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A Mathematical Approach to Evaluating Managerial Skills: Economic Cybernetics and the Convex Operational Field

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Shaqir Elezaj[1], Vehbi Ramaj[2*], Ramë Elezaj[2], Fatos Ukaj[3]

[1] Department of Management, UBT College, Prishtine 10000, Kosovo
[2] Faculty of Business, University “Haxhi Zeka”, Pejë 30000, Kosovo
[3] Economic Faculty, University “Hasan Prishtina”, Prishtinë 10000, Kosovo

Corresponding Author Email: vehbi.ramaj@unhz.eu

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ABSTRACT

This paper presents a novel methodology for quantifying managerial competence through the lens of economic cybernetics. The proposed model is premised on the definition of a convex operational field, wherein the limiting economic conditions are delineated by operational management (MO), strategic management (MS), and predictive management (MP) skills. Any given point (representative of an economic situation) within this convex operational field is attributed to a successful manager, whose leadership abilities are proportionally expressed depending on their position. It is posited that the adeptness of a successful manager inherently shapes the criterion function, while the boundaries of the convex operational field define the specifications of this function. The convex operational field is examined through two lenses: the identification of managerial skills and the calculation of the elasticity coefficient. The case study presents the convex operational field as defined by the economic conditions of MO, MS, and MP. This analysis can be applied to both linear and non-linear programming, thereby providing avenues for the application of advanced mathematical methodologies in resolving economic and managerial challenges.

1. INTRODUCTION

The economic cybernetics, not only has significantly altered the way businesses operate but also the expertise necessary for successful management. Considering the growing dependence on technology coupled with the enormous amounts of available data, it is essential managers possess a variety of technical and digital proficiencies to effectively lead their teams [1]. Some of the required managerial skills in the cybernetic economy include the ability to effectively manage data and technology, adapt to rapid technological change, and utilize digital tools for decision-making [2]. The costs incurred by the enterprise in Research and Development play a major role in its innovative potential [3]. This paper analyzes the required managerial skills in the context of the cybernetic economy. It elaborates on a new approach regarding the assignment of managerial skills from the aspect of the economic cybernetics. By exploring these skills, this analysis seeks to identify key competencies for managerial success in today's rapidly evolving business landscape.

1.1 Traits of a successful manager

The successful manager can and should have various relevant qualities. The basic qualities of a successful manager can be grouped into – decision-making and leadership, personal attribute, and continuous improvement and learning [4-7].

Effective leadership is the basis of successful organizations. Managers play a fundamental role in guiding their teams and driving the company towards its goals. Nonetheless, not all managers are in the same way successful in their roles. Certain key traits set apart exceptional managerial leaders from the rest. There traits can be grouped into – decision-making and leadership, personal attribute, and continuous improvement and learning.

Decision-making and Leadership: One of the most critical aspects of managerial leadership is the ability to make sound decisions. Successful managers possess strong decision-making abilities, allowing them to analyze complex situations, consider various perspectives, and arrive at well-informed choices. Moreover, they demonstrate leadership prowess, inspiring and motivating their teams to work cohesively towards shared objectives. Effective leadership also entails understanding the opinions of team members, ensuring a collaborative and inclusive decision-making process [5-7]. Moreover, successful managers are able to adapt to new situations and take calculated risks. They are not afraid to embrace challenges and step outside their comfort zones to drive innovation and progress within the organization. These leaders monitor favorable outcomes, leveraging them as learning opportunities and replicating success across different projects.

Personal Attributes: In addition to possessing leadership qualities, successful managerial leaders exhibit a range of personal attributes that contribute to their effectiveness. Personal integrity is paramount, as it establishes trust and credibility with team members and stakeholders. Enthusiasm for managerial leadership is contagious, fostering a positive work environment and encouraging a sense of ownership among employees. Willingness to work hard and the ability to handle unpleasant and intriguing situations demonstrate resilience and determination, essential for navigating the dynamic landscape of business. Entrepreneurship and ambition drive managers to seek growth opportunities and explore new ideas that can lead to organizational success [5, 6]. Furthermore, strong communication skills are crucial for managers to articulate their vision clearly and foster open and honest communication within the team. The capacity to write clearly enables them to convey complex concepts effectively, influencing stakeholders and ensuring that objectives are well-defined and understood.

Continuous Improvement and Learning: Outstanding managerial leaders are committed to continuous improvement and learning. They actively seek new ideas and insights, staying abreast of industry trends and best practices [4-8]. Logistic and progressive thinking skills enable them to strategize for the future and anticipate potential challenges.

A successful manager can have different qualities. Of course, these properties include different fields, and thus the manager can develop his influence on the successful realization of managerial work [9].

In addition to the previously emphasized characteristics, there are also other desired characteristics, such as: being intelligent, emotionally stable, dominant, conscientious, important, shrewd in terms of business management, caring, stable in the implementation of ideas progressive management, and similar [10, 11]. In summary, to attain success in management, it is necessary to have a combination of these attributes [12].

2. DATA AND METHODS

2.1 Determination of managerial skills

2.1.1 Convex operational field

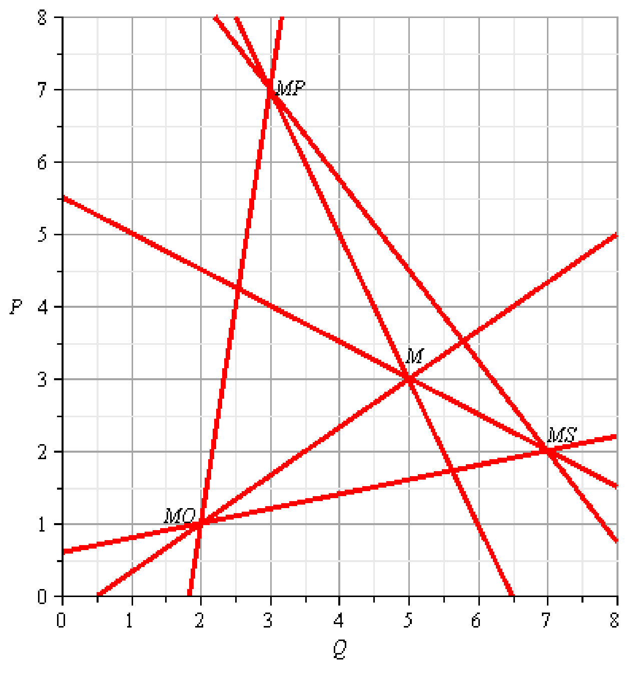

Figure 1. Regarding the analysis of managerial skills

Managerial skills form the bedrock of successful organizational leadership, it encompasses a wide range of qualities necessary for efficient management. These abilities revolve around the capacity to manage projects with accuracy and knowledge. The key to achieving corporate goals is through the management team. Their job involves more than just assigning tasks; it also entails knowing the specifics of each position, comprehending its difficulties, and directing staff with wisdom and expertise. Management skills make sure that tasks are not merely performed, but are done effectively and with a great eye for quality, whether it's allocating responsibilities, managing resources, or organizing complicated projects [13-16].

Additionally, managerial skills enable people to make cautious and strategic judgments. Making decisions in a managerial setting is rarely simple. It entails analysis. As regards the implementation of the model for the analysis of managerial skills, it is suitable to define appropriately the operational areas convexly as shown in Figure 1.

The convex operational field are primarily defined by the definitions of operational management skills (MO), strategic management skills (MS), and predictive management skills (MP). The manager's position must be within the defined operational area; so, it can be stated as follows:

$$M = \alpha \cdot MO + \beta \cdot MS + (1-\alpha-\beta)\cdot MP \tag{1}$$

so that coefficients α and β must meet the conditions:

$$0 \le \alpha \le 1; \quad 0 \le \beta \le 1 \tag{2}$$

For example, for conditions:

$$\begin{aligned} 5 &= \alpha\cdot 2 + \beta\cdot 7 + (1-\alpha-\beta)\cdot 3; \\ 3 &= \alpha\cdot 1 + \beta\cdot 2 + (1-\alpha-\beta)\cdot 7 \end{aligned} \tag{3}$$

it is obtained:

$$M = \frac{6}{29}\cdot MO + \frac{16}{29}\cdot MS + \frac{7}{29}\cdot MP \tag{4}$$

The efficiency of implementing managerial skills is:

$$AM = \frac{1}{2}\left|\begin{pmatrix} 2 & 1 & 1 \\ 7 & 2 & 1 \\ 3 & 7 & 1 \end{pmatrix}\right| = \frac{29}{2} \tag{5}$$

Furthermore, managerial capabilities can be assigned across sectors. For instance, within the convex operational area *M-MO-MS*, the managerial skills are:

$$AM_1 = AM \cdot (M - MO - MS) = \frac{1}{2}\cdot\left|\begin{pmatrix} 2 & 1 & 1 \\ 7 & 2 & 1 \\ 5 & 3 & 1 \end{pmatrix}\right| = \frac{7}{2} \tag{6}$$

Analogously, managerial skills are determined across sectors:

$$AM_2 = AM \cdot (M - MS - MP) = \frac{1}{2}\cdot\left|\begin{pmatrix} 7 & 2 & 1 \\ 3 & 7 & 1 \\ 5 & 3 & 1 \end{pmatrix}\right| = 3 \tag{7}$$

$$AM_3 = AM\cdot(M-MP-MO)=\frac{1}{2}\cdot\left\|\begin{pmatrix}3 & 7 & 1\\ 2 & 1 & 1\\ 5 & 3 & 1\end{pmatrix}\right\| = 8 \qquad (8)$$

3. RESULT AND DISCUSSION

3.1 Determination of managerial skills within the convex operational field

Thus, from the above Eqs. (6)-(8), it is possible to obtain the following:

$$\frac{AM_1}{AM}=\frac{7}{29}=24.138\%;\quad \frac{AM_2}{AM}=\frac{6}{29}=20.690\%;\quad \frac{AM_3}{AM}=\frac{16}{29}=55.172\% \qquad (9)$$

This means that the AM_1 managerial skills of the successful manager (within the convex operational area *M-MO-MS*) are 24.138% higher compared to the managerial skills of managers when taking into consideration, operational and strategic managerial skills (for the case analyzed). Similarly, the magnitude of the managerial capabilities/skills across sectors are determined to be AM_2=20.690% and AM_3=55.172%.

It is understood, for any other managerial position within the convex operational area *MO-MS-MP* (for all points, respectively, within the convex operational area), the corresponding values for *AM*, AM_i (i=1, 2, 3). This analysis is based on the principles of economic cybernetics.

3.2 Determination of elasticity coefficient

The idea of elasticity of coefficient is a key economic indicator that provides deep understanding of market dynamics and consumer behavior [17]. A major applications of elasticity coefficients is in pricing strategies. Based on the elasticity of demand, businesses can modify their prices. Producers can raise prices without significantly changing the quantity demanded for products with inelastic demand, where consumers are less responsive to price changes (such as vital goods), maximizing revenue. On the other hand, price decreases might increase sales for goods with elastic demand and very price-sensitive consumers (such as luxury goods) [17].

The elasticity coefficient, in its simplest form, is a flexible economic indicator that goes beyond simple numerical computations. It sheds light on the complex link between pricing changes and customer behavior, aiding firms, decision-makers, and economists in making tactical choices. Its wide range of uses highlight how important it is as a foundational tool for understanding market dynamics and creating sensible economic policies.

According to the analysis of economic cybernetics, one of the most important aspects is the elasticity coefficient (ε). The elasticity coefficient serves as an economic indicator to ascertain the percentage change in one variable when there is a 1% change in another variable.

Thus, for the *MO-MS-MP* convex operational field, the elasticity coefficient is:

$$\varepsilon = \frac{2Q\cdot\left(45Q^2-223Q-233\right)}{3\cdot(Q+3)(5Q-43)\cdot(6Q-11)} \qquad (10)$$

The magnitude assigned is the simple arithmetic mean of the coefficients of elasticity between the economic processes MO-MS, MS-MP, and MP-MO. Generally, the coefficient of elasticity $\varepsilon(Y, X)$ between two economic magnitudes X (independent economic variable) and Y (dependent economic variable) is determined according to:

$$\varepsilon(Y,X)=\frac{\partial Y}{\partial X}\frac{X}{Y} \qquad (11)$$

where:

∂Y=change in the dependent economic variable

Y=initial value of the dependent economic variable

∂X=change in the independent economic variable

X=initial value of the independent economic variable

By applying this formula separately to the economic processes MO-MS, MS-MP, MP-MO, and then calculating the average arithmetic mean of these coefficients, the assigned magnitude for the limiting economic state is obtained.

Figure 2 graphically presents the elasticity coefficient for the MO-MS-MP convex operational field. For example, for Q=4 according to the diagram, ε=0.5 is obtained, which means that when the production (Q) changes by 1%, then the price of the product (P) increases (plus sign) by 0.5%, divided by operational management skills, strategic and predictive manager, and so on.

Analogously, the coefficients of elasticity across sectors ε_1, ε_2 and the ε_3 can be determined respectively, also as simple arithmetic averages:

ε_1 – coefficient of elasticity between economic magnitudes within the sectors MO-MS

ε_2 – coefficient of elasticity between economic magnitudes within the sectors MS-MP

ε_3 – coefficient of elasticity between economic magnitudes within the sectors MP-MO

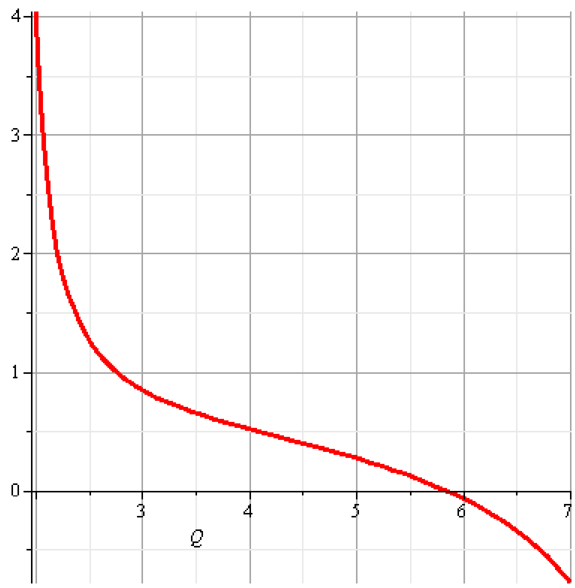

Figure 2. Coefficient of elasticity to the MO-MS-MP convex operational field

Figure 3 graphically presents the ratio $\varepsilon_1/\varepsilon$ of the coefficient of elasticity ε_1 of the convex operational field *M-MO-MS* to the coefficient of elasticity ε of the convex operational field *MO-MS-MP*.

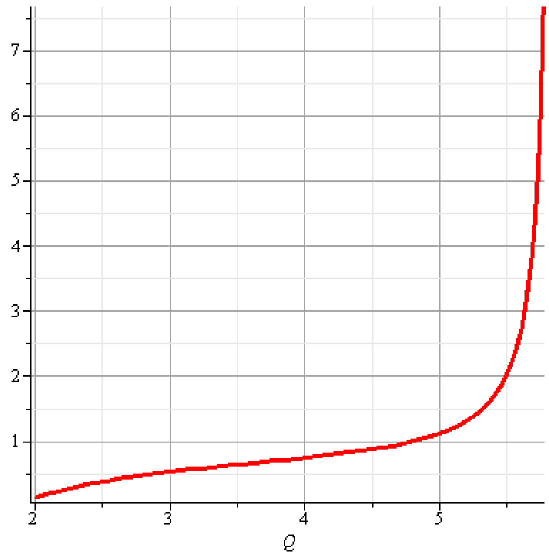

Figure 3. Graphic presentation of the ratio ε₁/ε of the relevant elasticity coefficients

For example, for Q=*5.5*, the diagram yields $\varepsilon_1/\varepsilon$=2, which means that when production (Q) changes by 1%, the price of the product (P) increases by 2%. Dividing the ratio $\varepsilon_1/\varepsilon$ by the respective managerial skills concerning the operational area across sectors *M-MO-MS* and the convex operational area *MO-MS-MP*.

$$\varepsilon_1 = \frac{2Q\left(3Q^2-17Q-29\right)}{2(Q+3)(2Q-1)(Q-11)}$$
$$\varepsilon_2 = \frac{2Q\left(5Q^2-87Q+370\right)}{(2Q-13)(Q-11)(5Q-43)} \qquad (12)$$
$$\varepsilon_3 = \frac{2Q\left(36Q^2-212Q+193\right)}{3(2Q-1)(2Q-13)(6Q-11)}$$

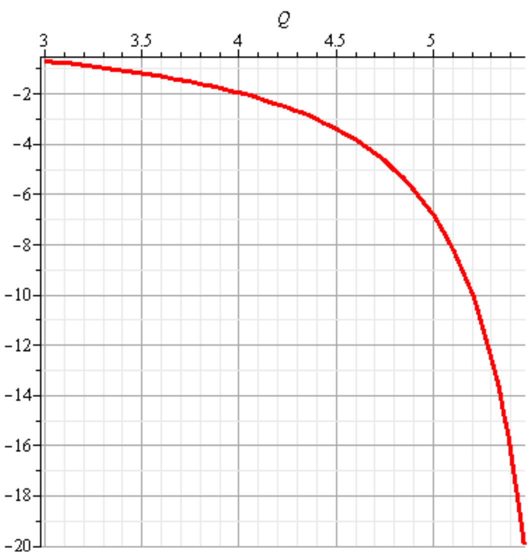

Figure 4. Graphic presentation of the ratio ε₂/ε of the relevant elasticity coefficients

Figure 4 graphically presents the ratio $\varepsilon_2/\varepsilon$ of the coefficient of elasticity ε_2 of the convex operational field *M-MS-MP* to the coefficient of elasticity ε of the convex operational field *MO-MS-MP*. For example, for Q=4, the diagram yields $\varepsilon_2/\varepsilon$=-2, which means that when production (Q) changes by 1%, the price of the product decreases (minus sign) by 2%, and divide the $\varepsilon_2/\varepsilon$ by the relevant skills of the manager to the cross-sectoral operational field *M-MS-MP* and the convex operational field *MO-MS-MP*.

Figure 5 graphically presents the ratio $\varepsilon_3/\varepsilon$ of the coefficient of elasticity ε_3 of the convex operational field *M-MP-MO* to the coefficient of elasticity ε of the convex operational field *MO-MS-MP*.

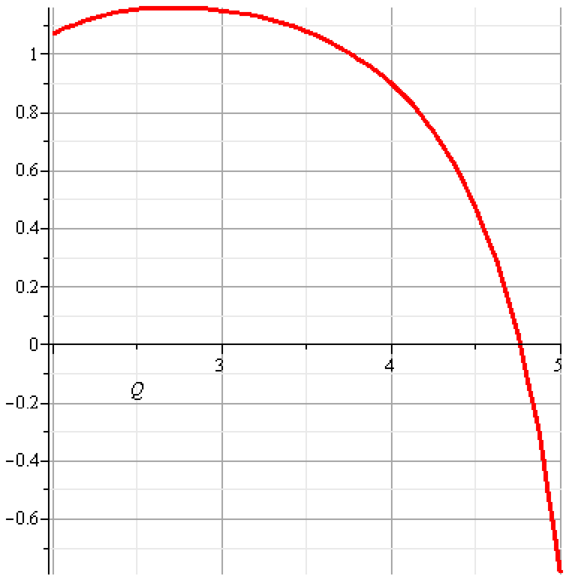

Figure 5. Graphic presentation of the ratio ε₂/ε of the relevant elasticity coefficients

For example, for Q=4, the diagram yields $\varepsilon_3/\varepsilon$=0.9, which means that when production (Q) changes by 1%, the price of the product (P) increases (plus sign) by 0.9%, divided by the times $\varepsilon_3/\varepsilon$ for the relevant skills of the manager across sectors *M-MP-MO* and the convex operational field *MO-MS-MP*. For this case, it can be emphasized that the maximum value can also be set, $(\varepsilon_3/\varepsilon)_{max}$=1.160, for Q=2.719.

3.3 Determination of Relevant Benefit

From the aspect of the economic cybernetics, it is more important, among others, to determine the relative benefit (profitability). The benefit can be determined based on the principle dependence, where $B=Q\cdot P$, so that for the analysis in question, the benefit is equal to the product of productivity (Q) multiplied by the product price. This model of determining relative benefit allows for the analysis of the impact of changes in productivity and product price on economic performance. It can be used to measure the profitability in various economic conditions within a business context.

$$B=\frac{33}{20}\cdot Q^2+\frac{7}{60}\cdot Q\ ;\ B_1=\frac{11}{90}\cdot Q^2+\frac{173}{90}\cdot Q\ ;$$
$$B_2=-\frac{5}{4}\cdot Q^2+\frac{39}{4}\cdot Q\ ;\ B_3=\frac{14}{9}\cdot Q^2+\frac{5}{9}\cdot Q \qquad (13)$$

The relative benefits are graphically presented according to

Figure 6. For example, for the benefit *B2*, the maximum value can be assigned to the convex operational field *M-MS-MP*, $B_{2(max)}$=1521/80=19.013, which is reached for *Q*=*Qe*=39/10=3.9.

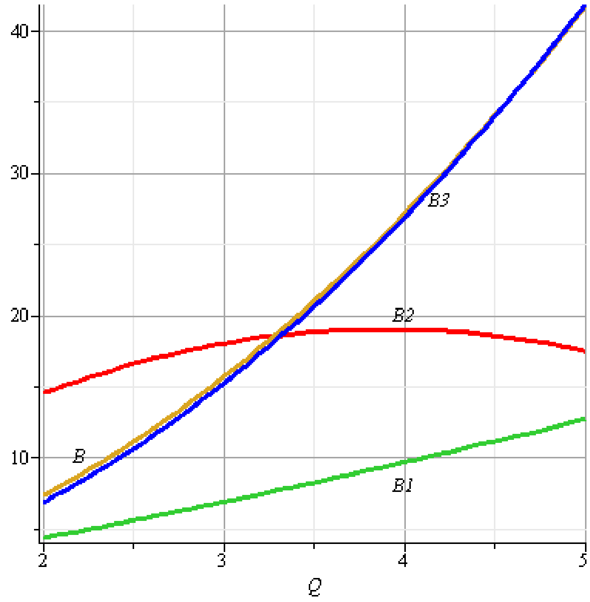

Figure 6. Graphic presentation of benefits B and B_i (i=1, 2, 3)

Figure 7 graphically presents the relative benefit ratios, B_i/B (*i*=1, 2, 3) as the ratios between the sectoral benefits and the benefit of the convex operational area *MO-MS-MP*. For example, for *Q*=3.5 it is B_1/B=0.4=40%, and so on.

It is understood, according to the analysis in question, other characteristic parameters can be determined according to the principle of economic cybernetics. This analysis complements modern analyses of economic processes and cycles, allowing for better comprehension of the economic dynamics and interrelationships between different sectors within the convex operational area.

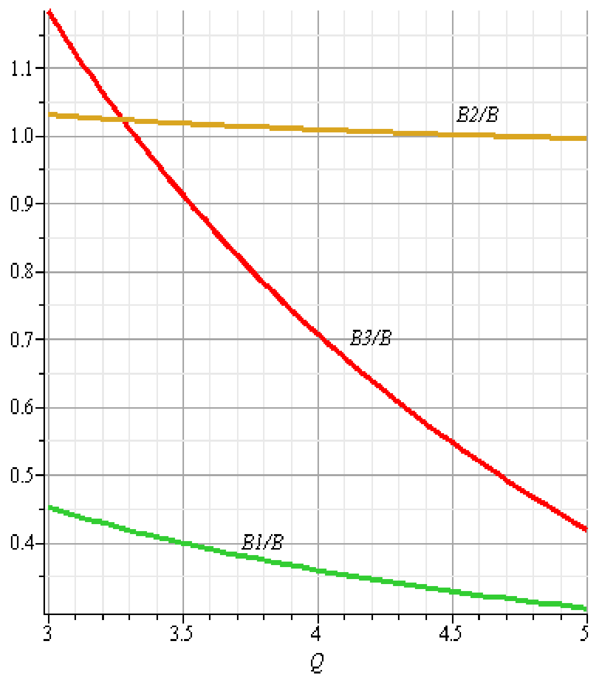

Figure 7. Relative ratios of benefits Bi/B (i=1, 2, 3)

4. CONCLUSIONS

The analysis presented through economic cybernetics is based on the modern formulation of economic processes and cycles. The criteria function and relevant definitions are determined according to the formation of the convex operational area. In the analyzed case, the convex operational area or field is defined by the economic conditions of operational management (MO), strategic management (MS), and predictive management (MP).

These skills are complementary and interrelated, which describes their nature. Effective operational management (MO) makes ensuring that daily tasks are completed successfully, giving the business a solid foundation. By establishing long-term objectives and directives and coordinating operational actions with the overall strategy, strategic management (MS) builds on this basis. By offering insights into potential future scenarios, predictive management (MP) therefore improves strategic planning by enabling firms to proactively adapt their plans and operations.

Operational (MO) and strategic (MS) decisions can both benefit from predictive management skills (MP). Organizations can optimize their operational operations and make strategic plans to address future market demands by evaluating patterns and projecting future demands. A continuous improvement cycle is created by this iterative process of data analysis, operational improvements, and strategy adjustments based on forecasts.

The analysis in question can be interchangeably related to linear and non-linear programming. Thus, opening the way for utilizing advanced mathematical methods to solve economic and managerial problems.

Economic Cybernetics is integrated with linear and nonlinear programming, which broadens the scope of the research and makes it possible to apply cutting-edge modeling methods to address challenging economic problems. This integration can help make more informed decisions and optimize economic performance effectively.

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NOMENCLATURE

MS	strategic management
MO	operational management
MP	predictive management
M	convex operational field
AM_1	managerial skills of the successful manager (within the convex operational field *M-MO-MS*)
ε	elasticity coefficient
X	independent economic variable
Y	dependent economic variable)
Q	production
P	product
B	principle dependence