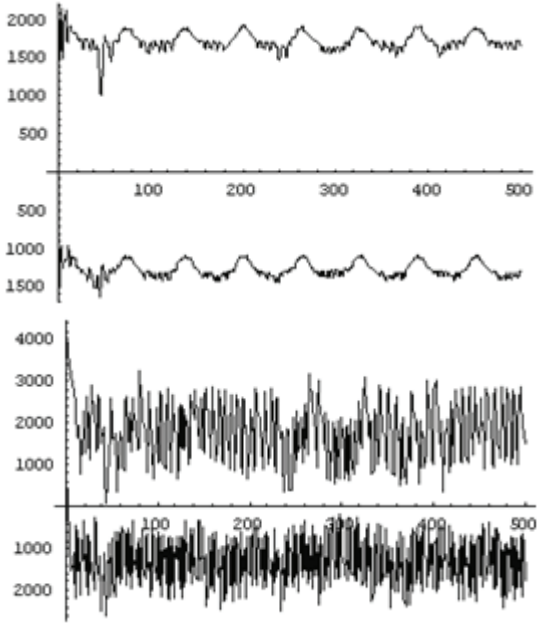


Fig.3.33. - Increasing the competitiveness of enterprises in the application of innovations in enterprises

Thus, the simulation shows that it is more effective in terms of increasing the market share and competitiveness of enterprises to switch to the use of automatic rebuilt Assembly lines instead of traditional Assembly lines.

3.7.5 Modeling and research of the competition process of enterprises when their market activity changes

From the point of view of the system-synergetic approach [61] all real enterprises are influenced by fluctuations that determine the degree of activity of market participants. In the model, this factor is determined by random functions. Therefore, the experiment decided to investigate the impact of market fluctuations on the size of the market share occupied by

enterprises. For this purpose, the average value of the fluctuation amplitudes was halved by reducing the coefficients d_1, d_2.

Simulation results (Fig. 3.34) showed that for a period of time after the fluctuations decrease, pairs of enterprises cease to function.

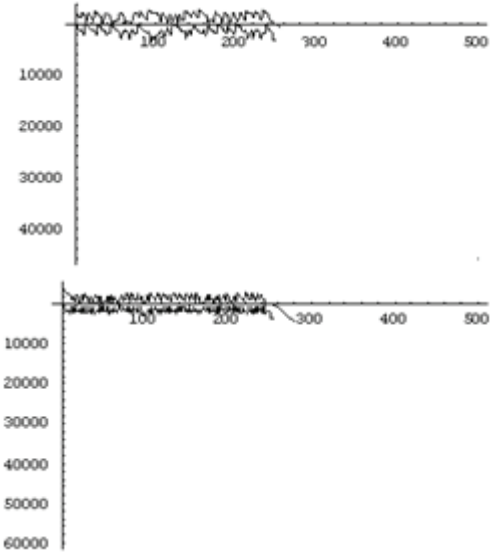


Fig. 3.34. - Termination of the operation of enterprises in the event of a double decline in market activity

When market activity returns to its previous state, the market shares held by enterprises are restored (Fig. 3.35) [60].

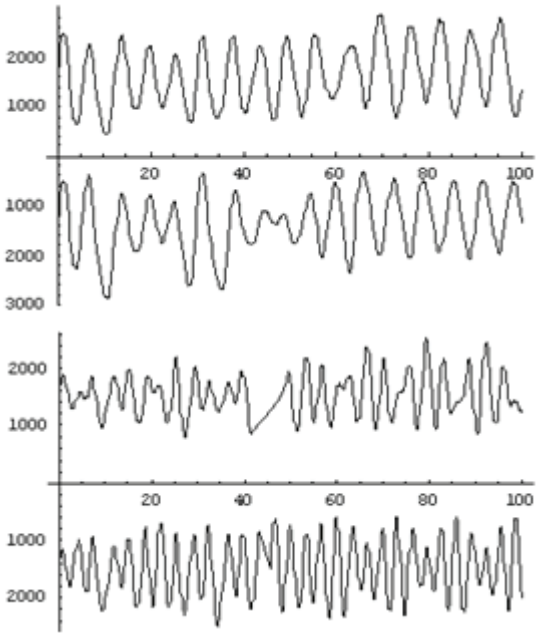


Fig. 3.35. – Restoration of market shares when the level of fluctuations in the market activity returns to its original state

The conducted experiments confirm the conclusion that market activity has a decisive impact on the functioning of enterprises.

3.8 Modeling and research of new enterprise behavior when entering the market with competitors

The next stage of mathematical modeling was the study of the changes in the market share occupied by a new single enterprise, which only appears on the market and does not interact in terms of information with competing companies. For this purpose, another Van der Pol equation is added to the equation system, which simulates the operation of a single enterprise. The single enterprise model preserves the effects of market fluctuations, as well as fluctuations in the external environment that model the effects of future competitors. Unlike enterprises that are already present on the market, have a significant share of ordinary and confidential information about each other and can be compared in the process of pair benchmarking, a new enterprise at the beginning of its market activity has only publicly available information

about the products and plans of competitors. However, the advantage of a new company is that its competitors do not know anything about it before its activity begins and therefore do not consider it as a competitor.

Under the same initial conditions for a single enterprise that is just entering the market and a pair of enterprises that already occupy their market niche, the simulation results are presented in Fig.3.36 [60].

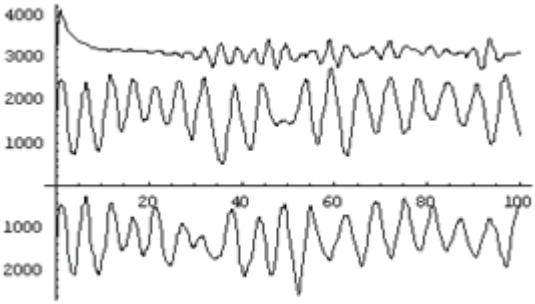


Fig. 3.36. - Dynamics of the market share of a single enterprise (upper graph)

The graphs show that the market share occupied by the new enterprise (the upper graph) is significantly less than that of paired enterprises that have been present on the market for a long time. It is noteworthy that in contrast to the curves that show the market share of paired enterprises, the dynamics of which are constantly changing due to market fluctuations, the market share curves of the new enterprise remain unchanged at the specified values of the coefficients.

This proves the practical absence of a market niche, which is expressed in the model by the lack of evolutionary development of the enterprise in the direction of increasing competitiveness. The consequence is that it is impossible to increase its competitiveness in the process of evolution of the organizational market field by traditional methods. If market activity declines (fluctuations are halved), the market share occupied by the new enterprise will also decrease (Fig. 3.37) [60].

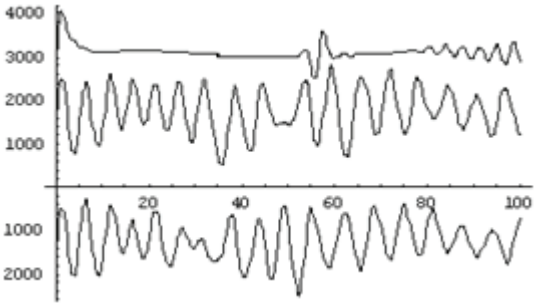


Fig. 3.37. - Disappearance of the market share of a single enterprise (upper graph) when market activity falls by half

The simulation results shown in the following graphs (Fig. 3.38), show that any changes in the market share of paired enterprises do not have a significant impact on the market share of the new enterprise, which remains at consistently low values.

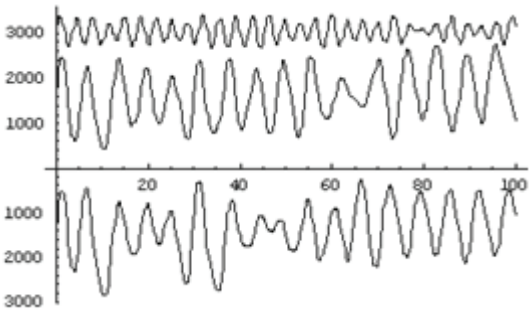


Fig. 3.38. - Stable market share of a single enterprise when the shares of paired enterprises change

Comparison of graphs of the dynamics of market shares occupied by paired enterprises and a single enterprise shows the complex relationship of elements of the dynamic system, which is a market organizational field. For example, if a loosely connected system such as a new single enterprise appears on the market, the dynamics of its market share is an autonomous process without evolution.

Thus, the main conclusion of the research is that a new enterprise entering the market with competitors and similar products and services has little chance to increase its competitiveness in traditional ways. To model and

study the competitiveness of this enterprise, it lacks a paired company with which it can be considered in the benchmarking process. Companies that are already present on the market cannot be used for interaction in the process of pair benchmarking, since they are in unequal conditions (the new company is practically not present on the market and does not have information links). However, in order to select the optimal indicators and configure the activity of a new enterprise for the most successful entry and occupation of a niche market, it is necessary to add some artificial abstraction to the model, which can be an equal competitive partner. To do this, we can create an artificial enterprise with similar indicators to simulate the process of competitive interaction in the benchmarking process. On this model, using predictive modeling for various interaction scenarios, you can choose the optimal values for the original enterprise, with which it should enter the real market. This mechanism for managing competitiveness will be considered in the next section using the example of a working enterprise for which a competitor was artificially synthesized and research was conducted in the framework of the mathematical model.

3.9 Modeling and research of the company's competitiveness in the process of benchmarking with an artificially created competitor

In the process of the research, a mechanism for managing the competitiveness of enterprises was proposed based on the scenario of entering an artificially created competitor into the market and synthesizing a benchmarking pair with the main enterprise. Studies of competitive interactions in this pair on the basis of the proposed model allow to select the optimal values of the coefficients and parameters of the enterprise's activity, which can later be used in the decision-making process as target indicators of its functioning in real market conditions.

Taking into account the previously obtained results of modeling the competitiveness of a new enterprise, it can be assumed that the mathematical model of competitiveness can be successfully used in the strategic planning of enterprises in the sphere of trade and services, as well as in other enterprises. The company «Kaluga plant» trading house was chosen for the research, which at the time of the research had a monopoly on the regional market and has no competitors. The company produces special - purpose products made of non-ferrous metals [59].

At the first stage of research, a forecast of the competitiveness dynamics for 4 years (from 2013) was made, taking into account the natural increase of 10% in the value of market fluctuations due to the appearance of unknown competitors. The results of the simulation showed the deterioration of the company's competitiveness, which is shown on the graph by the attenuation of fluctuations in sales volume (Fig. 3.39) (vertical – weight in tons of non-ferrous metal products sold, horizontal-months).

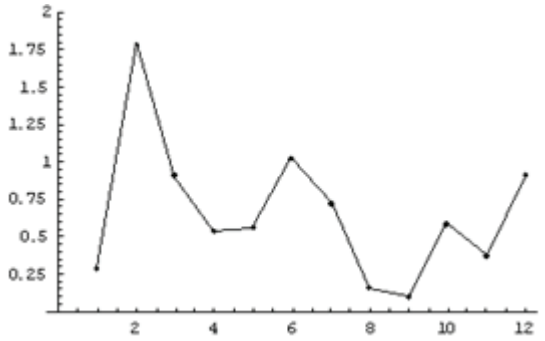


Fig. 3.39. - Dynamics of monthly sales for 2013

The nature of fluctuations in the company's sales includes a tendency to occur during transitions (the beginning of the schedule) and a seasonal decline characteristic of sales (the second part of the schedule) [59].

The following graph shows the projected decrease in the competitiveness of the company's products in the absence of competitors in the next four years and eight months (Fig. 3.40) (horizontal axis-months, vertical axis-tons per month).

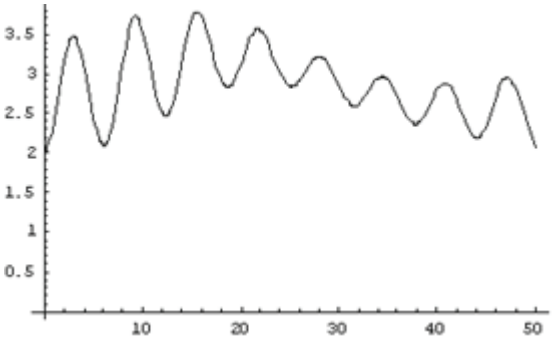


Fig. 3.40. - Projected decrease in competitiveness

A program has been developed for modeling the company's activity. The introduction of an artificial competitor to the Kaluzhsky plant Trading house, associated with it through mutual awareness (20% of confidential and 80% of daily information), led to the restoration of the company's competitiveness (Fig. 3.41) [59].

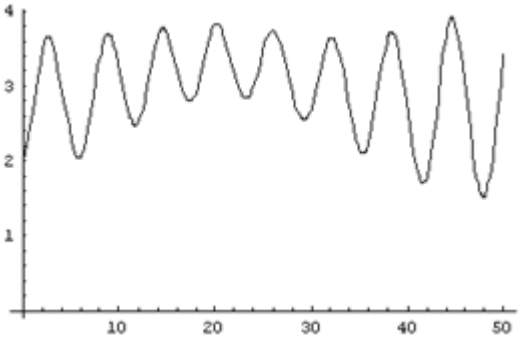


Fig. 3.41. - Projected recovery of the competitiveness

The study of the model in the absence of information about each other showed a predicted drop in the competitiveness of both enterprises (Fig. 3.42).

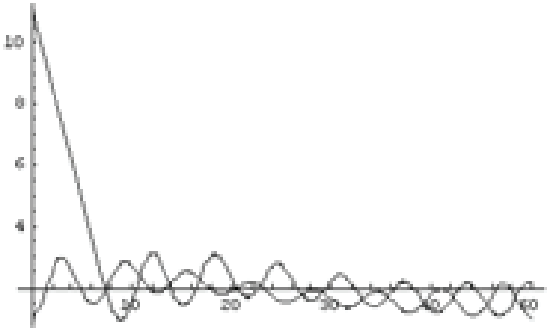


Fig. 3.42. - Forecast of falling competitiveness of enterprises

Introducing the same mutual awareness of enterprises about each other (50% of daily information) into the model leads to the restoration of competitiveness (Fig. 3.43).

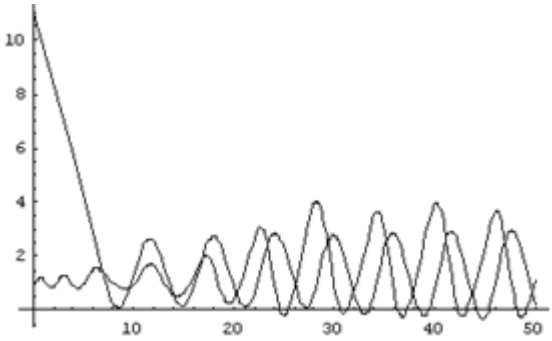


Fig. 3.43. - Projected recovery of the competitiveness of enterprises

CHAPTER 4

EXPERIMENTAL RESEARCH OF MODELS AND METHODS OF DECISION SUPPORT FOR INCREASING COMPETITIVENESS ON THE EXAMPLE OF LARGE TRADING COMPANIES

In the previous sections, we have shown the possibilities of using the developed software and tools for predictive modeling and decision support to analyze the activities and forecast the main indicators of competitiveness of small and medium-sized enterprises in the sphere of trade, production, scientific and technical, and financial and credit activities. To complete the picture and confirm the universal nature of the proposed models and methods in terms of research, analysis, evaluation, and forecasting of competitiveness, this section presents the results of experimental studies of the developed tools for intellectual analysis, predictive modeling of the largest network companies that are leaders of domestic retail. The main goal is a comparative analysis of the competitiveness of these companies in the process of benchmarking and making recommendations to support decision-making in the process of improving the efficiency of functioning in modern market conditions, taking into account the crisis phenomena and the impact on the competitiveness of various external and internal factors.

4.1 Selection of enterprises to analyze competitiveness indicators in the process of benchmarking and development strategy development

Large trade enterprises were selected for the pilot study, and the developed models and methods for managing the competitiveness of enterprises were tested as a part of the benchmarking process. The research was conducted using retrospective data collected from open sources (accounting and audit documents). Since the proposed model can be used to forecast financial and economic indicators for future periods based on the analysis of retrospective data, the results of the forecast are comparable with the actual obtained

indicators to confirm the adequacy of the proposed models and methods. The obtained data will later be used as input parameters for an automated decision support subsystem, which results in options for strategies to improve the competitiveness of a particular enterprise. The analysis of the company's performance is performed using the method of pairwise comparison with competitors in the framework of the benchmarking process model. Here is a description of the selected companies.

The first company is a well-known company «Magnet». This is Russian retailer that owns a chain of grocery stores of the same name. The analysis of economic indicators will be based on specific data obtained from open sources. The results of the analysis and evaluation will allow to calculate forecast indicators and compare them with actual indicators to check the adequacy of the proposed mathematical forecast model. For example, in the first quarter of 2013, the company received revenue of 126.3 billion rubles and had a retail network of 3,868 stores [78], and by the end of 2013, the company was among the five largest food retailers in the world by capitalization [79]. At that time, it had 6684 stores within walking distance, 147 hypermarkets, 30 «Family Magnet» stores and 713 cosmetics stores located in 1605 localities in Russia. Retail space was more than 1.97 million м². The company uses more than 4.7 thousand trucks to organize logistics. At the same time, motor transport companies operate at each distribution center of the company with an officially certified service. The company's net profit for 2013 amounted to 35.6 billion rubles [80].

We will choose X5 Retail Group as the second competing company. Russian company X5 Retail Group is the owner of «Pyaterochka», «Perekrestoк», «Karusel» and «Kopeyka» retail chains. The total retail network includes 1,472 «Pyaterochka» stores, 303 «Perekrestoк» supermarkets, 71 hypermarkets, 47 stores within walking distance, and 652 «Kopeyka» stores [81].

The third competing company had taken the company «Dixie» (the former company «Yunilend»). This is a Russian group of companies that also owns one of the largest food retail chains. The number of employees of the company is more than 35 thousand people. Consolidated revenue in 2012 was 147.02 billion rubles, and profit was 1.05 billion rubles [82, 83].

The Russian chain of «Ok» stores was chosen as the fourth company [84]. In 2012, the retail chain comprised 72 hypermarkets and supermarkets in St. Petersburg, Moscow, and other major cities. The company's net profit for 2012 amounted to 4.7 billion rubles [85].To model the benchmarking process in order to automatically develop recommendations to support

decision-making in managing competitiveness, a comparative analysis of existing business strategies of the listed companies was carried out.

The peculiarity of the company «Magnet» is that most of its space is leased. This results in expansive growth, but the efficiency of stores (profitability per unit area) is lower than that of X5 Retail Group. However, as a rule, the market share of an expansive company increases faster, since it is not burdened with its own real estate. The strategy of expansive market capture is most successful in the short and medium term (5 and 10 years), when the priority is to gain a foothold in the region ahead of the competitor and not let it go. However, in the long term, such companies need to move to an intensive path of development in order to confirm their leadership. The expert method for new fast-growing companies with a tendency to expand has shown that the optimal ratio is 30% of their own area to 70% of the leased area. For large companies that already have a sufficient market share, the most suitable inverse ratio of 70% to 30% with the prospect of increasing their own space to 100%, which will reduce rental costs. A comparison of the companies listed above for this indicator shows that «Magnet» and «Dixie» have about 30% of their own space, while X5 has about 60% for the same period of time (2008). X5 Retail Group's average revenue per unit of space was higher than Magnet's, while X5 Retail Group's net profit is not, and Magnet's net profit exceeded 25 billion rubles for 2012.

This means that «Magnet» was currently in the process of actively capturing the market. The «Dixie» company also repeats the «Magnet» strategy, but due to lack of resources, it can't compete adequately. X5 Retail Group has the maximum financial resources, but its strategy mistakenly did not take into account the possibility of competition and, therefore, «Magnet» successfully in 2012 began to occupy its market niche even in the Central region. «Magnet» has developed an optimal competition strategy by renting multiple premises for stores at low rates in small towns where other retail chains were poorly represented, and has achieved leadership in the domestic retail market due to the effective location of stores [86] within walking distance. This tactic of short-term rentals in places where there are already competitors is less risky, since in case of unprofitability of the store, you can abandon it with less losses than if this store was owned or built with your own funds. The opening of retail properties is associated with high capital investments, which are the main component of costs. This increases the cost of the error in case of an unsuccessful store location. However, in the long term, own space will allow to exclude rental costs from the cost of goods and thereby increase the competitiveness of the enterprise. In

addition, premises in the property increase the capitalization of enterprises in the context of a steady increase in real estate prices.

The analysis of market introduction strategies allowed to draw the following conclusion: increasing the presence in the regions is a priority direction for the development of retail networks. However, there is a problem of choosing between rapid growth with extensive expansion and planned development that is characterized by financial stability. Most experts believe that the amount of retail space in the property has little impact on the operating results of companies and in a growing market, the availability of real estate has little impact on the valuation of companies. On the other hand, experts believe that the more leased space, the higher the rental costs, which reduces profitability [87].

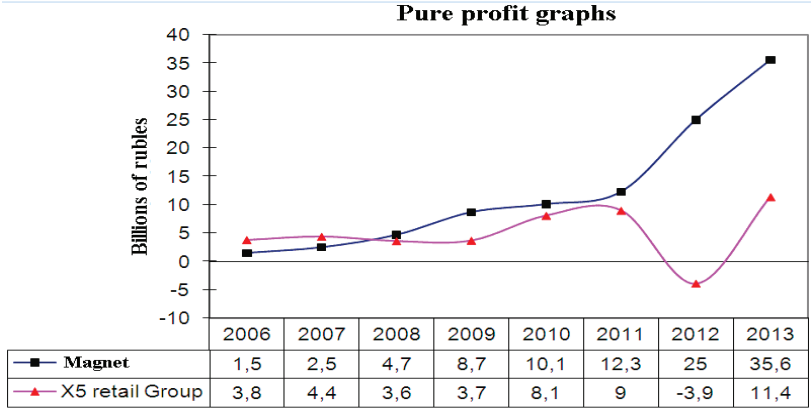
Let us choose the competitive pairs of companies to model the pairwise benchmarking process. Based on the above, we can conclude that «Magnet» and X5 Retail Group are competitors for their research in the framework of the benchmarking process. The object of benchmarking in this case is the key economic indicators (order parameters) of companies in the dynamics. As such, we take the following order parameters: annual net profit, annual gross profit, EBITDA, the company's share price, the total trading area of the company, and net revenue per unit of trading area.

The pair of benchmarking includes the company «Dixie» - «Ok». However, there are some features here. «Dixie» and «Ok» do not actually have a common target audience, as can be seen from the difference in the formats of their stores. Dixie gives priority to the format of stores within walking distance with the implementation of the discount mechanism, and «Ok» gives priority to the format of the hypermarket. However, in terms of net profit, EBITDA, gross profit, and coverage of the total territory, they may well act as partners for benchmarking. EBITDA (earnings before interest, taxes, depreciation and amortization) is equal to the amount of profit before deducting interest, tax and depreciation expenses.

The next stage of research is a pairwise analysis of 4 companies. The analysis allows to most accurately identify strengths and weaknesses, help you choose the optimal strategy for each company, and make a predictive scenario model that will allow to identify possible scenarios for the development of companies. Thus, the first pair of «Magnet» and X5 Retail Group companies, leading in the market, and the second pair of «Dixie» and «Ok» companies, will serve as benchmarking partners.

4.2 Analysis of the dynamics of changes in competitiveness indicators to develop recommendations for optimizing the development strategy of the DM

Collecting and processing information about companies ' activities to model the benchmarking process is implemented in the subsystem for collecting and analyzing large unstructured data on the Internet from public company sites. The collected information is grouped by research objects, importance and relevance, and then actual and model prognostic graphs are constructed [39]. Integral indicators and trends for net profit received by all companies were calculated for the years 2006-2013. Figure 4.1 shows graphs of net profit dynamics for «Magnet» and X5 Retail Group [39].



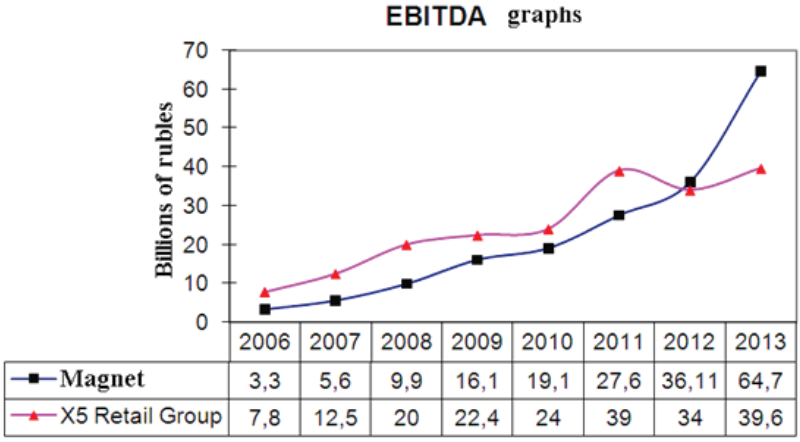
	2006	2007	2008	2009	2010	2011	2012	2013
Magnet	1,5	2,5	4,7	8,7	10,1	12,3	25	35,6
X5 retail Group	3,8	4,4	3,6	3,7	8,1	9	-3,9	11,4

Fig. 4.1. - Chart of pure profit dynamics of «Magnet» and X5 Retail Group

The graph shows that until 2008, Magnet was behind X5 Retail Group in terms of net profit. In 2008, they switched places, and the X5 Retail Group index continued to fall until 2009. In 2008, the crisis began, which lasted until 2012. The chart shows that the crisis hit X5 Retail Group more sharply than it hit «Magnet». There are several reasons for this. First, Magnet specializes in discounters, whereas X5 Retail Group has a majority of stores that are supermarkets, and in times of crisis, discounters are in high demand. In addition, X5 Retail Group adheres to the strategy of absorbing regional networks, which requires capital expenditures, as it requires funds for rebranding and debt payment. In addition, the strategy of «Magnet» is focused on renting space in order to faster payback and reduce capital costs,

and X5 Retail Group prefers to have its own stores, which requires capital expenditures.

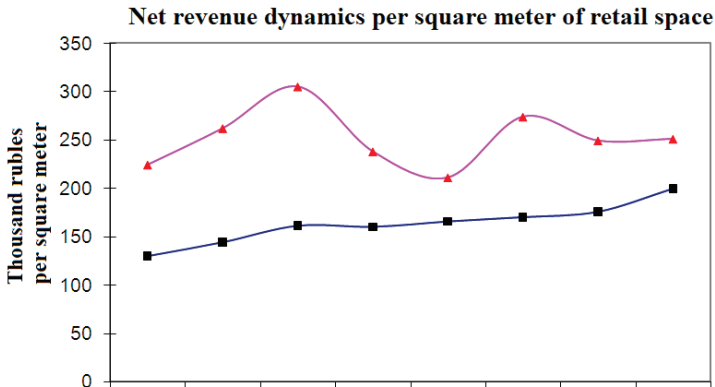
In the following Fig. 4.2 the obtained graphs of the annual EBITDA dynamics of «Magnet» and X5 Retail Group are presented. One can see that in 2011 there was a sharp surge in EBITDA for X5 Retail Group, and then a sharp decline. This is due to the General decline in the company, which could not prepare for the crisis, and lost its position to «Magnet». «Magnet» continues to grow exponentially [39].



	2006	2007	2008	2009	2010	2011	2012	2013
Magnet	3,3	5,6	9,9	16,1	19,1	27,6	36,11	64,7
X5 Retail Group	7,8	12,5	20	22,4	24	39	34	39,6

Fig. 4.2. - Graphs of EBITDA dynamics

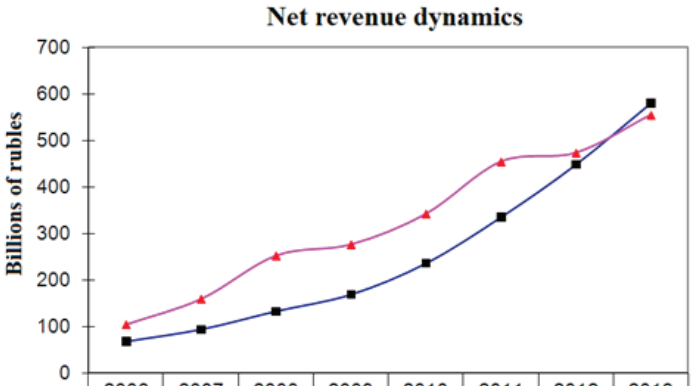
Figure 4.3 shows graphs of the net revenue per м² of retail space of Magnet and X5 retail Group for 2006-2013.The average revenue per м² for X5 Retail Group for 7 years is 252 thousand rubles (more than the same indicator for Magnet by 1.6 times). The chart shows a strong failure of X5 Retail Group in 2009-2010, which can be explained by a delayed response to the 2008 crisis. From the nature of the curves, it can be seen that the dynamics of the net revenue per unit area shows that Magnet uses an extensive (exponential) development strategy, while X5 Retail Group uses an intensive (oscillatory) strategy [39].



	2006	2007	2008	2009	2010	2011	2012	2013
Magnet	130	144,4	161,5	160,4	166	170,4	176	200
X5 Retail Group	224,3	262	305,2	238	211	274	249,3	251

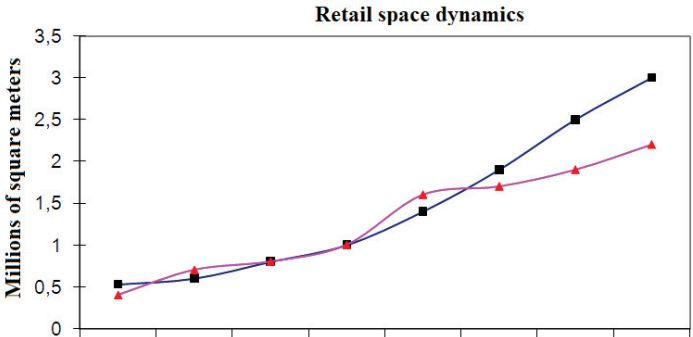
Fig. 4.3. - Dynamics of net revenue per square meter of retail space

In the following figures 4.4 and 4.5. graphs of net revenue dynamics and dynamics of the retail space of «Magnet» and X5 Retail Group are presented [58].



	2006	2007	2008	2009	2010	2011	2012	2013
Magnet	68	94	133	169	236	335	448	579,7
X5 Retail Group	104	159	252	276	342	454	473	554,4

Fig. 4.4. - Dynamics of pure company revenue



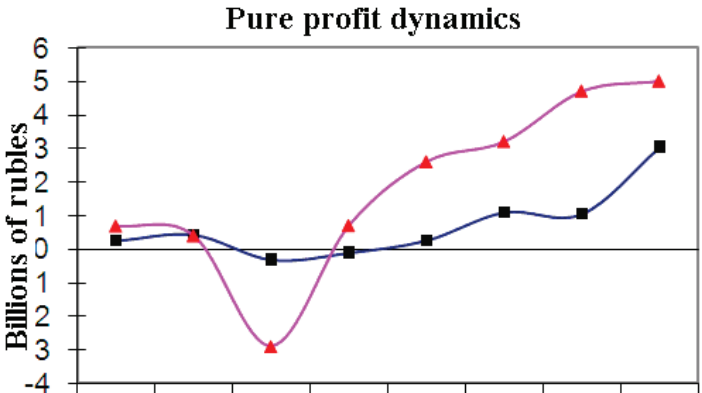
	2006	2007	2008	2009	2010	2011	2012	2013
Magnet	0,53	0,6	0,8	1	1,4	1,9	2,5	3
X5 Retail Group	0,4	0,7	0,8	1	1,6	1,7	1,9	2,2

Fig. 4.5. - The dynamics of the trade area

On these charts, you can see that the «Magnet» is growing exponentially, while the X5 Retail Group is gradually entering the oscillatory stage and the dynamics of its growth is decreasing. This is due to the fact that an internal management crisis is growing in X5 Retail Group, which appeared due to the fact that Magnet entered into competition with X5 Retail Group in the regions [89].

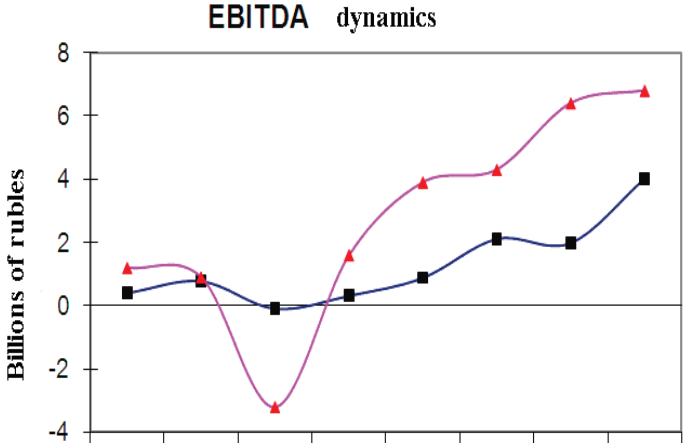
Next, let us to «Ок» at the results of the analysis of the dynamics of indicators of the companies «Ок» and «Dixie». To compare the dynamics of indicators, the dynamics of net profit and EBITDA of companies is studied (Fig. 4.6, and Fig.4.7) [39].

As follows from the nature of the curves for the «Dixie» and «Ok» companies, the performance of the companies for the period 2006-2013 represents an increase in the form of an exponent. Analysis of the dynamics of net profit and EBITDA indicates a weak dependence of trading activity on each other. This suggests that companies have permanent groups of customers and that they are isolated from each other. In order to increase profits, companies need to increase competition for customers by diversifying their products, creating new stores that target low-income segments of the population, and so on.



	2006	2007	2008	2009	2010	2011	2012	2013
Dixi	0,24	0,42	-0,3	-0,1	0,25	1,1	1,05	3,05
Ok	0,68	0,39	-2,9	0,7	2,6	3,2	4,7	5

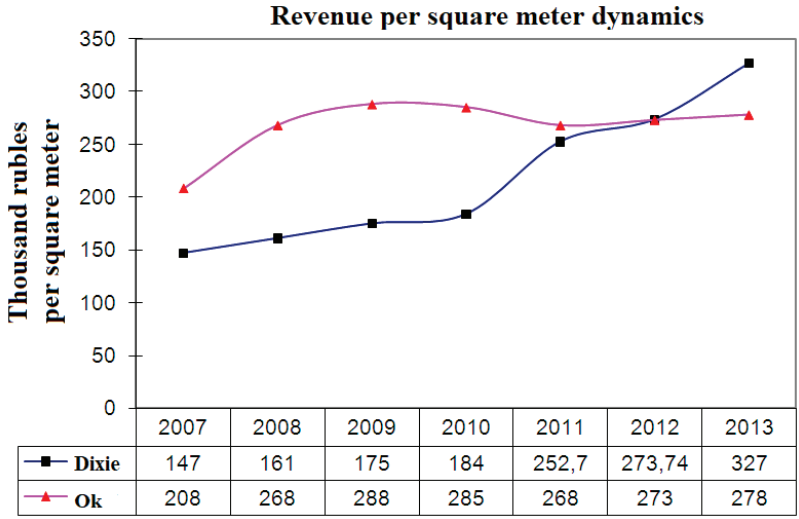
Fig. 4.6. - Annual dynamics of pure profit of «Dixie» and «Ok» companies



	2006	2007	2008	2009	2010	2011	2012	2013
Dixi	0,39	0,76	-0,1	0,30	0,87	2,1	1,97	4
Ok	1,2	0,9	-3,2	1,6	3,9	4,3	6,4	6,8

Fig. 4.7. EBITDA indicators annual dynamics of «Dixie» and «Ok» companies

The conducted intellectual analysis allowed to find out the degree of influence of net revenue attributed to the unit of area on the competitiveness of companies. To do this, we synthesized graphs of the ratio of net profit per unit area of stores (Fig. 4.8) [39].



	2007	2008	2009	2010	2011	2012	2013
Dixie	147	161	175	184	252,7	273,74	327
Ok	208	268	288	285	268	273	278

Fig. 4.8. - Dynamics of the ratio of revenue to retail space

From the chart, we can conclude that Dixie has a steady growth rate, while «Ok» has a downward trend. In 2012, the indicators of both companies actually converged at the same point. This point represents the bifurcation point from which the companies for this indicator diverged: one went down and the other went up. It is most likely that the decline in the efficiency of «Ok» will continue-this is evidenced by its tendency to reduce the profitability of retail space over the past years.

Figures 4.9 and 4.10 show the dynamics of net revenue and the area of «Dixie» and «Ok» retail stores [39].

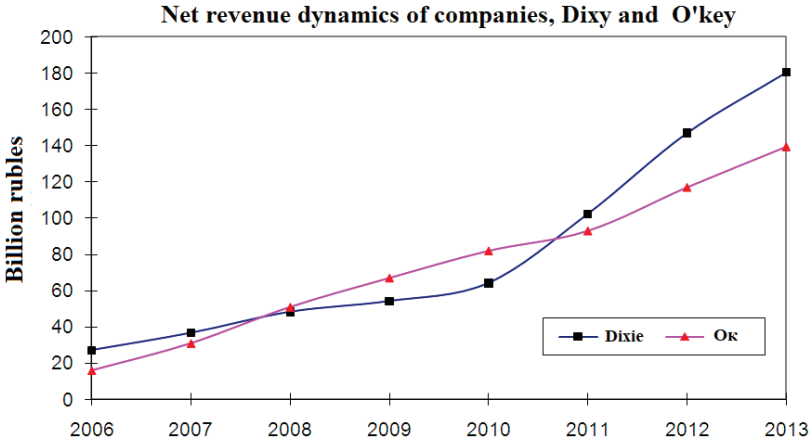
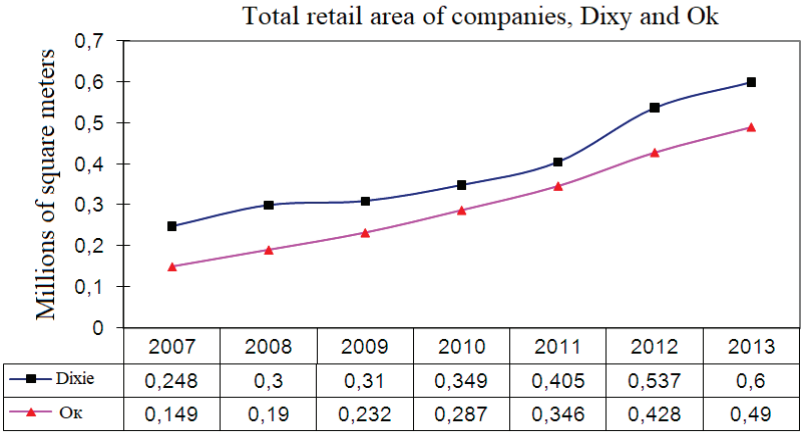


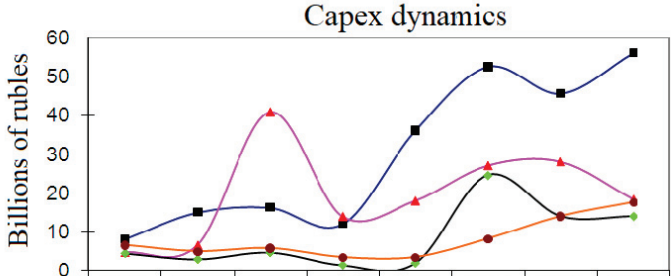
Fig. 4.9. - Net revenue dynamics of companies, «Dixie» and «Ok»



	2007	2008	2009	2010	2011	2012	2013
Dixie	0,248	0,3	0,31	0,349	0,405	0,537	0,6
Ок	0,149	0,19	0,232	0,287	0,346	0,428	0,49

Fig. 4.10. - Total retail area of companies «Dixie» and «Ok»

The results of the analysis of changes in capital expenditures of all four companies «Magnet», X5 Retail Group, «Dixie» and «Ok» for the period 2006-2013 are shown in Fig. 4.11 [39].

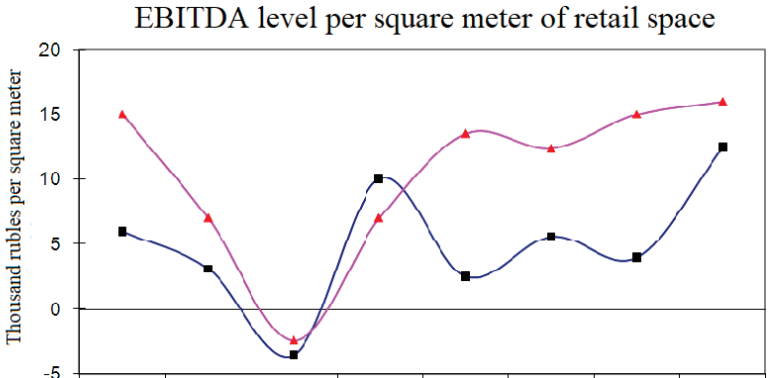


	2006	2007	2008	2009	2010	2011	2012	2013
Magnet	8,1	15	16,25	12	36	52,5	45,63	56
X5 Retail Group	4,8	6,6	40,75	14	18	27	28	18,4
Dixie	4,5	3	4,7	1,5	2	24,5	14	14
Ок	6,6	5	5,8	3,5	3,5	8,2	14	17,6

Fig. 4.11. - Dynamics of capital expenditures of 4 companies

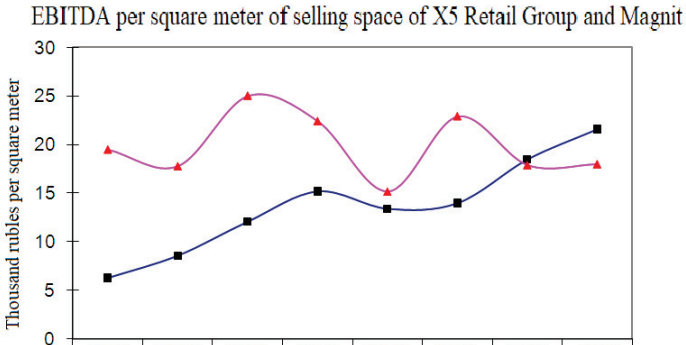
The graph shows that companies approach capital investments in different ways. «Dixie» and «Ok» are making cautious investments, having reduced this figure in 2009 due to crisis risks. The sharp decline in CAPEX (capital expenditure) in 2009 is visible for all four companies. The sharp surge in 2008 was mainly observed in X5 Retail Group. However, the depth of the failure of this company is the greatest, since during the crisis, capital expenditures stopped paying off. After the failure in 2009, all companies are trying to get out of the crisis as quickly as possible. Moreover, the sharpest increase in capital expenditures was observed in the company «Magnet» in 2011, and then after 2011, the indicators of X5 Retail Group and «Magnet» are smoothed out, but at «Dixie» they are growing sharply. The growth of costs in the company «Ok», following the general trend, is also growing, but is weaker than that of the competitors. At the end of the analyzed period, the companies are approximately at the same level, and the company «Magnet» becomes the leader.

The following figures 4.12 and 4.13 show the dynamics of the ratio of EBITDA to the square meter of retail space for two pairs of companies: «Magnet» and X5 Retail Group, «Dixie» and «Ok» [39].



	2006	2007	2008	2009	2010	2011	2012	2013
Dixie	6	3,1	-3,5	10	2,5	5,6	4	12,5
Ок	15	7	-2,4	7	13,5	12,4	15	16

Fig. 4.12. - . Level of EBITDA / m2 of retail space



	2006	2007	2008	2009	2010	2011	2012	2013
Magnet	6,3	8,6	12,1	15,2	13,4	14	18,5	21,6
X5 Retail Group	19,5	17,8	25	22,4	15,2	22,9	17,9	18

Fig. 4.13. - EBITDA level per square meter of retail space

As one can see, in 2008, there was a decline in the indicators of the company «Ок», which can be attributed to the failure in the Ukrainian market, where it was not possible to introduce its hypermarkets. In 2009-2010, a similar pattern was observed for both companies. A small failure at «Dixie» is related to the purchase of the Victoria chain of stores.

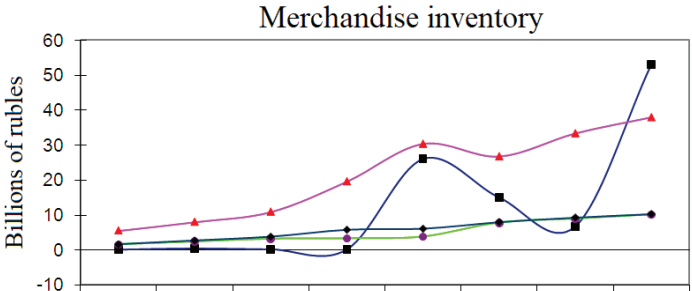
The maximum failure of X5 Retail Group occurred in 2010, when the «Kopeyka» chain of stores was purchased. As for the company «Magnet», the record CAPEX index in 2011 gave its result in 2012, when «Magnet» for the first time took over the X5 Retail Group and trended to increase.

According to the website [86] of «Magnet», an extensive development of the company has its risks. These include the lack of information about the real estate market in the Russian Federation, which makes it difficult to assess its value. The amount of available information about the real estate market in Russia is still limited, and it is less reliable than similar information about real estate markets in other industrial countries. The lack of information makes it difficult to estimate the market value and the rental value of real estate. Therefore, the value of real estate companies does not reflect the market value. The market price can decrease or increase as a result of three circumstances:

a) changes in the competitive environment;
b) changes in the level of attractiveness of real estate due to changes in regional risks;
c) changes in demand for commercial real estate.

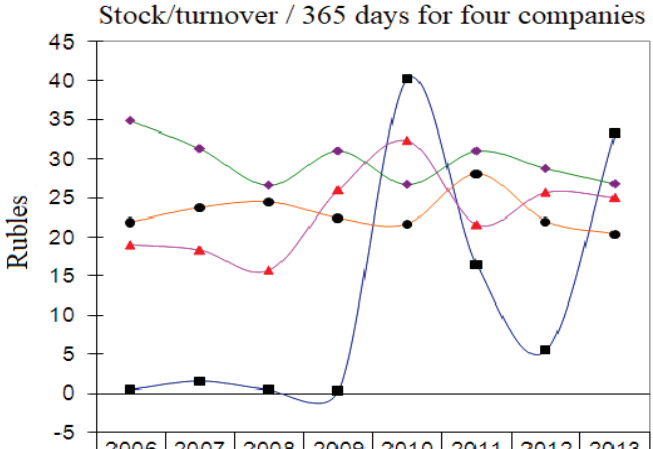
The current situation in 2014-2015 in the real estate market showed adverse changes that were manifested as a result of the sanctions policy. The value of purchased property is reduced for all companies, which negatively affects the value of assets. As a result of the sale of property, the company can compensate for the acquisition costs, which negatively affects its financial position.

The following indicators obtained from the analysis reflect the dynamics of changes in annual inventories (Fig. 4.14) and the dynamics of changes in the annual stock/turnover/365 days of companies (Fig. 4.15) [39].



	2006	2007	2008	2009	2010	2011	2012	2013
Magnet	0,08	0,402	0,16	0,14	26	15	6,7	53
X5 Retail Group	5,5	8	10,9	19,6	30,4	26,8	33,4	38
Dixie	1,6	2,4	3,2	3,3	3,8	7,8	8,9	10,1
Ок	1,5	2,6	3,7	5,7	6	7,9	9,2	10,2

Fig. 4.14. - Dynamics of annual inventory



	2006	2007	2008	2009	2010	2011	2012	2013
Magnet	0,43	1,5	0,43	0,30	40,2	16,3	5,46	33,3
X5 Retail Group	19	18,3	15,7	26	32,4	21,6	25,7	25
Dixie	21,9	23,7	24,4	22,4	21,7	28	22	20,4
Ok	34,8	31,3	26,6	31	26,7	31	28,7	26,7

Fig. 4.15. - Dynamics of the stock/turnover/365 days parameter

From the analysis of the charts, we can make a number of important conclusions about what the dynamics of the company's trading stock indicators and the company's stock/turnover/365 days show. The company «Magnet» shows oscillatory activity, which is known for exponential steady growth of most indicators. With a linear increase in the trade inventory indicator at the end of the year, the stock/turnover/365-day indicator tends to decrease for almost all companies. This suggests that the companies tend to increase their efficiency when the growth rate of product turnover exceeds the growth rate of trade stock. However, the company «Magnet» shows the opposite trend. The graphs show that in five points out of eight, Magnet is significantly lower than other companies in terms of these indicators. In the first four years, the indicators are extremely low compared to other companies. It can also be noted that in 2012, when «Magnet» doubled its net profit, the indicators were also lower. One can conclude that the smaller the inventory at the end of the year, the better and this shows that the company is working effectively, and that the demand for its products is high. In 2013, «Magnet» became the leader in revenue, but the growth rate of net profit slowed down, despite the fact that the inventory was the highest for all time observations. Whether this is good or bad depends on the chosen strategy. Thus, «Magnet» prefers a growth strategy with an established logistics system. However, efficiency is lagging behind extensive growth. By adding more stores, «Magnet» is losing efficiency. This is facilitated by entering less developed regional markets, where purchasing power is lower. Expansion into low-budget regions does not generate the same revenue as in solvent regions. Other companies combine weak extensive growth with low efficiency growth. For X5 Retail Group, the final performance indicator (net profit) is at a low level due to the debt load. The factors presented in the latest graphs have their own mathematical meaning in the Van der Pol model. In particular, the company's stock / turnover/365 days corresponds to the coefficient T in the system of equations and the dynamics of the average annual trading stock is described by the Z function.

4.3 Predictive modeling and assessment of the competitiveness of «Magnet» and X5 Retail Group companies in the benchmarking process

At this stage of the study, in order to conclude the applicability of the mathematical model proposed in the second chapter in the form of a system of coupled Van der Pol equations, a method for analyzing the financial reporting indicators (profit and EBIDTA) of the companies considered is being implemented. As an example, we will analyze two retailers «Magnet» and X5 Retail Group in the framework of benchmarking, which are similar in terms of parameters and have common customers. To solve the problem of predictive modeling and verification of the proposed mathematical model based on the system of coupled Van der Pol equations, the model was set up to predict the dynamics of net profit of the first pair of companies «Magnet» and X5 Retail Group for 2013-2015 with an increase in three initial parameters. Let the average annual level of capital expenditures increase by 20% for the company «Magnet» to 51.6% (the initial figure is 43%), and for the company X5 Retail Group also by 20% for 102% (the initial figure is 85%). Let us take an increase in the average number of employees of both companies by 50% per м² of retail space, and the company's turnover by 20% per м² of retail space. This increase in baseline indicators was obtained on the basis of expert analysis of actual observations of real data published on the Internet, and experimental confirmation of their impact on net profit. For the simulation, predictive modeling was performed for three scenarios of competing companies ' behavior in the market: optimistic, pessimistic, and optimal for each of the companies. Descriptions of the three scenarios and initial data (values of input coefficients and functions) for mathematical predictive modeling, which were entered into the system of equations, are given in Table 4.1.

Table 4.1 Initial data for predictive modeling

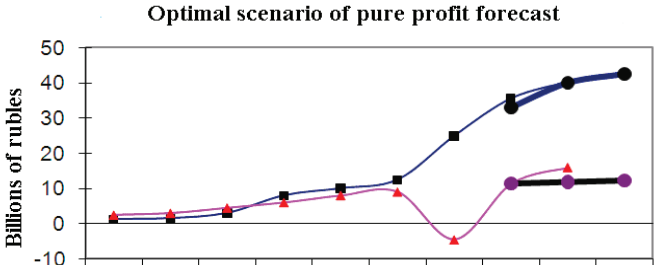
	Optimistic scenario	The pessimistic scenario	The optimal scenario
Description of company scenarios «Magnet» and X5 Retail Group	1. «Magnet»: sustained organic growth is maintained, while improving performance indicators, the influence of the main competitor is reduced (X5 continues the strategy of merging and absorption, thereby inhibiting its development with capital and time costs for rebranding stores and profitability). The CAPEX index is growing, the number of employees / 100 sq. m. is growing, and the turnover is growing due to well-built logistics and attracting additional employees for increased turnover of cash registers. The market situation is favorable. 2. X5 Retail Group: the company is moving smoothly from an aggressive absorption strategy to an organic growth strategy, working to improve the	1. «Magnet»: stagnation begins, the growth rate of net profit falls, first of all, the threat of stock and bond «overload». Increase in rent for chain stores that are under lease. The decrease in performance indicators in most leased stores, the development of the process of «cannibalism», when the company's stores select customers from each other, their partial closure due to the exceeded rate of expansion, insufficient exploration of the region, CAPEX decreases compared to the average nominal value, there may be a decrease in the growth rate of capital investment, reduction of the number to the level when the speed of processing of cargo turnover decreases, the number per 100 sq. m. does not correspond to the potential turnover	1. «Magnet»: «Magnet» continues to successfully pursue its organic growth strategy. Indicators of increasing profitability do not exceed the average price. CAPEX increases according to the average annual growth rate. Labor productivity is increasing due to the improvement of the structure of trade turnover. The trade turnover is growing according to the planned growth rate. 2. X5 Retail Group: X5 is gradually moving from an acquisition and rebranding strategy to an organic growth strategy and it emphasizes on improving the efficiency of supermarkets and hypermarkets, bringing them from the bottom to the average industry level. SAREH is growing according to the company's plan. The turnover is growing according to the company's plan.

	profitability of its bottom lines. Debt indicators are decreasing. Part of the shops «Crossroads» translated to «roundabout», as an experiment, which aims to increase the turnover of the network (assuming a preliminary exploration, through surveys, monitoring, and experimental rebranding a number of shops, etc., hypothetical situation). The reduction in CAPEX, the increase in turnover of companies, the competent organization of the number of store employees to stop the process of reducing staff, closing unprofitable retail facilities, downsizing of stores in loss-making stores and their «transfer» into a more successful (hypothetical situation). The trade turnover increases due to organic growth. The market situation is favorable.	(decreases, does not have time to increase the sales area) turnover / sq. m. decreases (decreases, does not have time to increase the sales area). Turnover is declining because new stores are opening in places with less market capacity. The market situation is unfavorable. 2. X5 Retail Group: the pessimistic scenario is based on the fact that the company's CAPEX is rising sharply (by 20% of the average annual value), there is excessive absorption, while the growth rate of turnover is falling, stagnation in the supermarket format and a crisis in the hypermarket format continues. Strict staff optimization continues. The market situation is unfavorable.	

Initial data for modeling (coefficients and functions): X_1, X_2 - indicators of average annual net profit of companies taken from 2006; a_1,a_2- number of staff /100m2 of space; Z_1,Z_2 – variables that reflect the performance of logistics and distribution centers over time (a function proportional to the average annual value of inventory); T_1, T_2 - average rate of change in inventory; b_1, b_2 - turnover per unit area of the first and second companies; ω_1, ω_2 - values that are the inverse of the turnover time equal to the annual or monthly periods; r_1, r_2 - constant coefficients proportional to capital expenditures (CAPEX indicator); F_1, F_2 - periodic functions for displaying the resonant influence of CAPEX; d_1 - a coefficient equal to 0.001 of the competitor's average annual market share; F_3 - random function; k_1, k_2 - coefficients of ownership of confidential information; c_1, c_2- coefficients of possession of everyday information (equal to 0.8).			
X_1, X_2	Average annual profit of companies since 2006 The «Magnet» is 1.5 billion rubles X5 Retail Group - 3.8 billion rubles		
$a_1 a_2$	1.2 for both companies	1 for both companies.	1 for both companies
b_1, b_2	The «Magnet» is 1.6 X5 Retail Group-1.5	«Magnet»-1,2 X5 Retail Group-1.1	«Magnet» and 1.4 X5 Retail Group-1.3
r_1, r_2	The «Magnet» is 1.6 X5 Retail Group-1.6	«Magnet»-1,2 X5 Retail Group-1.8	«Magnet» and 1.4 X5 Retail Group-1.8
d_1	0.56 for both companies		
k_1, k_2	0.5 for both companies		
	1 for both companies		

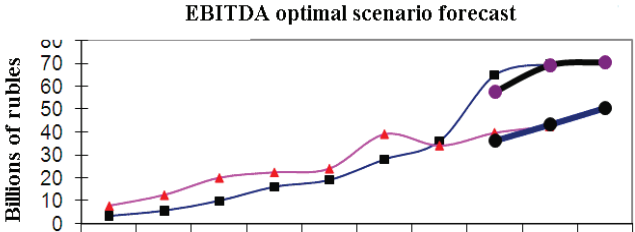
As a result of the predictive modeling module, we obtained graphs of the forecast of changes in the net profit of «Magnet» and X5 Retail Group for 2013-2015 based on the Van der Pol mathematical model for all three scenarios. We will analyze the results of modeling the dynamics of net profit and EBITDA for the optimal scenario of competitors ' development (Fig. 4.16 and Fig. 4.17) [39].

The capital investment indicator creates a fluctuating activity for X5 Retail Group, which is caused by the inconsistency of the company's economic policy. Other indicators and coefficients are equal to their nominal values when the model is initialized.



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Magnet	1,2	1,5	3	8	10	12,	25	35,	40,	
X5 RG	2,5	3	4,5	6	8	9	-4,	11,	15,	
Magnet forecast								33	40	42,
X5 RG forecast								11,	11,	12,

Fig. 4.16. Graphics of the forecast profit dynamics



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Magnet	3,3	5,6	9,9	16	19	28	36	64,	69,	
X5 Retail Group	7,8	12,	20	22,	24	39	34	39,	42,	
Magnet forecast								57,	69,	70,
X5 forecast								36	43	50,

Fig. 4.17. - Prognostic graphs of the net profit changes of companies «Magnet» and X5 Retail Group

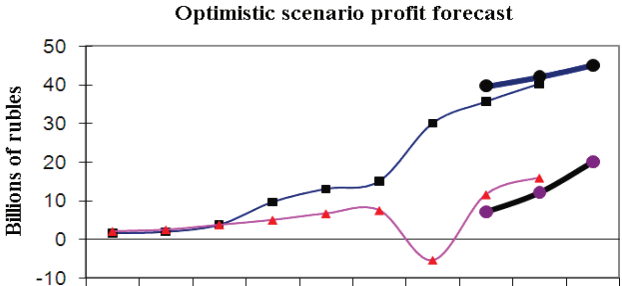
Note that the mathematical model allowed generating in the scenario analysis module a number of similar scenarios for increasing changes in competitiveness (from 3 to 5) with the same input parameters, which is a feature of nonlinear dynamic systems. This fact proves that the benchmarking process is the most optimal when considering paired interactions of similar companies in the market.

The 2011 EBITDA forecast chart shows a sharp spike for X5 Retail Group, followed by a sharp decline. This is due to problems at X5 Retail Group, which was unable to prepare for the crisis and lost its position to «Magnet». However, the X5 Retail Group website [104] failed to find critical comments on its economic policy. The main strategy of X5 Retail Group is to maximize the use of a multi-format retail network. At the same time, the company focuses on the following aspects of its business:

- selection of high-quality products based on multi-format positioning and transition to the range of products according to customers ' needs.
- interested and motivated staff;
- positive reputation of brands, support of their recognition by means of advertising and promo actions;
- increase in retail space as part of a regional expansion with a geographical presence;
- cost and loss control, logistics optimization;

- increased investment in improving stores, as well as improving customer service based on feedback channels;
- improvement of the employee evaluation and motivation system;
- establishing and strengthening relations with local producers, increasing their product range;
- maintaining relations with charitable organizations;
- increase in direct imports, especially of fruits and vegetables;
- increasing the share of own brands in the assortment, etc.

Consider the results for an optimistic scenario (Fig. 4.18) [39].

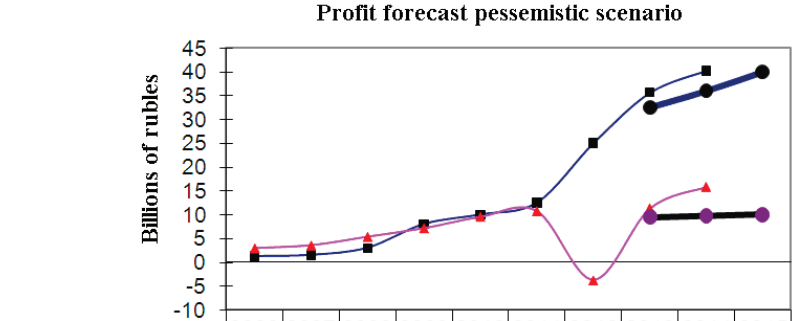


	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Magnet	1,5	1,8	3,6	9,6	13	15	30	35,	40,	
X5 Retail Group	2,0	2,5	3,7	5	6,6	7,5	-5,	11,	15,	
Magnet forecast								39,	42	45
X5 forecast								7	12	20

Fig. 4.18. Optimistic prognostic graph of the net profit dynamics of the companies of retail trade «Magnet» and X5 Retail Group

From the obtained prognostic charts, it can be seen that the net profit of the company «Magnet» in 2013-2015 will increase to about 40 – 42 billion rubles per year. The chart of profit dynamics of X5 Retail Group predicts an increase in profit to 7-12 billion rubles in 2015. When modeling an optimistic scenario, it was assumed that «Magnet» continues to work on a proven organic growth strategy, while X5 Retail Group stops mergers and acquisitions and acts cautiously. It should be noted that the indicators of turnover were not considered in the model, since they are a consequence, not a cause, of profit growth. The graph shows that the crisis of 2008-2009 had a stronger impact on X5 Retail Group than on «Magnet». The reason for this is the large investment of X5 Retail Group, which was currently engaged in the absorption of regional competitors ' companies [82]. The

forecast results were also influenced by the companies' approaches to renting retail space. From the beginning, «Magnet» is focused on leasing, and X5 Retail Group is focused on using its own retail space, which requires increased capital expenditures. In the forecast period from 2013 to 2015, one can see the positive dynamics of the efficiency of both companies, which confirms the correctness of the optimistic development scenarios they have chosen, which are proposed by the author of the book. In our opinion, an optimistic strategy for «Magnet» is the «organic growth» strategy, which allowed the company to dominate the market since 2012 [86] in all economic indicators. For X5 Retail Group, this strategy may also be an organic growth strategy, which it should adopt instead of a strategy of absorbing competitors and rebranding them. The results of the forecast prove the correctness of this strategy for X5 Retail Group, which has not made any major acquisitions since 2012, which has had a positive impact on the net profit indicator. However, previously made capital expenditures for the acquisition of property, made on borrowed funds, led the company to credit obligations, which for a number of years will reduce the effectiveness of competitiveness in comparison with the company «Magnet», which is more competitive, as shown by the forecast chart. Let's analyze the results for a pessimistic scenario (Fig. 4.19) [39].



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Magnet	1,2	1,5	3	8	10	12,	25	35,	40,	
X5 Retail group	3	3,6	5,4	7,2	9,6	10,	-3,	11,	15,	
Magnet forecast								32,	36	40
X5 forecast								9,5	9,7	10

Fig. 4.19. Pessimistic prognostic graph of the net profit dynamics of the companies of retail trade «Magnet» and X5 Retail Group

The resulting forecast graph showed an increase in net profit of «Magnet» in 2015 to 38-40 billion rubles. For the dynamics of net profit of X5 Retail Group, the model predicts a decrease (compared to the optimal forecast) to 9.7-10 billion in 2015.

The pessimistic scenario is based on the assumption that the market behavior scenarios chosen by companies are erroneous. At the same time, the charts showed that even for such a scenario, the most successful development strategy was adopted by «Magnet», which led X5 Retail Group to failure in 2012. However, it is clear that X5 Retail Group is beginning to gradually regain its position in the market. Magnet's strategy, on the contrary, proves that its competitiveness remains high even in times of crisis, as the increase in wholesale prices in modern conditions hits companies that have higher credit obligations and incur higher operating costs. In addition, the format of discounted trade of «Magnet» is the most stable in times of crisis, which contributes to the outflow of customers from stores of other formats. The results of the simulation show that the most effective way to increase competitiveness is the activity of «Magnet», which is an extensive approach with a short-term strategy for exponentially increasing sales. However, the main advantages of this approach are shown only in the short term and consist in a sharp increase in sales due to cheapness, capture of new markets and creation of new areas. In the future, competitive risks of loss of purchasing power become more significant, which are caused by low quality of products and services, weak customer involvement in the store's policy through surveys, lack of bonus mechanisms for attracting customers, etc. The result is stagnation and decline in the long term. X5 Retail Group, despite its failures in 2008 and 2012, has a margin of safety due to attracting different segments of the population, implementing IT innovations, establishing flexible links with suppliers, and targeting a stable target audience linked to stores by a system of cumulative bonuses [86]. Therefore, X5 Retail Group, in the long term, has the potential to lead it to the market leadership. The main advantages: orientation to different segments of the population, diversification of products and stores, orientation to customer feedback, focus on forming their customers, feedback from customers and suppliers, transition to electronic document management, etc. The main disadvantages are underestimation of discount stores, the desire to dominate in different segments, inflexible policy in a crisis.

The main conclusion from predictive modeling of a pair of companies in the framework of the benchmarking process is the following [47]: in a crisis (shown in the forecast charts), the company's policy is more effective, which

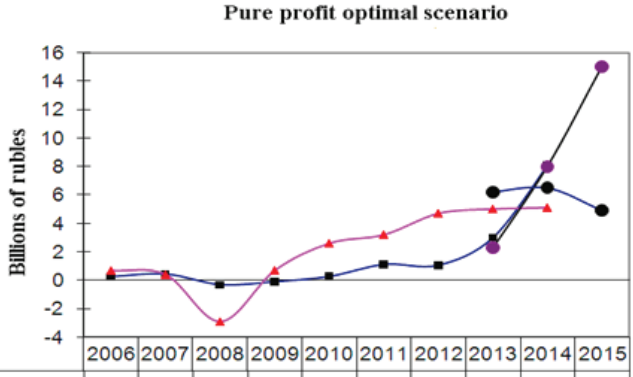
is based on a strategy of low prices and extensive market capture. In a well-functioning market, a company with large capital investments, implementation of innovative mechanisms and orientation to different segments of the population has more competitive opportunities to realize its leadership potential.

In the process of modeling, when the CAPEX indicator increases by 20%, X5 Retail Group has an additional load on the net profit indicator, which is associated with the policy of absorption of retail chains. With the growth of this indicator, the company «Magnet» has the opposite effect, because its stores quickly recoup the money invested by renting.

4.4 Results of predictive modeling on the example of «Ok» and «Dixie» companies in the process of pair benchmarking

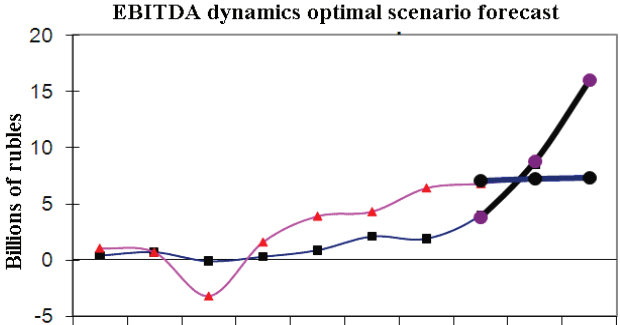
This section presents the results of predictive modeling and analysis of the work of the companies «Ок» and «Dixie». Although the simulation was performed for all three scenarios, the section provides forecast graphs only for the optimal scenario due to the limited scope of the book. Figures 4.20 and 4.21 show graphs of the dynamics of net profit and EBITDA (billion rubles) / year for «Dixie» and «Ок».

As follows from the nature of the curves of similar companies «Dixie» and «Ок, the economic policy of these companies for the period 2006 – 2012 represented an exponential growth. Analysis of the dynamics of net profit and EBITDA for 2006-2012 indicates a weak dependence of their trading activity on each other. This suggests that the companies have a constant group of customers and a high degree of isolation from each other [39].



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dixie	0,2	0,4	-0,	-0,	0,2	1,1	1,0	3	8,1	
Ок	0,6	0,4	-2,	0,7	2,6	3,2	4,7	5	5,1	
Dixie forecast								2,3	8	15
Ок forecast								6,2	6,5	4,9

Fig. 4.20. - Graphs of the optimum forecast of dynamic changes of net profit of the companies «Dixie» and «Ок»



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dixi	0,4	0,7	-0,1	0,3	0,87	2,1	1,9	4	8,5	
Ok	1,05	0,7	-3,2	1,6	3,9	4,3	6,4	6,8	7,4	
Dixi forecast								3,8	8,8	16
Ok forecast								7	7,2	7,3

Fig. 4.21. Graphs of the optimum forecast of dynamic changes of the EBITDA parameter of the companies «Dixie» and «Ок»

Then, to increase profits, the companies need to increase competition for customers. As recommendations, one can offer a product diversification, creating new stores with a discount format of trade. Judging by the presence of fluctuations at the beginning of the net profit schedule, the transition to a balanced trade and economic policy in these companies will not present difficulties.

4.5. Experimental studies of the influence of coefficients and functions of the mathematical model on competitiveness for making decisions to improve it

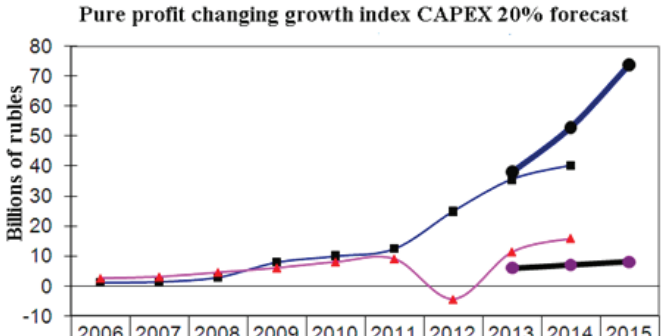
This section presents the results of mathematical modeling and research of the behavior of competing companies in the benchmarking process to assess the impact of the initial parameters of the model on the main indicator of competitiveness-the dynamics of changes in net profit. The main goal of such studies is to experimentally select such values of coefficients and functions that affect competitiveness, which, based on the results of predictive modeling, give the maximum growth in net profit. This allows to develop logical decision-making rules for the DM to manage the competitiveness of your own enterprise. To do this, all competitors ' businesses are selected on the market. Next, we select pairs of companies with the most similar characteristics that can be studied on this model in the process of pair benchmarking. For each company in the pair, information is searched and processed using a search robot on the Internet. First of all, data is extracted from the balance sheets published in the network for the past periods. The necessary data is normalized and recorded in the database for subsequent extraction and use as coefficients of the developed mathematical model and for assessing the competitiveness of enterprises from each pair. In addition, for each set of coefficients in the knowledge base of the expert subsystem, a set of decision rules is recorded in the form of recommendations for improving competitiveness or conclusions on situations that will happen if the source data takes the appropriate values. An example of the first type of rules: «to increase the profitability of a company with a discounted trading format by 2 times, it is advisable to increase the capital expenditure index by 20%». An example of the second type of rules: «if the coefficients r_1 , r_2= 1,2, coefficients b_1,b_2=1,2, then the profit of a company with a discounted trading format will increase by an average by 2 times, and a company with sales through a supermarket chain by an average 70%» , etc.

A set of recommendations and rules with simulation results are issued for the DM after the collection and analytical processing of retrospective data by the expert component of the decision support system and competitiveness management. In addition, the predictive modeling subsystem provides graphs with the results of automatic forecasting of changes in the competitiveness index (profit dynamics) in the short and medium term for various input parameters for comparison of the selected enterprise development strategy with alternative scenarios to management personnel, owners, and DM. Comparative analysis can also be performed automatically in the scenario analysis subsystem, where the results of predictive modeling for different vectors of the initial values of the order parameters are compared and the most optimal forecast options and corresponding parameter vectors are selected for developing the enterprise development strategy and evaluating the possibility of changing these parameters to the recommended values.

In order to fill in the knowledge base, generate recommendations and forecast graphs for DM, an experimental study of the developed mathematical model is necessary in order to assess the impact of various factors on the main indicator of competitiveness – the dynamics of changes in net profit for pairs of the competing companies in the process of benchmarking. For this purpose, the model system of equations includes coefficients that reflect a particular factor that may have an impact on the company's main indicators in the future. As a result, of modeling, the forecast graphs are obtained that reflect the trends in the behavior of companies in the market when the values of parameters change or when the current situation is in order to select their optimal values. In the process of research, specific goals are set in the field of improving the efficiency of the company's operation and increasing its competitiveness. Based on the results of the research, specific recommendations have been developed for most companies of different types in each of the areas of their operation under consideration. When modeling and analytical processing of the set goals in the process of the research described in the book, a lot of illustrative material was obtained in a form of graphs, tables, flowcharts and diagrams, which clearly reflect the various parameters of companies, as well as their impact on the overall dynamics of companies ' competitiveness. Due to the volume of the book, this section presents only a small number of examples of the impact of various factors on profitability and competitiveness for a pair of trading companies in the benchmarking process.

4.5.1 Assessing the impact of CAPEX on competitiveness

In the following figure (Fig. 4.22) the forecast graphs of changes in the net profit of «Magnet» and X5 Retail Group for 2013-2015 are presented, with an increase in the annual level of capital expenditures for «Magnet» by 20% to 51.6% (an average annual increase of 43%), and an increase of 20% for X5 Retail Group to 102% (an average annual increase of 85%) [39].



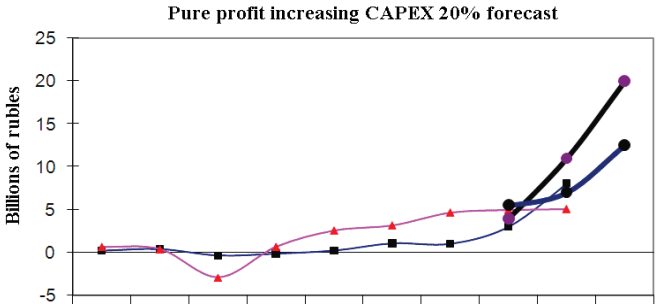
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Magnet	1,25	1,5	3	8	10	12,5	25	35,6	40,2	
X5 Retail Group	2,5	3	4,5	6	8	9	-4,5	11,4	15,9	
Magnet forecast								38	53	74
X5 forecast								6	7	8

Fig. 4.22. - Hypothetical graphs of net profit dynamics of «Magnet» companies and X5 Retail Group under average annual CAPEX increase by 20%.

The initial data for mathematical modeling were set as follows: - CAPEX indicators for companies are equal to 1.2 (20% more) compared to the original values. The remaining indicators correspond to the values in summary table 4.1. On the chart, you can see that a 20% increase in CAPEX affects companies in different ways. The increase in this indicator leads to an improvement in net profit indicators for «Magnet» and a deterioration for X5 Retail Group. This is due to the fact that the companies in different ways try to manage capital costs. The selection of the 20% increase allowed to get the most optimal forecast for both companies. Similar graphs were constructed for increment values from 10% to 100% in increments of 10%. Thus, as a result of experimental research on the Van der Pol mathematical model, the optimal ratio for the CAPEX indicator was selected, which is very likely effective for any trading companies. The value of 20% was optimal, since this value changes capital expenditures in the business

development process according to the proposed model for the end result of predictive modeling is more weakly affected by other important factors, and the influence of this factor becomes appreciable for the system of equations. When an indicator exceeds 20%, this indicator is leveled, which makes it difficult to assess the extent of its influence.

The following figure shows graphs of the dynamics of the net profit of «Dixie» and «Ok» companies with a hypothetical increase in the average annual capital expenditure of CAPEX by 20% (Fig. 4.23) [39].

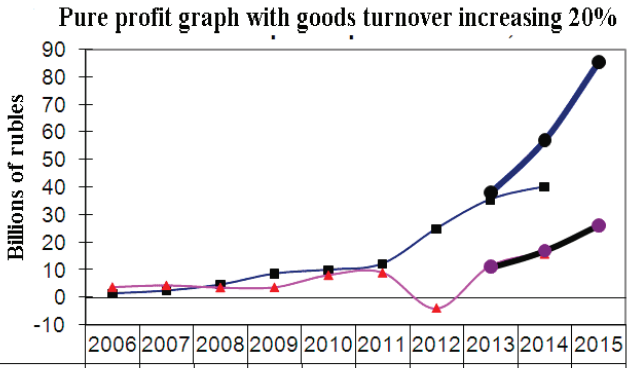


	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dixi	0,24	0,42	-0,3	-0,1	0,25	1,1	1,05	3,05	8,1	
Ok	0,68	0,39	-2,9	0,7	2,6	3,2	4,7	5	5,1	
Dixi forecast								4	11	20
Ok forecast								5,5	7	12,5

Fig. 4.23. - Hypothetical graphs of net profit dynamics of companies «Dixie» and «Ок» under average annual CAPEX increase by 20%.

4.5.2 Assessment of the impact of the indicator turnover/ м^2 of retail space

In the framework of experimental studies of the mathematical model, hypothetical graphs of changes in the profits of competing companies with an increase in turnover/m2 of area by 20% were obtained (Fig. 4.24) [39]

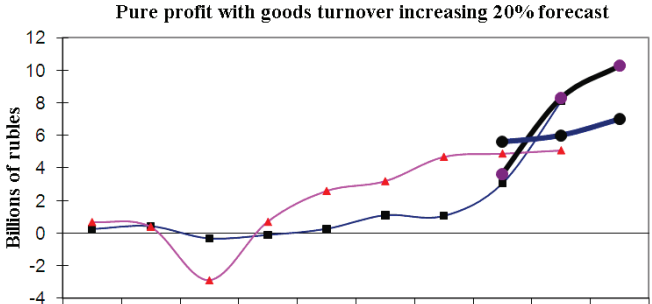


	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Magnet	1,5	2,5	4,7	8,7	10,1	12,3	25	35,6	40,2	
X5 Retail Group	3,8	4,4	3,6	3,7	8,1	9	-3,9	11,4	15,9	
Magnet forecast								38	57	85,5
X5 Retail Group forecast								11	17	26,3

Fig. 4.24. - Hypothetical graphs of profit competitors «Magnet» companies and X5 Retail Group while increasing turnover / square m by 20%

For the simulation, the following initial data were set: - the turnover / $м^2$ for the company «Magnet» was taken as a unit, and the same indicator for X5 Retail Group was taken as 1.4, since the value of the indicator was more than that of «Magnet» by 1.4 times for 2012. The remaining indicators correspond to the values in summary table 4.1. It is known that trade turnover is a multi-factor property that depends on the volume of customer traffic, logistics, teamwork of staff, and other factors. One of the reasons for the increase in turnover is the capacity of the cash register store (if there is a lot of traffic and demand for goods). The increase in turnover is the reason for the increase in revenue and, consequently, net profit. Magnet's lower net profit is driven by an increasing rental rate, while X5 Retail Group's net profit is driven by loan repayments.

The following figure shows graphs of the dynamics of the net profit of «Dixie» and «Ок» companies with a hypothetical increase in turnover by 20% (Fig. 4.25) [39].



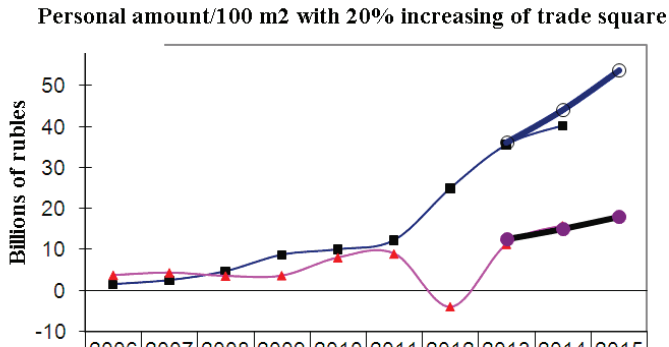
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dixi	0,24	0,42	-0,3	-0,1	0,25	1,1	1,05	3,05	8,1	
Ok	0,68	0,39	-2,9	0,7	2,6	3,2	4,7	4,9	5,1	
Dixi forecast								3,61	8,3	10,3
Ok forecast								5,6	6	7

Fig. 4.25. - Hypothetical increase in turnover by 20% for companies «Dixie» and «Ок»

4.5.3 Assessment of the impact of the number of employees/100 м^2 indicator

In the following figure (Fig. 4.26) the forecast graphs of changes in the net profit of companies for years with an increase of 20% in the number of store staff/100 м^2 of retail space [39] are presented.

Initial data for modeling: normalized coefficients equal to 1.2 compared to the initial value (5 people/100 m2) taken per unit, the remaining indicators correspond to the nominal model values from table 4.1. The 20% increase in staff brings great benefits for the company «Magnet», as can be seen from the model. The fact is that the traffic of «Magnet» stores is constantly increasing, which is especially noticeable during the crisis due to discounted pricing.



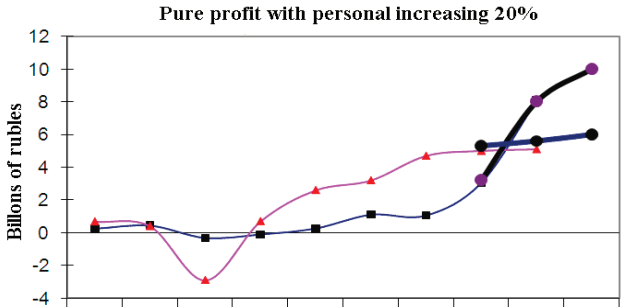
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Magnet	1,5	2,5	4,7	8,7	10	12,	25	35,	40,	
X5 Retail Group	3,8	4,4	3,6	3,7	8,1	9	-3,	11,	15,	
Magnet forecast								36	44	53,
X5 forecast								12,	15	18

Fig. 4.26- Net income rise with an increase by 20% the number of store personnel / 100 м^2 of retail space in «Magnet» and X5 Retail Group companies

Despite the fact that according to the discount format of trade, the number of store staff should be minimal, when traffic increases, it is necessary to increase the staff at the cashier offices so that there are no queues. This is especially necessary in rented areas, since such premises are often not adapted for mass trade and can create great inconvenience for customers. Therefore, as shown by the results of the simulation, it is the increase in staff that leads to a higher payback, as it solves the problems of queues, increases traffic and turnover, which ultimately leads to an increase in profit and increased competitiveness for stores of this type while keeping prices at a fairly low level. For stores that operate on their own premises (X5 Retail Group), which are more adapted for the convenience of customers, the impact of changes in the indicator on profit and competitiveness is less significant, as shown by the simulation. The 20% increment was also obtained from simulations with values from 10 to 100% in increments of 10. Charts with maximum forecast values for both types of stores were obtained for this value. These results can be explained by the fact that in any stores, the main influx of visitors takes about 20% of the time of the working day, when most people end the working day and at lunchtime. An increase of 20% in the number of small stores is due to the attraction of new cashiers who will serve customers more quickly, which will increase the capacity of cash registers to the level of supermarkets. X5 Retail Group supermarkets

also increase profits by increasing throughput and turnover, but not in the same size as on discounted trading platforms.

In the figure (Fig. 4.27) graphs of the dynamics of the net profit of «Dixie» and «Ok» companies with a hypothetical increase in the company's staff by 20% are presented [39].



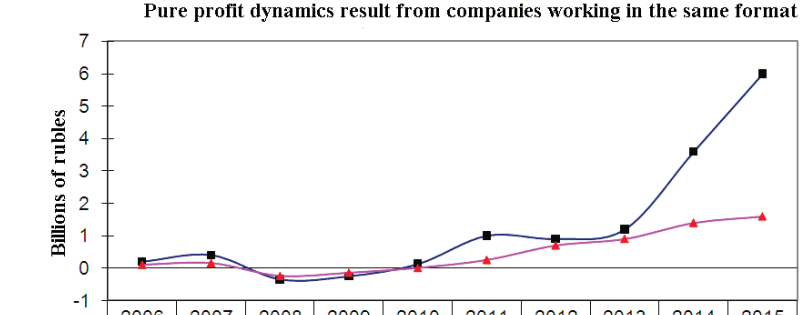
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dixi	0,24	0,42	-0,3	-0,1	0,25	1,1	1,05	3,05	8,1	
Ok	0,68	0,39	-2,9	0,7	2,6	3,2	4,7	5	5,1	
Dixi forecast								3,2	8	10
Ok forecast								5,3	5,6	6

Fig. 4.27. - Hypothetical increase of net profit in the companies' «Dixie» and «Ок» with the hypothetical increase in the companies' personnel by 20%

4.6 Modeling of profit dynamics when selecting identical strategies for improving competitiveness for interconnected enterprises

It was assumed that the company's management, based on the results of a comparative analysis of the two strategies in the framework of the benchmarking process, decided to fully copy the entire competitor's strategy. The results of predictive modeling based on the proposed mathematical model proved that complete and blind copying of methods for improving the competitiveness of a leading company leads to some improvements, but not to victory in the competition. The transition of X5 Retail Group to the strategy of the leader company «Magnet» means the transition to extensive development and this is reflected in the change in the form of the net profit dynamics function from an oscillatory to an exponential nature.

«Dixie» and «Ok» are already working under the same strategy. For them, this means setting the same source data in the model. In the process of modeling, the influence of the same coefficients on profit was studied: the value of capital expenditures (r_1, r_2), the specific number of store staff (a_1, a_2), and the turnover of goods (b_1, b_2). As a result of the simulation, a hypothetical graph is obtained that shows the relationship between two companies operating in the same format (Fig. 4.28) [39].



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dixi	0,2	0,4	-0,35	-0,25	0,127	1	0,9	1,2	3,6	6
Ok	0,1	0,15	-0,25	-0,15	0	0,25	0,7	0,9	1,4	1,6

Fig. 4.28. Hypothetical graph showing the relationship between the two companies if they were operating in the same format

As can be seen from the graphs, if the existing strategy is maintained, the net profit of «Dixie» will fluctuate in the range of 1.2 to 1.5 billion rubles. The forecast of net profit for the company «Ок», which will follow a similar development strategy, gives values of 0.9-1.1 billion rubles. Analysis of graphs shows that they represent increasing functions close to the exponent, and reflect the desire of companies for extensive development. The nature of the graphs shows that companies work in parallel with their regular customers and almost do not interact with each other.

During the study, the following results were obtained:

1. The result of selecting the coefficients in such a way that X5 Retail Group switched from an oscillatory function of changing the profit dynamics to an exponential function, which is typical for Magnet, showed worse forecast results with other parameters being equal. This is proved by the fact that a company that claims to be a leader among competitors should not completely copy a competitor's

strategy, even if this strategy is more competitive according to benchmarking. You need to make adjustments based on your own characteristics.

2. In the course of the study, it was determined that capital expenditures have a different effect on the net profit of companies, depending on the chosen strategy and the corresponding nature of the function.
3. In the course of the study, it was possible to show that a slight increase in turnover can have a large impact on the level of net profit of the company with both types of profit dynamics function.
4. With the exponential nature of the net profit dynamics function, a company that claims to be the leader must necessarily increase the turnover of its cash registers by increasing the staff (cashiers) in stores, which is not too important in the case of the fluctuating nature of this function.

Based on the results of the simulation, we developed methods for making companies that do not blindly copy the leader's strategy, but only approach it using the most appropriate options, taking into account the peculiarities of their own business, based on strengthening the interaction of the two companies within the benchmarking process. Companies that are already working within the same format at the time of research are most suitable for implementing the strategy of enhancing interaction. These companies do not have to radically change their development strategy with large capital expenditures, as in the case of «Magnet» and X5 Retail Group. Next, we consider an example of increasing the profits of «Dixie» and «Ok» stores based on a strategy to strengthen interaction between companies. The circle of potential clients of companies in the Venn diagram is also considered (Fig. 4.29).

The Venn diagram shows that companies have a common range of potential customers who can move to other areas. The chart also shows customers who have not made any purchases in these stores, or do so sporadically (area I). Companies have customers who are hesitant to choose between companies between «Dixie» or «Ок» (area VI). Companies also have their own customers (area IV for «Dixie» and area V for «Ok»). There are customers who have made a choice, but have not yet become regular customers (area II for «Dixie» and area III for «Ок»). Area VII represents customers who are regular customers of one company, but plan to move to a competitor [39].

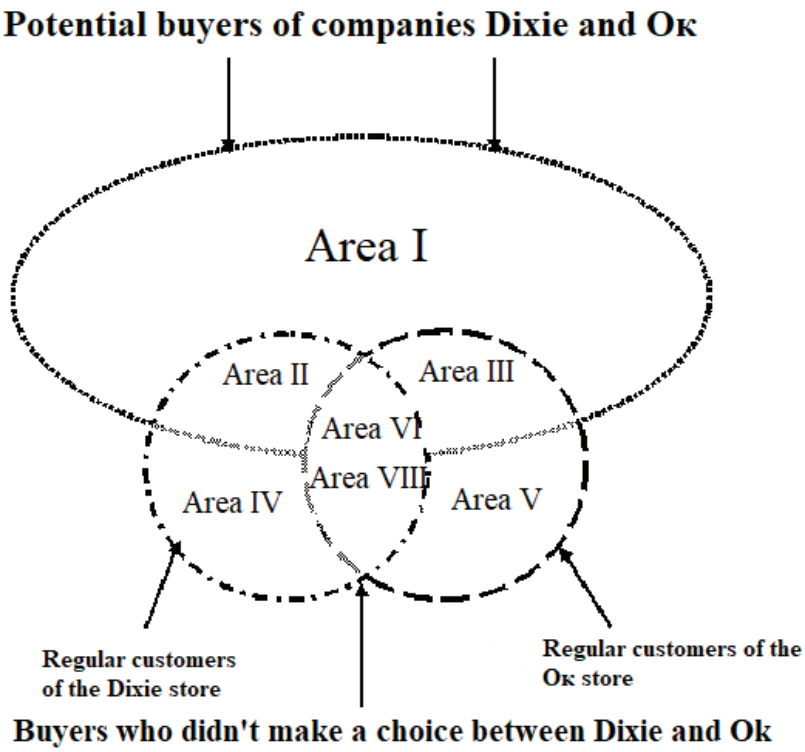


Fig. 4.29. - Venn diagram showing the intersection of the CA of Dixie and OK

Both companies, at the first stage, are invited to monitor the market and establish feedback with the market for their development. The previously presented charts show that companies are developing, and they do not have sharp dips in profits. However, there is a risk of stagnation and slow development, which other competitors can take advantage of. Therefore, the strategy suggests active interaction with each other, with buyers, with the market, as well as the use of a benchmarking strategy for evaluation. Thus, companies should establish information exchange based on cooperation within the framework of a mutual information field (Fig. 4.30) [39].

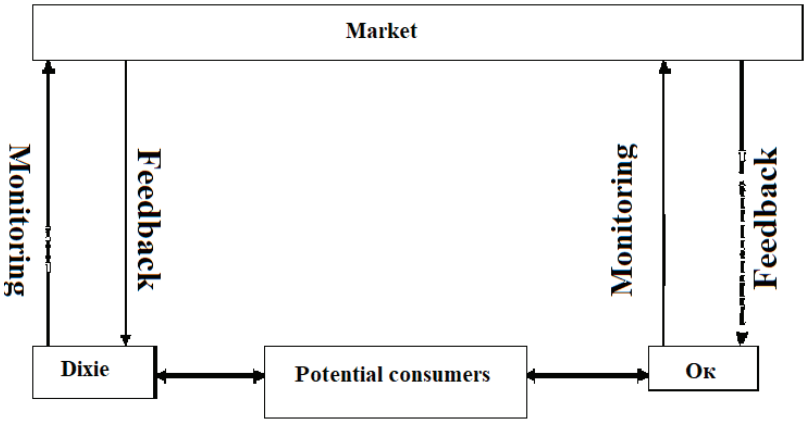


Fig. 4.30. - Block diagram of the interaction of companies «Dixie» and «Ok»

For predictive modeling of the dynamics of increasing profits of the interacting companies «Dixie» and «Ок» in the mathematical model, the following parameters were changed: the coefficients of information relationship between companies increased to 60%, and the coefficient of market fluctuations increased by 50%. The increase in coefficients actually stimulates the process of increasing the number of new customers in stores attracted by advertising and discount campaigns. We will analyze the results of modeling when changing the strategy of development of companies by diversifying store formats, similar to a competitor based on the strengthening of mutual exchange of commercial information, in conditions of increasing market fluctuations.

On the graph (Fig. 4.31) you can see an increase in the net profit of the company «Ок» with an increase in mutual information exchange, which allows to increase the diversification of the store format and attract additional customers, including customers of «Dixie». The graph (Fig. 4.32) also shows a hypothetical increase in Dixie's profits, due to diversification and attracting an additional number of buyers, among which are regular customers of the company «Ок». The opportunity to diversify and attract customers arises through market monitoring and exchange of information received, through mutual awareness of customers by advertising stores and products from competitors, and by expanding the range of products by placing products of a competitor [39].

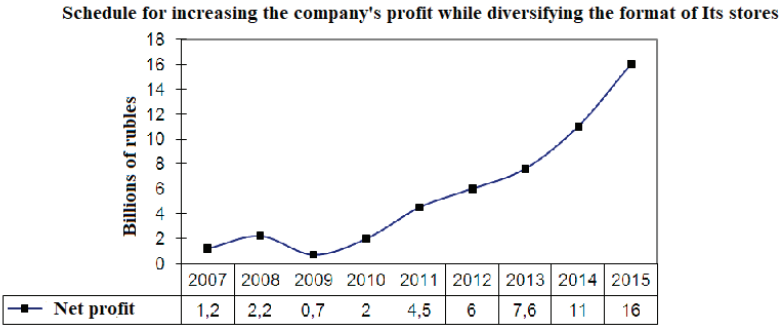


Fig. 4.31. - Hypothetical graph of increasing profits «Ок»

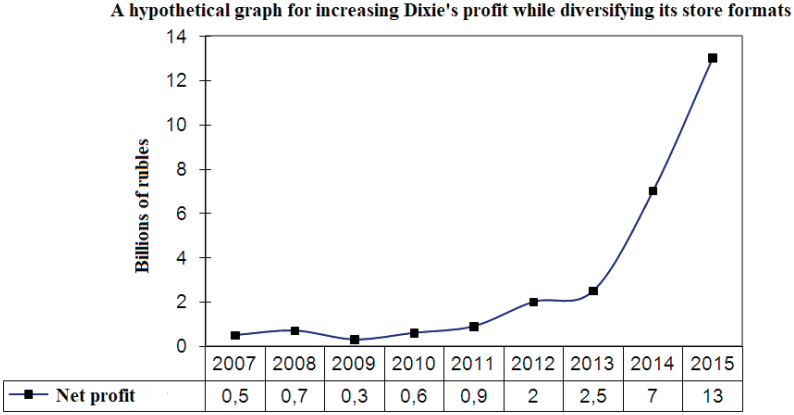


Fig. 4.32. - Hypothetical graph of increasing profits «Dixie»

CONCLUSION

In the process of working on the research, the following results were obtained:

1. Comparative studies of competitive interactions, models and methods for assessing the competitiveness of enterprises, existing DSS, have shown the feasibility and need to develop new tools for managing the competitiveness of enterprises in market conditions and in times of crisis.

2. A mathematical model and methodology for modeling competitive interaction between enterprises has been developed, which is characterized by formalization of the benchmarking process based on the system of coupled Van der Pol equations. The model allows to assess the impact of external and internal factors on competitiveness and predict the dynamics of its changes in the conditions of random market fluctuations and crisis phenomena.

3. A set of mathematical models is proposed for predictive modeling of the dynamics of changes in the competitiveness of enterprises with the possibility of comparison with real or artificially created competitors in the process of benchmarking. A distinctive feature of the models is the study of the processes of competitive interaction between pairs of enterprises in order to select the necessary values of their performance indicators to improve competitiveness.

4. An algorithm for predicting the competitiveness of enterprises for various scenarios of interaction between competitors in the organizational market field has been developed. A distinctive feature of the method is the evaluation of alternatives in order to select the optimal scenarios of competitive behavior of the enterprise in the market based on the results of the forecast.

5. There has been developed a method of decision support for managing the competitiveness of enterprises based on the results of modeling and forecasting, which allows to analyze the scenarios of competitors ' behavior with different values of influence factors and synthesize recommendations to decision-makers in order to achieve competitive advantages in market conditions and in case of a crisis. A distinctive feature of the method is the

prognostic assessment and selection of competitive strategies for enterprise development in conditions of market fluctuations and crisis phenomena.

6. The architecture (mathematical, information and software) of a set of decision support tools for managing the competitiveness of an enterprise in terms of developing effective competitive strategies for its development has been developed. The method was tested in the course of practical implementation at a number of enterprises Spl-lab, ZAO EC-leasing, OTP-Bank of Russia, as well as in the educational process of the Moscow Academy of Entrepreneurship (Moscow).

REFERENCES

1. Thomas A. Stewart: Intellectual Capital: the Wealth of Organizations; Currency, 1998 ISBN 978-0385483810

2. Expert-online. There are no monopolies and no competition. - 2013. [Electronic resource]. URL: http://expert.ru/2013/07/25/monopolij-net-konkurentsii-tozhe/ (accessed 13.05.2016).

3. Boxwell Jr, Robert J (1994). Benchmarking for Competitive Advantage. Robert J Boxwell Jr, New York: McGraw-Hill. p. 225. ISBN 0-07-006899-2.

4. Gilles Walter Competitiveness: a General approach (project). Russian-European center for Economic Policy (RECEP). - 2005. [Electronic resource]. URL: http://recep.ru/files/documents/General_approach_competitiveness-Walter-ru.pdf (accessed 13.05.2016).

5. Voronov D. S. Correlation of the enterprise's competitiveness and the competitiveness of its products. - 2013. [Electronic resource]. URL: http://gaap.ru/articles/Sootnoshenie_konkurentosposobnosti_predpriyatiya_i_konkurentosposobnosti_ego_produktsii/

6. Jill Ringland Scenario planning for developing a business strategy. - Moscow: Dialectics, 2007. – 560 p.

7. Bernard. I., Kolli Zh. K. Explanatory economic and financial dictionary. - Moscow: International relations publishing House, 1994. - vol. 1. - 324 p.

8. Andrianov V. D. Russia in the world economy. TextboOк for universities in economic specialties. - Moscow: humanitarian publishing center «Vlados», 2002. - 400 p.

9. Stajano, A. Research, Quality, Competitiveness. EU Technology Policy for the Knowledge-based Society. - Springer, 2009. - 256 p.

10. Porter, M. E. Competition. - Moscow: Williams, 2002. - 496 p.

11. Improving the competitiveness of an organization based on knowledge management. — M.: publishing house of state University of management, 2008. — 222 p.

12. Beketov N. V. The concept of competitiveness and its evolution / / Economic analysis: theory and practice. - 2008. - No. 11. - Pp. 34-44.

13. Kortunov S. V. Dialectics of national and international security: some methodological problems. - 2009. [Electronic resource]. URL: http: / / www. politstudies. ru/fulltext/2009/1/2. pdf (accessed 13.05.2016).

14. Senchagov V. K., Zakharov A. N., ZOкin A. A. Competitiveness and investment potential of the Russian economy / / Business and banks. - 2010. - No. 43. - Pp. 56-67.

15. Dmitry Ivanov. Supernova economy // the Banner. - 2013. - No. 3. [Electronic resource]. URL:
http://magazines.russ.ru/znamia/2013/3/i15.html.
(date accessed: 13.05.2016).

16. Coase, Ronald H. The Problem of Social Cost // Journal of Law and Economics. – 1960. - №3. – C. 1-44.

17. Bertrand, J. Booк review of theorie mathematique de la richesse sociale and of recherches sur les principles mathématiques de la theorie des richesses // Journal de Savants. - 1883. - V. 67. - P. 499-508.

18. Nogin V. D. Decision-Making in a multi-criteria environment: a quantitative approach. - Moscow: FIZMATLIT, 2005. - 176 p.

19. Ilyin S. I. Competition in the market economy. TextboOк: Moscow Academy of Entrepreneurship, 2012. - 320 p.

20. Forrester D. World dynamics. - Moscow: AST, 2006. – 384 p.

21. Parsons.T. On institutions and social evolution: selected writings. Chicago: University of Chicago Press, 1982. - 430 p.

22. Adizes I. managing the life cycle of the Corporation. - St. Petersburg: Azbuka publishing house, 2008. - 384 p.

23. Thompson, A, Strickland, J. Strategic management: concepts and situations for analysis. - Moscow: Publishing house «Williams», 2003. – 328 p.

24. Krevens David V. Strategic management. - Moscow: Publishing house «Williams», 2003. – 268 p.

25. Thompson, A, Strickland, J. Strategic management: concepts and situations for analysis. - Moscow: Publishing house «Williams», 2003. – 328 p.

26. Lambert Jean-Jacques. Strategic marketing. European perspective. Per. FR. - SPb.: Nauka, 1996. – 345 p.

27. Nelson Richard R., Winter Sidney J. Evolutionary theory of economic changes / TRANS. from English. – M.: Case, 2002, 536 p.

28. Hill S. 60 trends in 60 minutes. - Moscow: Ed. Krylov, 2004. – 342 p.

29. Kearns D. T., Nedler D. A. Prophets in the dark, or the story of how «Xerox» rose from the ashes and gave battle to the Japanese. – SPb.: Azbuka, 1996. – 167 p.

30. Harrington Zh.J. Benchmarking at its best! 20 steps to success. St. Petersburg, 2004. - 173 p.

31. Camp, R. Legal industrial espionage: Benchmarking business processes: search technologies and implementation of the best practices of your competitors.; under the editorship of O. B. Maximova. - Dnepropetrovsk: Balance-Club, 2004. - 180 sec.

32. Saati.T. L. decision Making with dependence and feedback. Analytical networks. - Moscow: LKI publishing House., 2008. - 360 sec.

33. Juglar C. Des Crises Commercials // Et De Leur Retour Periodique En France. - Paris. - 1862. Pp. 4-11.

34. Kitchin, Joseph Cycles and Trends in Economic Factors // Review of Economics and Statistics. - 1923. - No. 5 (1). - P. 10-16.

35. Wiener. N., Dynamical systems in physics and biology / / Bulletin of the USSR Academy of Sciences. - 1964. - No. 7. - Pp. 98-113.

36. Kuznets S. Secular Movements in Production and Prices. Their Nature and their Bearing upon Cyclical Fluctuations. - Boston: Houghton Miffin, 1930. - 324 p.

37. Pavlovsky V. S. Modeling, decomposition and optimization of complex dynamic processes. - Moscow: Computer Center of Russian Academy of Sciences, 1991. - 149 p.

38. Parsons, T. On social systems. - Moscow: Academic Project, 2002. - 832 p.

39. Berezin A. A. Innovative and instrumental mechanism for increasing competitiveness. Mathematical model of competitiveness. ISBN 978-659-66687-2: LAP Lambert Academic Publishing, Saarbrucken Germany, 2014. - 156 p.

40. Plotinsky, Yu. M. Models of social processes. - M: Logos, 2001. - 296 p.

41. Volterra V., Lecons sur la Theorie Mathematique de la Lutte pour la Vie. - Paris, Gauthier-Villars, 1931. – 335 p.

42. Teodorchik K. F. self-Oscillating systems. - Moscow: State publishing house of technical and theoretical literature, 1952. – 271 p.

43. Juglar C. Des Crises Commercials // Et De Leur Retour Periodique En France. - Paris, 1862. - P. 4-11.

44. Romanovsky. Yu. M., Stepanova I. V., Chernavsky D. S. Mathematical Biophysics. - Moscow: Nauka, 1984. - 304 p.

45. Blechman I. I. Synchronization of dynamic systems. - Moscow: Nauka, 1973. – 895 p.

46. Berezin, A. A. Benchmarking in the system of competitive actions of business structures / A. I. Kovalenko, A. A. Berezin / / Modern competition. - 2014. - No. 5 (47). - Pp. 117-129.

47. Berezin, A. A. Mathematical model of the benchmarking process for predictive assessment of the dynamics and competitiveness of companies / A. A. Berezin, A. G. Finogeev / / Modern science-intensive technologies. - 2016. - No. 2-3. - Pp. 411-415.

48. Gaponov-Grekhov A.V., Rabinovich M. And Autostructure, chaotic dynamics of ensembles of // in the book. Non-linear waves. - Moscow: Nauka,1987. – 399 p.

49. Simon Z. Benninga, Oded H. Sarig. Corporate Finance: A Valuation Approach. - McGraw-Hill, 1997. – 322 p.

50. Berezin, A. A. Mathematical modeling of enterprise competitiveness dynamics based on Van der Pol equations / A. A. Berezin, A. G. Finogeev / / Fundamental research. - 2016. - No. 2. - part 3. - Pp. 467-471.

51. Benzi R, Sutera A., Vulpiani A. The mechanism of stochastic resonance / Journal of Physics A: mathematical and general. - 1981. - V. 14. - issue 11. - p. L453.

52. Linkens D. A. Stability of Entrainment Conditions for RLC Coupled Van der Pol oscillators used as a Model of Intestinal Electrical Rhythm / / Bull. Math. Biol. 1977. No. 39. Pp. 359-378.

53. Philip R. S. Symmetric equation of the generator that has asymmetric solutions / / Proceedings of electrical and radio electronics engineers. - 1976. - T. 64. - No. 5. Pp. 308-315.

54. Yudovich, V. I., Asymptotic behavior of limit cycles of the Lorenz system for large Rayleigh numbers. – Rostov: Rostov state University, 1977. – 216 p.

55. Lorenz, E. N. / / Atmos. Sci. 1963. No. 20. R. 130 – 141.

56. Berezin A. A. Certificate of state registration of the computer program no. 2016E00292 / A. A. Berezin / / - Registered in the Register of computer programs from «14» January 2016.

57. Williams, B. Money without textbooκs // the Expert. - 2006. - No. 5(9). Pp. 34-43.

58 Berezin, A. A. Instrumental approach to describing the organizational and economic mechanism of competitiveness / A. A. Berezin / / Transport business of Russia, Moscow: Ed. Marine news of Russia, 2012. - No. 4. - Pp. 120-124.

59. Berezin, A. A. Influence of cost strategies on the company's competitiveness / A. A. Berezin / / Microeconomics. - 2012. - No. 5. - Pp. 47-50.

60. Berezin, A. A. Study of the dynamics of competitiveness of companies ' products in the framework of the model of competition for market share between two pairs of companies / A. A. Berezin / / Russian Economy in the

conditions of modernization: problems, prospects, solutions: materials of the VI international conference. scientific.- prakt. Conf. - Moscow, 2013. - pp. 278-286.

61. Finogeev A. G. Modeling research of system-synergetic processes in information environments: Monograph. - Penza: PSU publishing House, 2004. – 223p.

62. Official website of Spl-lab. [Electronic resource] URL: http://Spl-lab.ru (accessed 13.05.2016).

63. Official website of the company «Term-lab». [Electronic resource] URL: http://termpro.com/storefront/termlab.asp (accessed 13.05.2016).

64. Cheglov V. p. Innovative retail. Organizational leadership and effective technologies. - Moscow: FORUM publishing house, 2013. – 167 p.

65. Berezin, A. A. Mathematical modeling of the dynamics of changes in Bank indicators in the process of evolutionary development of the organizational field / A. A. Berezin, A. G. Finogeev / / Naukovedenie: online journal. - 2016. - vol. 8. - No. 1 [Electronic resource]. URL: http://naukovedenie.ru/PDF/09EVN116.pdf (date accessed: 13.05.2016).

66. Official website of Russian OTP Bank Section: «reporting». [Electronic resource].URL:https://www.otpbank.ru/en/about/recording/2015/ (accessed: 13.05.2016).

67. Official website of Russian Standard Bank Section: «reporting». [Electronic resource]. URL: http://www.rsb.ru/about/recording/2015/ (accessed: 13.05.2016).

68. Bauer, C. Hibernate in Action. / Christian Bauer, Gavin King // Manning Publications Co. 2004. 420 p.

69. Brown, K. Creating enterprise Java applications for IBM WebSphere. / Brown, K.; Craig, G.; Hester G. and others // M.:Kudits-Image, 2005. - 860c.

70. Clarence Ho, Rob Harrop Spring 3 for professionals-Pro Spring 3. - Moscow: «Williams», 2012. — 880 p.

71. Berezin, A. A. Method of managing the competitiveness of enterprises based on mathematical modeling of the benchmarking process / A. A.

Berezin, A. G. Finogeev / / Proceedings Of the international Symposium Reliability and quality. - 2016. - No. 2. - Pp. 246-252.

72. Taylor, Ian J. From P2P to Web Services and Grids - Peers in a Client/Server World. Springer, 2005. pp. 89-117.

73. Herbert Schildt. Java and Apache POI. Complete guide. The Complete Reference Java with Apache POI. - Moscow: Williams, 2012. — 504 p.

74. Al Hilwa, Randy Perry Adobe Flex in the Enterprise: The Case for More Usable Software. IDC. 2010. [Electronic resource]. URL: http://www.adobe.com/enterprise/pdf/idc.pdf]. (accessed 13.05.2016).

75. Fedulov A. A., Fedulov Yu. G., Tsygichko V. N. Introduction to the theory of statistically unreliable solutions. - Moscow: Statistics, 1979. - 340C.

76. Laptiev D. A. the System of financial management of the Bank: the Process - task model - based methods. Moscow: BDC-press, 2005. - 230C.

77. Berezin A. A. Ways to increase the competitiveness of the company's products / A. A. Berezin / / Modernization of the economy, innovative technologies and higher school of Russia: materials of the IV international conference. scientific.- prakt. Conf. - Moscow, 2012. - Pp. 330-342.

78. Gazetasi. «Magnet» over to «Ок» and X5 Retail Group and became the leader in sales in Russia, 2013. [Electronic resource]. URL: http://www.gazeta.ru/business/news/2013/04/12/n_2850129.shtml (accessed 13.05.2016).

79. Zlata Gerasyuta, Anton Zverev. «Magnet» ranked among the top five retailers in the world by value, 2012. [Electronic resource]. URL: http://www.reuters.com/article/2012/07/25/orubs-russia-retail-market-cap idRUMSE86O0AZ20120725 (accessed 13.05.2016).

80. Official website of «Magnet», section «company History». [Electronic resource]. URL: http://www.Magnet-info.ru/about/history/ (accessed: 13.05.2016).

81. Official website of the company X5 Retail Group. [Electronic resource]. URL: x5.ru/ (accessed 13.05.2016).

82. The official website of «Dixie». [Electronic resource]. URL: dixy.ru/ (accessed 13.05.2016).

83. Finmarket. In 2012, «Dixie» reduced its net profit under IFRS by 4.5%, 2013 [Electronic resource]. URL: finmarket.ru/news/3322855/ (accessed: 13.05.2016).

84. Mikhailova M. R. Benchmarking is a universal quality management tool. [Electronic resource]. URL: http://benchmarkingclub.ru/mih_bench.html (date accessed: 13.05.2016).

85. Official website of the company «Ок». [Electronic resource URL]. URL: Окmarket.ru/ (accessed 13.05.2016).

86. Btlregion information portal: ZHZL: Sergey Galitsky (Magnet network). [Electronic resource]. URL: btlregion.ru/stat/ros_retail/44a615a840c54121650bbef657d77bfa/index.htm (accessed 13.05.2016).

87. Buffett. Strategy of retailers: «Magnet» and «Dixie» / / Finance. - 2008. - No. 20. [Electronic resource]. URL: buffett.ru/actions/?article=2175 (date accessed: 13.05.2016).