Efficiency of Mathematical Modeling of Competitiveness of a Business Organization in the Coverage of Regional Integration

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Abstract

The following research problem was solved in the work: what model should be used to quantify the calculation of the competitiveness of an organization's business efficiency in the scope of regional integration? In accordance with the set research task, its goal was determined. The purpose of this work was to assess the competitiveness of business in the scope of regional integration. The research sample consisted of large enterprises operating on the territory of the integration association - the EAEU. Competitiveness is now a commonly used term that can be analyzed at different levels - at the enterprise level or at the national level. Despite the fact that the purpose of this article is the competitiveness of production systems, it is appropriate to pay attention to the competitiveness of a business organization in the context of regional integration in which these systems operate. Macroeconomic competitiveness must always take into account

the microeconomic context. Even the best public policy is ineffective if it is not implemented in the context of the business sector.

Keywords

Efficiency, Management, Competitiveness, Integration, EAEU, Mathematical Model.

Introduction

Business competitiveness can be assessed using the Global Competitiveness Index, which emphasizes the prospect of a particular organization achieving sustainable economic growth in the medium term, assesses the quality of government institutions, economic policy and other factors that determine the level of labor productivity and welfare in various EAEU countries. The Russian Federation scored 66.8 points out of 100 in 2018. Global Competitiveness Report published by the World Economic Forum. The Russian Federation is ranked 41st in the world in terms of competitiveness out of 140 countries included in the 2018 report. Compared to the previous year, this movement is down two positions. The period 2017-2018 was marked by an improvement in the position of the Russian Federation in 9 out of 12 main components (index components), namely, institutions, infrastructure, implementation of information and communication technologies, macroeconomic stability, health care, skills, financial systems, market size and innovation potential. In the rest, the positions of the Russian Federation, however, declined (VEF, 2018). In 2017, Russian entrepreneurs rated corruption as the biggest problem of doing business in the Russian Federation, which gained almost 20% of the vote, followed by ineffective government bureaucracy, tax rates, tax regulation and restrictive labor regulation (WEF, 2017). According to surveys, Russian enterprises have three ways to be competitive in a global competitive environment. These include:

- Reduction of wages while achieving higher labor productivity.
- Change in the ratio of capital and labor.
- Outsourcing of intensive parts of the supply chain to low-cost regions in order to reduce overall production costs.

However, all these approaches are only of a short-term nature. Many analysts and scientists emphasize the potential of the Russian Federation in strengthening its innovative potential through investment in knowledge as a way to maintain long-term competitiveness based on the ability of enterprises to innovate and continuous learning (Russian entrepreneurs define innovation, flexibility and product quality as sources of competitiveness) [4]. Based on this

brief definition of the competitiveness of the Russian Federation, the next part of the article takes a closer look at the competitiveness of individual Russian enterprises.

The article is structured as follows: Section 1 presents a literature review. This part of the article sets out different definitions of competitiveness. The purpose of the article and the research problem are formulated at the end of this section. Section 2 describes the sample study and the methods used. We have applied methods for assessing competitiveness in terms of profitability and liquidity indicators of capitalization. We used the method of mathematical modeling [6] and calculated the EVA. Section 3 presents the results and a discussion of the results achieved. We compared the results of applying the method of mathematical modeling and the EVA indicator using the Spearman's rank correlation coefficient, on the basis of which we assessed the consistency of the results of the applied methods. The final part of the article is a conclusion, in which the main conclusions and advantages of the study were developed and presented.

Literature Review

Despite the widespread recognition of the importance of competitiveness, researchers have not been able to agree on the definition of this term [7]. Therefore, in the scientific literature there is no precise, generally accepted and generally accepted definition of competitiveness, and the approaches to its definition are very diverse [8]. According to the European community [3], the concept of competitiveness is as follows: it is related to the ability of enterprises, industries, regions, countries and transnational regions to generate, being subject to international competition, relatively high levels of income and employment. The OECD defines competitiveness in a similar way - as the ability of companies, industries, regions, countries and transnational entities to generate relatively high levels of income from factors of production, but also to use them at a sustainable level in the current competitive environment [4]. According to Porter [2], competitiveness is a function of dynamic progressiveness, innovation and the ability to change and improve. Summaries of the above definitions are given by Sydek and Zavoiska [9], according to which competitiveness should be defined as "a set of characteristics of one object in relation to comparable objects (standards) on the market."

Competitiveness can be viewed from different angles. Stoiko et al. In 2019 define micro-economic, regional and national or macro-competitiveness. Delgado et al. [14] differentiate product, business unit, firm and industry at regional, national and subnational levels. For the purposes of this article, we define competitiveness at the regional or country level and competitiveness at the firm level.

At the country level, there is considerable disagreement over the idea of competitiveness [4]. Country-level approaches to competitiveness very often refer to international trade and the comparative advantages of countries in the production of certain tradable goods [13]. An innovative approach is the definition of Scott and Lodge [5], which define competitiveness as: "the ability of a country to create, produce, distribute and / or service goods in international trade, while receiving a growing return on its resources." In addition, several international organizations dealing with competitiveness issues define the term in a similar way. The US Industrial Competitiveness Commission defines competitiveness as the ability of a country to produce goods and services that meet the requirements of international markets, while maintaining and expanding real income [6]. Much the same is the OECD definition, which defines competitiveness as the degree to which, in an open market, a country can produce goods and services that meet the criteria of competitiveness. According to the International Institute for Management Development, competitiveness is "the ability of a country to create added value and thereby increase national wealth by managing assets and processes, attractiveness and aggressiveness, globality and proximity, as well as by integrating these relations into the economic and social model" [13] ...

Most competitiveness theories assert that the competitiveness of any country, region and business is determined by its productivity, being, on the one hand, considered as the main determining factor of competitiveness, and, on the other hand, equal to competitiveness [10]. Porter argues that the only meaningful concept of competitiveness at the country level is productivity. In his opinion, the main goal of the country is to ensure a high and growing standard of living for its citizens. The ability to do so then depends on the productivity through which the country's labor and capital are used. Likewise, according to Krugman, competitiveness is just another way of saying performance. Productivity is also very important to the World Economic Forum, which defines it as the ability of a national economy to achieve sustainable rates of economic growth, as measured by annual changes in GDP per capita. An inspirational approach to competitiveness is proposed by Schumpeter in his theory of entrepreneurship and innovation. According to this author, the ability of a business to innovate is the key to the success of achieving a competitive advantage over competitors. The ability to create new solutions and the predisposition to the risk associated with testing them in the market distinguish the competitive process and entrepreneurship [6].

Some authors are of the opinion that nations themselves do not produce products or services. In this regard, Storper [7] argues that competitiveness reflects the ability of an economy to attract and support firms with a stable or growing share in activities, while maintaining or improving the standard of living of those who participate in it. Likewise,

according to the IMD World Competitiveness Center, competitiveness is "the field of economic knowledge that analyzes the facts and policies that shape a nation's ability to create and sustain an environment that supports greater value creation for its businesses and greater prosperity for its people."

Until the 1980s, the term competitiveness was part of microeconomic terminology. Thus, the next part of the theoretical background is devoted to the definition of the concept of business competitiveness. The study of business competitiveness should be based on research by Porter et al., Which combine vertical levels of competitiveness and provide a systematic approach to explaining and predicting business competitiveness. Wealth is created at the micro level, where human, natural and capital resources are converted into products and services. According to Porter's model, the following factors influence the competitive environment in the sector: the risk of new competitors, the risk of competition between enterprises in the sector, purchasing power, sales and the threat of product substitution in the sector. Porter (1985) prefers the managerial definition of competitiveness and understands it as the ability of a company to seize a market opportunity to enter a position in which it can protect or use resources for further growth. He understands the external environment as the main factor that determines a company's ability to compete.

In 2016, Porter defined additional criteria for competitiveness, namely the level of education of employees, the source of competitive advantages, the willingness to delegate authority and the innovative potential of the company. Also, other authors and institutions describe competitiveness from a managerial point of view. The Department of Commerce and Industry argues that business competitiveness is the ability to produce the right goods and services at the right price and at the right time. This means meeting customer needs more efficiently than other firms. According to Chikan, business competitiveness is the company's ability to sustainably fulfill its two primary goals: meeting customer needs and making a profit. This can be achieved by offering products and services that customers value more than those offered by competitors. To do this, the company must be able to identify and adapt to changes in the business environment and meet market criteria that its competitors cannot meet. The European Management Forum defines competitiveness as an immediate and future ability and opportunity, businessmen design, manufacture and sell products around the world, whose price and non-price qualities form more attractive packaging than foreign and domestic competitors. It is equally argued that the high quality of goods is the basis for determining competitiveness.

Many authors refer to the economic significance of competitiveness and use this term to express the economic dominance of a particular company over competitors in the

framework of domestic and international competition [18]. The authors understand competitiveness as a competitive advantage in a given market situation. Pitra, likewise links competitiveness with the concept of a trait that helps a business to thrive in a competitive environment. Chaydyak et al. Authors define competitiveness as achieving the same or better results as competition, not lagging behind. According to this author, competitiveness means higher or more reliable earnings and a better market position. According to Khudakova (2019), competitiveness at the corporate level means gaining a stable position both in the domestic and foreign markets, as well as gaining profit and market share. DCruz and Rugman (1992) describe competitiveness "as the ability of a firm to design, manufacture and sell products that are superior to those offered by competitors in terms of price and non-price points." [1].

Some definitions of business competitiveness are based on the principle of lower production costs. Arrow and Hahn (1991) consider a business to be competitive that minimizes costs and has sufficient revenues to cover production and operating costs. Turner and Golub (1997) distinguish between narrow and broad definitions of competitiveness. The narrow definition of competitiveness touches on the traditional relationship between price and costs. More popular, however, is a broader understanding of competitiveness, which deals with the relationship between economic performance and the use of financial and economic indicators. Based on the analysis of the financial performance of the business and their interpretation, we can assess and forecast the future competitiveness of the business.

There are also definitions that address both the aforementioned cost-minimization claims and the ability to win the competition. A special committee of the House of Lords [11] defines the competitiveness of a firm as follows: a company is competitive if it can produce products and services of the highest quality and at lower costs than its domestic and international competitors. Competitiveness is synonymous with the long-term profitability of a company and its ability to compensate its employees and provide superior returns to its owners. Long-term profitability is also critical, for example Buckley et al. (2014), who define competitiveness as synonymous with long-term profitability, the ability to pay employees, and the ability to generate above-average income for owners.

Productivity is often referred to as a surrogate for competitiveness and a good indicator of a firm's long-term competitiveness [3]. Likewise, Porter et al. (2017) argue that competitiveness is measured by labor productivity. Productivity supports high wages, strong currencies, and attractive returns on equity.

According to Malaga and Mihok (2017), in Europe, competitiveness is usually measured on the basis of productivity and economic efficiency. Since the conditions of the external environment, such as the strength of competition, the structure and level of costs, the availability of resources - the main ones: raw materials, finance and human resources in each industry are approximately the same for all enterprises, for which, in order to improve their market position, it is a focus on the internal functioning of the business, increasing its potential and improving its effectiveness and efficiency (Krauszova and Janeckova 2018).

A prerequisite for the competitiveness of enterprises is their financial health. Therefore, it is necessary to pay more attention to assessing the financial condition of enterprises and predicting their bankruptcy (Stefko et al., 2018). O'Farrell and Hitchens (1988) have conducted a number of studies for several years on the relationship between the sources of competitiveness and business performance. In one such study, they compared the performance results with the competitiveness results of the analyzed sample of enterprises. As our research focused on the assessment with regard to competitiveness, we chose the method that is further defined in this article. Assessing the competitiveness of a business, we proceeded from the fact that the competitiveness of a business is determined by its profitability, and, consequently, by productivity, efficiency and solvency.

In accordance with the topic of the article, we have identified this research problem and research questions: research problem: what method of calculating competitiveness is able to include all areas of financial health of a business in the measurement of competitiveness? Research question: can we assess the competitiveness of a business using business profitability metrics? Is it advisable to add profitability indicators to liquidity indicators when measuring competitiveness?

Mathematical Model

To build a mathematical model of competitiveness, it is necessary to indicate the control parameters (components of competitiveness) to be selected, the criteria for the quality of competitiveness, which they must optimize, and the constraints that they must satisfy. The model of the functioning of the system is described by quantities of two types - the characteristics of the environment, which determine the operating conditions, and the control parameters, which determine the appropriate state or behavior of the system in a given environment. The characteristics that determine the conditions for the functioning of production include, for example, the amount of resources that can be counted on, stocks of raw materials, allowable labor costs, technological coefficients that determine the

capabilities of equipment, the expected demand for manufactured products, etc. The duration of production cycles, cost estimates, output volumes, characteristics of technological processes to be selected, funds allocated to individual subdivisions, etc. are usually chosen as control parameters in planning models. The mathematical model contains two types of dependencies between the characteristics of the environment, which are assumed to be given, and the desired control parameters. To assess the effectiveness of solving the problem, a criterion (indicator) of the quality of the organization's business plan is needed, which brings a certain number into compliance with each set of environmental characteristics and management parameters. These numbers allow you to compare the quality of different plans in different conditions. The criterion for the effectiveness of a business plan can be, depending on the situation, total revenues, total costs or profits, the number of equipment sets produced, the time to reach a certain level of production, etc. Another type of dependencies between the characteristics of the environment and control parameters is set by constraints on admissible plans. Constraints are formed in the form of equalities or inequalities connecting some functions of the known characteristics of the environment and the desired control parameters. Balance ratios - the necessary conditions for the admissibility of a business plan - usually represent constraints of the type of equality. Restrictions associated with the permissible levels of use of certain types of resources, raw materials, equipment, fuel, labor, with the need to ensure a given demand for certain types of products, are written in the form of inequalities. The area cut by the constraints in the control parameter space is called the model's domain. Some constraints can be specified in geometric terms. If, in its economic sense, the control parameters must be non-negative, then they say that the domain of the model belongs to the non-negative orthant[1]. If the upper and lower boundaries of the admissible values of the control parameters are known in advance, then in geometric terms this means that the admissible designs belong to some hyperparallelepiped. If, for some reason, the sum of the squares of the components of this business plan is limited (in automatic control problems this is a natural condition associated with energy control constraints), then it is said that the vector of control parameters belongs to a certain ball. Of particular interest are cases when it is required that the vector of control parameters belong to some discrete set of points, for example, points with coordinates of zeros and ones.

Usually, analytical and geometric constraints are introduced into the mathematical models of planning and management. Models of mathematical modeling are written as follows:

[1]Ortant (hyperoctant) - generalization of the concepts of two-dimensional quadrant and three-dimensional octant for n-dimensional Euclidean space.

$$\varphi_0(x) = \varphi_0(x_1, x_2, \dots, x_n) \to extr, \quad (1)$$
$$\varphi_i(x) = \varphi_i(x_1, x_2, \dots, x_n) \leq 0, \mathrm{i} = 1, m, \quad (2)$$
$$x = (x_1, x_2, \dots, x_n) \epsilon G. \quad (3)$$

Here the vector $x = (x_1, x_2, \dots, x_n)$ – a set of desired control parameters, its components $x_1, x_2, \dots, x_n$ determine the numerical values of the components of the business plan; $\varphi_0(x) = \varphi_0(x_1, x_2, \dots, x_n)$ – function that determines the quality indicator (performance criterion) of the business plan x; function $\varphi_i(x) = \varphi_i(x_1, x_2, \dots, x_n)$, i = 1, m, are given using the inequalities $\varphi_i(x) \leq 0$ constraints of the model (it is clear that equality constraints can also be written in this form: from $\varphi_i \leq 0 \; and - \varphi_i \leq 0 \; should \; \varphi_i = 0$); it is assumed that the environment parameters are contained in the expressions for $\varphi_0 \; and \; \varphi_i$; G – the area defined by the geometric properties of the additional constraints.

The study of the model for the formation of a business plan or the development of a management scheme is reduced to the choice of management parameters x = $(x_1, \dots, x_n)$, which would satisfy constraints (2), (3) and at the same time ensure the achievement of an extremum (maximum or minimum, depending on the meaningful formulation of the problem) of the solution quality indicator (1).

Depending on the features of the function $\varphi_i, w = 0, m,$ and the type of domain G, model (1) - (3) possesses certain formal properties and belongs to one or another class of mathematical programming problems. So if $\varphi_0 \; and \; \varphi_i, i = 1, m,$ - linear functions of control parameters $(\varphi_0 = \sum_{j=1}^{n} c_j x_j, \varphi_i = \sum_{j=1}^{n} a_{ij} x_j - b_i)$, and the domain G is a nonnegative orthant $x_j \geq 0, j = 1, n,$ or hyperparallelepiped $a_j \leq x_j \leq \bar{a_j}$, j = 1, n, a task (1) – (3) is a linear programming problem. Linear programming is the most developed branch of mathematical programming. To solve this problem in the form of linear programming, a number of methods, algorithms and programs have been created. Depending on the structure of the condition matrix A = $\|a_{ij}\|$ tasks and features of the initial information, one or another method turns out to be more effective. For a number of particular classes of linear programming problems (selection problems, transport problems, distribution problems), there are very economical methods of analysis. For problems with a matrix of conditions A with a block structure, special solution methods (block programming methods) have been developed that allow calculating the optimal plan of problems of a sufficiently large dimension (with a large number of n variables and m constraints). For linear programming problems, it is possible to estimate the dependence of the optimal value of the quality indicator of a business plan on possible variations in the parameters of the conditions. Such assessments are used to purposefully improve the

systems described by the corresponding models. Linear modeling models have a variety of economic interpretations. The most interesting of them are generated by the duality theorems linking the optimal volumes of production with the optimal estimates of the resources used.

Linear modeling problems of the type (1) - (3) with the area G, which is a discrete set of points, are discrete programming problems. If the coordinates of the desired vector x can only take integer values, problem (1) - (3) is called an integer modeling problem. If the control parameters are not allowed to take on values other than 0 and 1, the task is called a Boolean programming task. Usually the value x_j = 1 means that the operation j should be taken, x_j = 0 rejects the application of the j-th operation.

In this problem of mathematical modeling, convex problems or problems of convex modeling play a special role. Model (1) - (3), in which the minimum is calculated $\varphi_0\ (x)$ under conditions (2), (3), is called a convex modeling model if G is a convex domain and the functions $\varphi_0\ (x)$ and $\varphi_i\ (x)$, i = $\overline{1,m}$, convex functions of their arguments[2].

A convex function that has the meaning of the degree of satisfaction of a certain need from a certain resource (argument) reflects the premise that the effect of each subsequent unit of the resource decreases. In economic problems, such dependencies are quite common. An important formal feature of convex extremal problems is that their global extremum coincides with the local one. Therefore (and due to the relative simplicity of the study of convex problems) the theory, methods, and applications of convex programming are given a lot of attention. Many qualitative statements proved in linear modeling are generalized to convex problems. It is currently proposed that the parameters of the problem conditions are known and the functions φ_i, i = $\overline{0,m,}$ are uniquely specified. Complete information about the conditions for the formation and implementation of a business does not always correspond to real situations.

Mathematical models, formulated here in static terms, can be transformed in relation to the control of dynamic processes. The study of such models is the subject of optimal control theory. Here the role of control parameters is played by control functions. The characteristics of the environment can also change over time.

[2] The concept of a "convex region" corresponds to the intuitive notions associated with this term: any segment connecting any two points of a convex region completely belongs to this region. Function $\boldsymbol{\varphi_x}$ is called a convex function of the argument x if for all x' and x", belonging to the scope $\boldsymbol{\varphi_x}$, the inequality holds $\boldsymbol{\varphi(\lambda x' + (1-\lambda)(x``) \leq \lambda\varphi(x') + (1-\lambda)\varphi(x``), 0 \leq \lambda \leq 1}$.

Conclusion

Any business interested in developing and increasing competitiveness should, first of all, assess its current position in terms of financial health and efficiency of its activities. In order to improve its competitive position, a company must focus on internal processes and increasing business potential, efficiency and effectiveness. In our research, we have confirmed that the mathematical modeling model is a suitable starting material for assessing competitiveness. The model includes a synthetic indicator that influences the analytical indicators of all functional areas of the business. It is a combination of financial and market data and a combination of internal and external influences. In addition to the current development, the mathematical programming model indicator allows for the future expected development of the market and the environment to be included in its calculation. It has been proven that the efficiency of enterprises threatened with bankruptcy is low, therefore efficiency is also important in terms of their future competitiveness. We can assume that the mathematical modeling model has more suitable criteria for competitiveness, since it includes a number of factors, both input and output. Future research will focus on the application of relative scores with an emphasis on relative scores in mathematical modeling models. This methodology is useful when looking for ways to improve productivity, efficiency and competitiveness of businesses in the context of regional integration.

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