Linear Programming as a Data Mining Tool in Assessing Competitiveness in the Face of Uncertainty

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Abstract: Entrepreneurial activity in the market is associated with risk and with a situation of uncertainty, which ultimately characterizes the random component in the functioning of enterprises, their competitiveness. The development of mathematical models and methods to improve competitiveness in conditions of uncertainty are relevant and are essential for theory and practice.In the article, the authors study the concept of competitiveness and competitive advantages. An outstanding achievement in the article is a visual representation of the linear programming method and testing it on a real practical example.

Index Terms: risk, uncertainty, linear programming, competitiveness, competitive advantages, sustainable competitive advantage.

I. INTRODUCTION

One of the most critical tasks of any enterprise in modern conditions is the search for effective ways of development, improving product quality, and increasing competitiveness. Entrepreneurial activity in the market is associated with risk and with a situation of uncertainty, which ultimately characterizes the random component in the functioning of enterprises, their competitiveness[1-3].

Currently, the issue of improving the competitiveness of organizations does not lose its relevance. Competitors - the essential component of the immediate environment of the organization, without taking them into account and studying it is impossible to develop a strategy and tactics for the organization to operate in the market. Therefore, in current conditions the success of any organization directly depends on what measures the company takes to maintain its competitiveness. Therefore, to achieve a sufficiently high level of competitiveness of an enterprise, risks must be rationally taken into account in management. The higher the level of uncertainty, the higher the level of risk.

It should be noted that the risk may entail certain losses. To prevent or reduce them, certain costs are required for analyzing the risk level and reducing it. These costs need to be minimized, taking into account possible losses, i.e. optimize. There are standards for risk assessment (ISO 31000 [4] and others), as well as various methods and approaches, including mathematical methods, but the risks associated with competitiveness are specific and, therefore, mathematical methods for their assessment require refinement and development. Thus, the development of mathematical models and methods to improve competitiveness in conditions of uncertainty are relevant and are essential for theory and practice.

II. COMPETITIVENESS AS AN OBJECT OF MANAGEMENT

Unbalance, uncertainty, multicriteria are typical signs of a market economy that is always accompanied by risks. Entrepreneurship and risk are organically interconnected phenomena in a market economy [5].

In general, the scientific achievements of scientists on risk issues are significant. The use of quantitative and qualitative methods for assessing the risks of the business activity has its advantages and disadvantages and is limited to the experience of its user by financial and risk managers of companies, the inability to take into account all factors of risk and other factors [6].

Competitiveness is the ability of a subject (enterprises, organizations, goods, services, etc.) to compete with similar items on the market [7-8].

The competitiveness of the subject of market relations can be assessed only with similar items. For example, it is impossible to determine the competitiveness of milk and machine tools, building materials and passenger buses, shoes and hairdressing services.

Usually, share the competitiveness of the goods and the competitiveness of the enterprise [9-10].

Competitiveness of an enterprise is a complex of economic characteristics that determine its position in the sectoral market (regional, global), including features of the goods and factors that generally form the economic conditions for the production and marketing of products of the enterprise.

Competitiveness of a product is a complex of its consumer and value characteristics that determine its market advantage over other products in the context of a wide range of competing-analogue products.

Competitiveness of a company is manifested in competitive advantages. Just as a company does not exist without the need for its products (services), so there are no market opportunities without competitive advantages.

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Competitive advantages make the company recognizable in the market, protect against the influence of competing forces. Competitiveness is a result that fixes the presence of competitive benefits, without which it is impossible.

Competitive advantage is a system that has some particular value, giving it superiority over competitors in the economic, technical and organizational fields of activity, the ability to more effectively manage available resources.

Sustainable competitive advantage is a long-term benefit from the implementation of a unique strategy aimed at creating value, which at the same time is not used by existing or potential competitors and the profits from the use of which cannot be copied.

The evaluation base for competitive advantages are the goals of the enterprise and the tasks associated with them, which the enterprise is capable of performing, taking into account the actual environmental conditions and given the quality of their implementation. Structural and functional changes in the enterprise are designed to provide conditions for successful activity "according to purpose", to bring the necessary competencies of the enterprise into compliance with the evolving environmental requirements. The combination of such changes and the work of change management is usually called development (the creation of competitive advantages).

The development process is aimed at building capacity – a set of enterprise resources used to solve tasks that an enterprise is capable of performing with an outcome that is acceptable for a goal-oriented entity or organization (for example, for the owner, the parent organization, etc.). The use of potential and created competitive advantages is aimed at achieving results following the objectives (goals) in the process of the activity. In general, there are several ways to use the potential, even under the conditions of a single goal. In this situation, the requirements of activity are determined by the external environment. The enterprise's business has two components: development (creation of competitive advantages) and target activity (use of competitive advantages). The task of progress can be formulated as follows: it is necessary to choose a development option in which at each moment the available potential allowed at least one way to achieve the desired results of the activity.

The main objective of the enterprise is to be better than specific competitors acting with the enterprise on the same market (with overlapping goals). In this regard, any performance must be compared with the results of competitors. For example, to assess the event "reduction of production costs in the company by 10%, "you need to know the same figure among competitors. Similarly, if the "firm's market share increased by 3% over the control period", and by 10–20% for the leading competitor, then such an event is difficult to assess positively.

The competitive advantage of the company is not always distinct. In practice, the differences between the firm and its competitors, which are selected to assess the advantages or disadvantages, can be very subjective, depending on what management attaches importance to - intra-company factors, customers or competitors. When forming a competitive advantage, the following options are possible:

- concentration on competitors, based on a comparison of the firm with its closest competitors (a significant competitive power characterizes the market environment in this case);
- customer orientation and satisfaction of their needs, when managers rely mainly on customer opinions on how the company looks in comparison with competitors;
- focus on the market perspective when attention is paid to both consumers and competitors.

For a factor to be not just a competitive, but a decisive advantage, it is necessary that it be of crucial importance in meeting the needs and at the same time based on the uniqueness of the company's business. What matters is the primary quality and the uniqueness of the product.

The factors that determine the competitive advantages of a company as a complex, multi-functional, open, hierarchical socio-economic system are many and varied in their sources and the nature of their manifestation. Their classification is difficult but necessary. Often, the following five groups of competitive advantage factors are distinguished: resource, technological, innovative, global, cultural. The above composition of elements of competitive advantage can be supplemented by organizational and structural factors, which at one time paid attention to J. Schumpeter. These include a large number of factors contributing to a synergistic effect due to:

Restructuring of the company by selling unprofitable and unpromising business units;

- simplify the production system;
- mergers and acquisitions in strategically promising industries;
- globalization of business operations.

Thus, it is not by chance that the overwhelming majority of industrial enterprises, banks, financial companies, communications and communications organizations, trade and other spheres of economic activity prefer to consolidate their efforts as conditions conducive to enhancing their competitiveness and achieving strategic advantages.

The competitive advantage of any type gives higher efficiency than the competition. Firms with low costs at comparable prices with competitors on comparable products have the opportunity to get more profit. Accordingly, for firms with differentiated products, the profit per unit of output will be higher, since differentiation allows a firm to set high prices, which, at equal costs to competitors, provides more top benefits.

The competitive advantage of an enterprise can be high competence, which is manifested in its superiority over its competitors in the economic, technical, technological, and organizational fields of activity. Often, there are two groups of factors that provide a company with competitive advantages - the superiority in resources (best quality, low prices, etc.) and the best quality, skill, abilities (everything related to the efficiency and quality of all types of work: research, design, planned, etc.). Of particular importance are the competitive advantages achieved through the improvement of the second group of factors, since they require a complex and systematic organization of work and considerable intellectual effort, but they are difficult to copy.

Competitive advantages must necessarily find a real embodiment in the product, price, quality of service, low costs and other indicators of the company's activity and be

perceived by the consumer, i.e. they must be measured, evaluated by economic indicators: higher profitability. a greater market share, a large sales volume, etc. The advantages that were not realized in the competitive struggle are not advantages as such since they were not embodied in new results of activity, did not lead to a new state of the company.

The composition of the benefits depends on the industry. So, for high-tech companies, competitive advantages will be mainly related to technical excellence, product and technological innovations, for companies serving mass demand, this is primarily brand awareness, low costs, and geographical location.

Competitive advantages should be:
- significant, i.e. noticeably stand out from the competition:
- visible, i.e. distinguishable buyers;
- meaningful to the consumer, i.e. bring him perceived benefits;
- resilient, i.e. to retain its importance in the context of environmental changes, non-reproducible competitors;
- unique, i.e. the benefits provided cannot be obtained from other manufacturers;
- profitable for the company, i.e. production volumes, cost structure and market prices for the offered goods make it possible to work successfully in the chosen field of activity and receive sufficient profit.

J.J. Lambin [11] grouped the competitive advantages of a firm, depending on various factors, into two categories, which can be internal and external. Competitive advantage is called external if it is based on the distinctive qualities of the product, which form value for the buyer by either reducing costs or increasing efficiency. Competitive advantage is internal if it is based on the superiority of the company concerning production costs, management of the company or product that creates value for the manufacturer, allowing you to achieve cost less than a competitor. These two types of competitive advantage are often incompatible since they have different origins and different natures and require different skills and cultures.

The organization is unable to influence external factors, but the management of the organization almost entirely controls internal factors, or more precisely, the organization's management has all the necessary conditions to control these factors. Achieving the inherent competitive advantages of the organization is carried out by staff, with a unique role assigned to the head.

Inherent competitive advantages of the organization include six groups:

1. Structural:
- Production structure of the organization.
- The mission of the organization.
- The organizational structure of the organization.
- Specialization and concentration of production.
- Level of unification and standardization of products and components of production.
- Accounting and regulation of production processes.
- Staff.
- Information and regulatory base of management.

- The power of competition at the exit and entry of the system.

2. Resource:
- Suppliers.
- Access to high-quality and cheap raw materials and other resources.
- Accounting and analysis of the use of all types of resources at all stages of the life cycle of large objects of the organization.
- Functional-cost analysis of products and elements of production.
- Optimization of resource efficiency.

3. Technical:
- Patented item.
- Patented technology.
- Equipment.
- The quality of manufacturing goods.

4. Management:
- Managers.
- Organization of delivery of raw materials, materials, components according to the "just in time" principle.
- The functioning of the management system (competitiveness) of the organization.
- The functioning of the quality management system in the organization.
- Conducting internal and external certification of products and systems.

5. Market:
- Access to the market for the resources needed by the organization.
- Access to the market for new technologies.
- Leading position in the commodity market.
- The exclusivity of the product organization.
- The exclusivity distribution channels.
- The exclusivity of advertising products organization.
- Effective sales promotion and after sales service.
- Prediction of pricing policies and market infrastructure.

6. The effectiveness of the organization:
- Indicators of profitability (in terms of cost-effectiveness of products. Production, capital, sales).
- The intensity of capital utilization (according to the turnover ratios of the types of resources or capital).
- Financial sustainability of the organization.
- The share of exports of high-tech goods.

III. USING LINEAR PROGRAMMING TECHNIQUES TO INCREASE COMPETITIVE ADVANTAGE

The enterprise security service found out that to achieve the highest quality of a product that surpasses competitors, at least 40 grams of products A, at least 4 grams of products B and at least 30 grams of products B must be added to the product. Supplier offers Set 1, which contains 10 grams of products B and 50 grams of products B, and Set 2 contains 40 grams of products A and gr for products B and B. The price of the first set is $ 60, and the

second is $ 50. It is necessary to create an optimal procurement plan that helps outperform the competition and at the same time has the lowest cost.

Let x_1 and x_2 denote the mass of Set 1 and Set 2 acquired by the enterprise, then the total amount of received production A will be $40x_2$ g, the amount of B production will be $10x_1 + 20 x_2$ g, and the amount of B production will be $50x_1 + 20x_2$ g. The total cost of purchased sets will be $z = 60x_1 + 50x_2$. Thus, we obtain the following linear programming problem:

$$z = 60x_1 + 50x_2 \to min,$$
$$\begin{cases} 40x_2 \geq 40, \\ 10x_1 + 20x_2 \geq 4, \\ 50x_1 + 20x_2 \geq 30, \\ x_1 \geq 0, x_2 \geq 0. \end{cases} \quad (1)$$

To transform the system of constraints into a system of equations, it is necessary to enter the balance unknowns x_3, x_4, x_5:

$$z = 60x_1 + 50x_2 \to min,$$
$$\begin{cases} 40x_2 - x_3 = 40, \\ 10x_1 + 20x_2 - x_4 = 4, \\ 50x_1 + 20x_2 - x_5 = 30, \\ x_1 \geq 0, x_2 \geq 0, x_3 \geq 0, x_4 \geq 0, x_5 \geq 0. \end{cases} \quad (2)$$

The newly introduced variables x_3, x_4, x_5 cannot be considered basic since they correspond to a basic solution with *negative components*.

Therefore, we introduce artificial basic unknowns s_3, s_4, s_5, and consider the problem:

$$z = -60x_1 - 50x_2 - Ms_1 - Ms_2 - Ms_3 \to min,$$
$$\begin{cases} 40x_2 - x_3 + s_1 = 40, \\ 10x_1 + 20x_2 - x_4 + s_2 = 4, \\ 50x_1 + 20x_2 - x_5 + s_3 = 30, \end{cases} \quad (3)$$
$$x_1 \geq 0, x_2 \geq 0, x_3 \geq 0, x_4 \geq 0, x_5 \geq 0, s_1 \geq 0, s_2 \geq 0, s_3 \geq 0.$$

The decision process is illustrated in Table 1.

Table 1 Solving a system of equations

$\tilde{c}$	Basis	h	−60 x_1	−50 x_2	0 x_3	0 x_4	0 x_5	−M s_1	−M s_2	−M s_3
−M	s_1	40	0	40	−1	0	0	1	0	0
−M	s_2	4	10	20	0	−1	0	0	1	0
−M	s_3	30	50	40	0	0	−1	0	0	1
	z_0−z	−74M− z	−60M + 60	−80M + 50	M	M	M	0	0	0
−M	s_1	32	−20	0	−1	2	0	1	−2	0
−50	x_2	1/5	½	1	0	−½0	0	0	1/20	0
−M	s_3	26	40	0	0	1	−1	0	−1	1
	z_0−z	−58M−10−z	−20M + 35	0	M	−3M+5/2	M	0	4M-5/2	0
−M	s_1	40	0	40	−1	0	0	1	0	0
−60	x_1	2/5	1	2	0	−1/10	0	0	1/10	0
−M	s_3	10	0	−80	0	5	−1	0	−5	1
	z_0−z	−50M+24−z	0	40M−70	M	−5M+6	M	0	6M−6	0
−M	s_1	40	0	40	−1	0	0	1	0	0
−60	x_1	0.6	1	2	0	−1/10	0	0	1/10	0
0	x_4	2	0	−80	0	5	−1	0	−5	1
	z_0−z	−40M−36−z	0	−40M+26	M	0	6/5	0	M	M−6/5
−50	x_2	1	0	1	−1/40	0	0	1/40	0	0
−60	x_1	1/5	1	0	1/100	0	−1/50	−1/100	0	1/50
0	x_4	18	0	0	−2/5	1	−1/5	2/5	−1	1/5
	z_0−z	−62−z	0	0	13/20	0	6/5	M−13/20	M	M-6/5

In the fifth simplex table there is no negative number among Δ_j and f (since M is greater than any positive number). Therefore, the fifth basic solution

$$x_1 = \frac{1}{5}, x_2 = 1, x_3 = 0, x_4 = 18, x_5 = 0, s_1 = 0, s_2 = 0, s_3 = 0.$$

is optimal.

Thus, the optimal procurement plan consists of 1/5 of Set 1 and 5 of Set 2.

IV. CONCLUSION

The study confirmed that the solution of the main problems of linear programming creates the necessary prerequisites for increasing the efficiency of production: the growth of income and profits or the reduction of production costs and technological waste during its production. Today, the linear programming method is a useful tool for increasing the competitiveness of a company on risk.

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