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OPTIMIZATION OF RESOURCES THROUGH MODERN DECISION-MAKING TECHNOLOGIES AS A FUNCTION OF CAPITAL INVESTED

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Abstract
In a dynamic and competitive economic environment, the efficient use of resources is essential for the success of manufacturing companies/enterprises. The study examines how modern economic-mathematical methods and technological solutions, such as artificial intelligence (AI), big data analytics and ERP platforms, can be used to help optimize resources and decision-making. To find the optimal solutions in the use of material, human and financial resources, the focus is on integrating linear programming models with complex IT tools. The study focuses on the use of customized IT solutions in value chain management, highlighting how they can improve operational efficiency and the quality of decision-making processes. Through the responsible use of resources, it emphasizes the sustainability of production processes, providing examples of reducing costs, maximizing benefits and minimizing losses. The conclusions emphasize that the adoption of modern digital technologies and the application of optimization techniques enable firms to quickly adapt to market requirements and strengthen their competitive position, ensuring long-term sustainable growth. The study provides a theoretical and practical perspective on the changes in decision-making and how integrated solutions can maximize economic performance in a globalized world.

Keywords: *optimal use of resources; production, advanced technology; economic phenomenon*

JEL Classification: C61, M15

INTRODUCTION

Efficient organization and management of an enterprise/manufacturing company is a challenge in the current economic context. The increasing complexity of economic activities at global level, influenced by technological developments (disruptive technology), digitalization, artificial intelligence (AI) and sustainability requirements, requires the adoption of advanced resource management methods (Cosmulese, 2022; Dragomir, & Alexandrescu, 2017). In this respect, the optimal use of resources is becoming a necessity for gaining a competitive advantage and adapting to market requirements. Data production, processing, reception, reception, transportation and storage activities are now supported by complex information systems (expert systems and neural networks). This facilitates rapid collection and analysis of relevant information. In this context, the modernity of decision-making in the economic environment is marked by the extensive use of technological developments and multi-dimensional integration of IT tools (Dragomir, 2017a). As for the human side, managers, with the help of economic-mathematical methods and specialized and highly performing IT platforms, can optimize their allocation processes, substantiating decisions and minimizing risks, thus streamlining their operational activity. Against this background, the example of the Simplex method, developed by George B. Dantzig, is used to solve complex decision problems. It underlies many computer systems currently used to solve linear programming problems and has demonstrated its usefulness in optimizing economic decisions by determining ideal production structures. This applies even in situations where there are few resources or tight constraints.

In today's economy, characterized by dynamic demands and intense competition, the main objectives of managers are to maximize profits and minimize costs through efficient use of existing resources (Cosmulese, 2019). Companies must embrace digital technology and integrate advanced optimization techniques into their management processes to achieve these goals. For example, when modern ERP systems are integrated with machine learning algorithms, companies can anticipate market demands, manage supply chains more efficiently and increase productivity. The optimization of resources through modern decision-making technologies as a function of capital invested highlights the importance of efficient resource allocation, while the analysis of investment issues related to the impact of higher education on sustainability underlines the role of strategic investments in developing human capital and creating a sustainable future (Kholiavko et al., 2021; Grosu et al., 2023).

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This study presents the economic-mathematical methods and technological solutions that are essential for the optimal use of resources. In addition, we examine the role these tools play in transforming decision-making processes and provide examples from relevant industry practices. We will emphasize the importance of sustainability and rapid adaptation to economic and technological change, providing an up-to-date perspective on how businesses can address the challenges of an evolving economy.

I. ECONOMIC MATHEMATICAL MODELS: MODERN APPROACHES

At the microeconomic and macroeconomic levels, decision-making processes and information obtained are measured by characteristic indicators (deterministic, stochastic and fuzzy) (Zhumadillayevaet al., 2020). Research on the organization and management of economic activity includes information related to human relations as well as decision-making issues (Ejimabo, 2015). Decision processes bring new problems that require rigor, and decision makers need to make the best or the closest to the best possible decisions. The theoretical foundations that characterize scientific processes are generally based on mathematical methods, and their orientation is general and practical (Bertrand & Fransoo, 2002). Managers use economic-mathematical modeling as an alternative to scientific experiments using computer programs. Economic modeling allows managers to think and make better and faster decisions without altering reality. It provides a strategy of how material, human and financial resources can be utilized according to objectives over a period of time, generating business models that combine theory with practice (DaSilva & Trkman, 2014).

Economic models start from many simplifying assumptions (Vanni et al., 2011) and that relate to small problems that lead to an optimal solution based on a given criterion. All adaptations of mathematical modeling to complex and concrete economic phenomena are based on a more correct conception of the magnitudes involved in the complex decision grounding process. The use of decision models in innovation management allows choosing the best option, taking into account limitations, risks and the level of human capital of the enterprise (Varnalii et al., 2020).

In a modern market economy where the complexity of human activities is increasing, managers in an enterprise/manufacturing company, depending on the existing resources, aim to achieve the minimum cost of the resources used and at the same time maximize the benefit (Horne et al., 2018; Macovei, 2005; Macovei & Siretean, 2006). They have to achieve their proposed objectives, i.e. managerial performance, depending on the existing resources (Holcomb et al., 2009). Starting from economic examples, the notion of linear programming problem has been introduced, consisting in finding the optimum of a function under certain conditions (Purcaru, 2004). This problem can appear in different forms, where the constraint system can be a finite or not finite manifold, bounded or not bounded by admissible solutions and then requires the use of computer systems to solve them. Therefore, an important role is played by admissible basic solutions and optimal solutions (Jdid et al., 2022). Linear programming not only facilitates the solution of practical problems, but also plays an essential role in the theoretical progress of applied mathematics and computer science. It is an inter-disciplinary field (figure 1), providing fertile ground for innovation and continuous development.

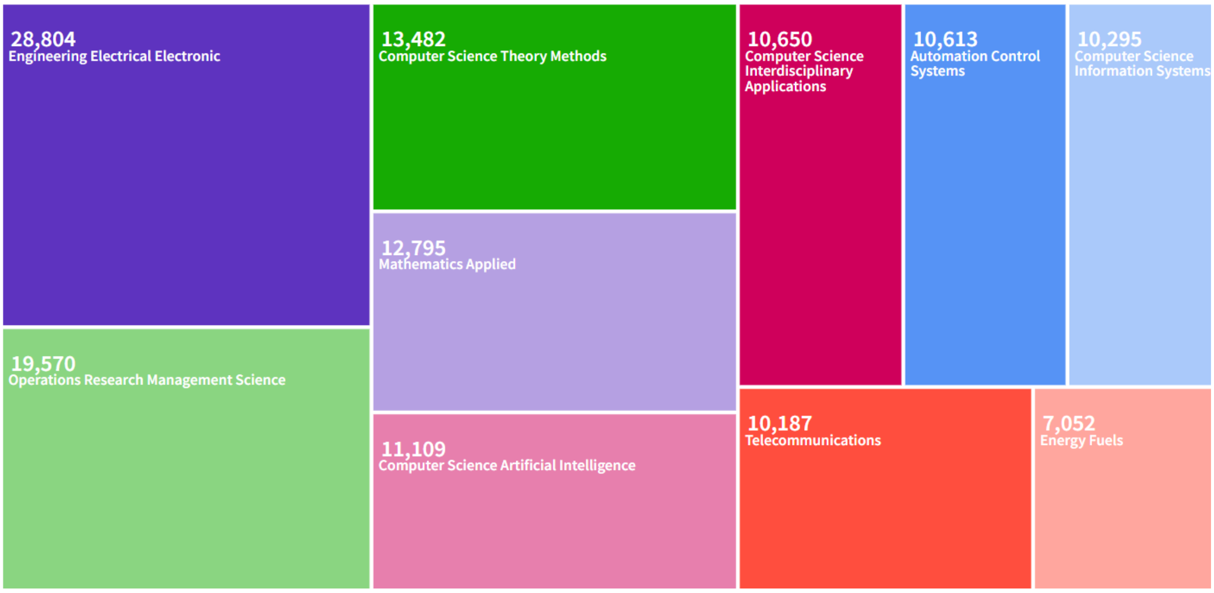

Figure 1. The inter-disciplinary nature of LP
Source: https://www.webofscience.com/wos/woscc/analyze-results/f42aed1b-135b-44e9-840b-a06f620fba3d-01398e460f

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Figure 1 highlights the growing interest in this topic, reflected by the large number of published papers (156548), citations and related fields. This shows the impact and usefulness of the topic among researchers and practitioners.

The general mathematical form of linear programming problems was given by George B. Dantzig. In his paper (Dantzig, 2002) he states "linear programming can be viewed as part of a great revolutionary development which has given mankind the ability to state general goals and to lay out a path of detailed decisions to take in order to "best" achieve its goals when faced with practical situations of great complexity. Our tools for doing this are ways to formulate real-world problems in detailed mathematical terms (models), tech-niques for solving the models (algorithms), and engines for executing the steps of algorithms (computers and software)". "Although George's lifetime achievements include a substantial body of deep theory, he derived his greatest professional satisfaction from the successful application of theory to real-world problems" (Gill et al., 2007). Linear programming is one of the main tools of economic analysis, as it encompasses the ideas of maximization, minimization or the determination of a saddle point.

George D. Dantzig proposed a very efficient method for solving linear programming problems, namely the Simplex method. Using the Simplex (primal or dual) method, the optimal solution is determined (Macovei, 2008; Paparrizos et al., 2003) and this method is the basis of many computer systems. The mathematical models associated with economic phenomena are found to have some similarities and therefore they can be incorporated into a general model. Thus, the general form of a linear programming problem model (Purcaru, 2004) is:

$$[\min / \max]\ f\left(x_1, x_2, \ldots, x_n\right) = \sum_{j=1}^{n} c_j \cdot x_j \tag{1}$$

$$\begin{cases} \sum_{j=1}^{n} a_{ij} \cdot x_j \le b_i,\ i = \overline{1, r} \\ \sum_{j=1}^{n} a_{ij} \cdot x_j = b_i,\ i = \overline{r+1, s} \\ \sum_{j=1}^{n} a_{ij} \cdot x_j \ge b_i,\ i = \overline{s+1, m} \end{cases} \tag{2}$$

$$x_j \ge 0,\ j = \overline{1, n} \tag{3}$$

Where: relation (1) represents the efficiency objective function or the goal function that measures the performance of the economic phenomenon and connects the variables; relation (2) represents the system of restrictions/constraints of the optimization problem, which contains certain restrictions on the variables of the economic phenomenon; relation (3) represents the conditions of non-negativity of the variables and ensures that a feasible solution is obtained from the point of view of economic logic. It is observed that a linear programming problem contains a set of input variables that are known and a set of output variables that are unknown (Dantzig, 2004). There is a certain relationship between these variables due to the economic phenomenon under study and the aim is to determine the output variables in terms of input variables (measured or determined) in such a way that the performance criteria of the economic phenomenon under study are satisfied.

Thus, starting from a real and complex economic phenomenon, we determine a linear programming problem containing logical conditions. Solving such a problem is based on an algorithm, and new technologies help us to solve these problems no matter how complex they are.

II. THE PROBLEM OF OPTIMAL USE OF RESOURCES

A key model in economics and industry is the optimal resource utilization problem, which provides a strict and efficient approach to maximize performance under limited resources (Challoumis, 2024). Firms/companies achieve better results, reduce risks and are more competitive in a dynamic and demanding market by combining linear programming methods with modern digital technologies (disruptive technologies) (Aina et al, 2023; Shoyimovna, 2024). In the context of the automotive industry, companies such as Tesla are using artificial intelligence and big data analytics to optimize supply chains and reduce production costs, while also leveraging AI techniques to enhance cybersecurity and protect critical data throughout the production and distribution networks (Dragomir, 2017b).

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An enterprise/company is an organized entity that combines human, material, financial, and information resources to produce products or services that are intended to satisfy needs. It represents a complex social-technical-productive organism and is based on an open and dependent economic-financial system (Fedele, 2015) and uses a set of inputs (resources necessary to carry out the act of production) and as a result a set of outputs (products obtained by processing material resources) (Boskova et al., 2022; Duflou et al., 2012) as shown in Figure 1 and underpin production:

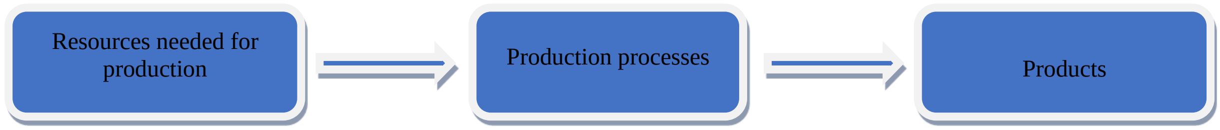

Figure 2. Stages of the production act
Source: author processing

Therefore, available resources, production processes and financial relationships are at the basis of the functioning of an enterprise/company in a complex economic and financial system. This system is open, meaning that it constantly interacts with the surrounding world, such as government regulations, supply markets and consumer demand (He et al., 2023). However, the system is dependent, as any change from external sources has the potential to affect system performance and sustainability. In the automotive industry, car manufacturers have to consider consumer preferences (lately electric cars), prices of raw and auxiliary materials, and environmental regulations.

Production is the process of transforming resources into finished products with added value and forms the core of the value chain of a manufacturing enterprise/company. The value chain involves sourcing the resources needed for the production act (raw materials, materials, energy, capital, labor, machinery, etc.), transforming them through technological processes into products and delivering the finished products to customers. In this context, the success of an enterprise/company is influenced by the quality and market competitiveness of the resulting products.

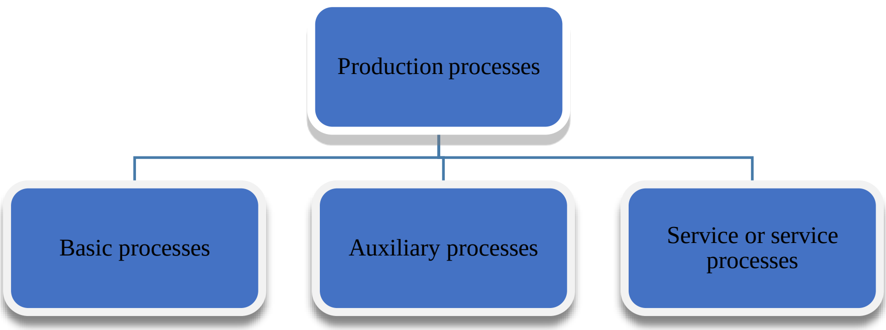

Figure 3. Types of production processes
Source: author processing

To ensure efficient and effective production, the entire value chain requires a well-organized management information system. From the purchase of raw materials to production planning, quality control and product distribution, an IT solution tailored to the needs of the enterprise/company enables efficient coordination of all phases of the process. So, every component of the value chain is optimized (Nunes e al., 2020). The optimization process increases competitiveness on the market and strengthens its position in relation to competitors. An enterprise/company can maximize the potential of the value chain by transforming the resources needed for the production act into products that meet the highest quality standards only by integrating IT solutions that are perfectly tailored to the activities. This not only improves your bottom line, but also gives you a stable position in an ever-changing market.

The optimal resource utilization problem is a model of a linear programming problem and can be introduced by a simplified production planning model. This problem can be described mathematically as a linear programming (LP) problem; LP is a powerful tool for analyzing and solving complex situations where there are multiple competing objectives and resources (Purcaru, 2004).

At the base of the economic phenomenon we consider a producing enterprise/company which has at its disposal certain resources necessary for the act of production, noted $R_i, i=\overline{1,m}$ şi a capital S with which it can

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supply itself with resources not held in stock and which aims to manufacture certain products, noted P_j, $j=\overline{1,n}$. To understand the problem, we systematize the data of the optimal resource use problem in Table 1.

Table 1. Data on the optimal resource use problem

Resources \ Products	P_1	...	P_j	...	P_n	Acquisition unit costs
R_1	a_{11}	...	a_{1j}	...	a_{1n}	α_1
⋮	⋮		⋮		⋮	⋮
R_i	a_{i1}	...	a_{ij}	...	a_{in}	α_i
⋮	⋮		⋮		⋮	⋮
R_m	a_{m1}	...	a_{mj}	...	a_{mn}	α_m
Unitary benefits	c_1	...	c_j	...	c_n	Capital S

Source: author processing

Where: a_{ij} represents technological consumption, i.e. the quantity of resource R_i consumed to produce one unit of the product P_j, $i=\overline{1,m}$, $j=\overline{1,n}$, $(a_{ij}\geq 0)$; S is the total amount available for the purchase of resources needed for the production process; c_j is the unit profit obtained by exploiting one unit of the product P_j, $j=\overline{1,n}$ and α_i is the amount needed to purchase one unit of the resource R_i, $i=\overline{1,m}$.

To solve the problem of the optimal utilization of resources according to the concrete conditions of the stages of the production process as well as the economic policy of the producing enterprise/company. This requires the rational use of available resources in order to maximize the total benefits obtained from production, taking into account the limitations related to the availability of resources and invested capital S. The aim of the problem is to determine the optimal quantities of each product P_j, $j=\overline{1,n}$ (production structure x_1, x_2, ... , x_n, where $x_j\geq 0$, $j=\overline{1,n}$), such that the objective function is attained under the optimal assumptions (either profit maximization or cost minimization). In order to determine a general mathematical model associated with this problem we need to determine the analytic expression for the total expenditure incurred in procuring resources. Since one unit of product P_j has a benefit c_j, then x_j units of product P_j will have a benefit of $c_j\cdot x_j$. Under these conditions the total benefit (Dantzig, 2016) of the entire manufacturing activity must be maximal and is a linear function of the form

$$f(x_1,x_2,\ldots,x_n)=c_1\,x_1+c_2\,x_2+\ldots+c_n\,x_n=\sum_{j=1}^{n}c_j\cdot x_j \qquad (4)$$

In order to recover the invested capital S, the total benefit must also be greater than S, so we have the relation:

$$\sum_{j=1}^{n}c_j\cdot x_j=c_1\,x_1+c_2\,x_2+\ldots+c_n\,x_n\geq S \qquad (5)$$

The amount consumed of resource R_i to manufacture one unit of the product P_j is a_{ij}, then under these conditions the quantity consumed from resource R_i to manufacture quantity x_j of the product P_j is $a_{ij}\cdot x_j$. Thus, to manufacture a quantity x_j of the product P_j, $j=\overline{1,n}$, total amount consumed from the resource R_i, i fixed, is

$$a_{i1}\,x_1+a_{i2}\,x_2+\ldots+a_{in}\,x_n=\sum_{j=1}^{n}a_{ij}\cdot x_j \qquad (6)$$

Bearing in mind that for the product P_j the unit purchase cost is α_i, then to procure each resource R_i, is spent $\alpha_i\cdot(a_{i1}\,x_1+a_{i2}\,x_2+\ldots+a_{in}\,x_n)=\alpha_i\cdot\sum_{j=1}^{n}a_{ij}\cdot x_j$, and to procure all the resources, you spend:

$$\sum_{i=1}^{m}\alpha_i\cdot(a_{i1}\,x_1+a_{i2}\,x_2+\ldots+a_{in}\,x_n)=\sum_{i=1}^{m}\left[\alpha_i\cdot\sum_{j=1}^{n}a_{ij}\cdot x_j\right]=\sum_{i=1}^{m}\sum_{j=1}^{n}a_{ij}\cdot x_j\cdot\alpha_i \qquad (7)$$

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Since we have capital S to procure resources, then we have $\sum_{i=1}^{m}\sum_{j=1}^{n} a_{ij} \cdot x_j \cdot \alpha_i \le S$.

So the mathematical model of this problem is:

$$[\max]\ f(x_1, x_2, \ldots, x_n) = \sum_{j=1}^{n} c_j \cdot x_j \tag{8}$$

$$\begin{cases} \sum_{i=1}^{m}\sum_{j=1}^{n} a_{ij} \cdot x_j \cdot \alpha_i \le S \\ \sum_{j=1}^{n} c_j \cdot x_j \ge S \end{cases}$$

$$x_j \ge 0,\ j = \overline{1,n}$$

An issue about optimal resource utilization for enterprises/companies in the context of limiting constraints involves determining the best production structure using analytical tools and an accurate mathematical model that guarantees both profitability and sustainability of economic policies. Thus, maximizing the potential of the value chain involves transforming resources into products that meet the highest quality standards only by integrating IT solutions that are perfectly tailored to the activities. For example, the implementation of IoT systems for real-time monitoring of resource consumption and machine performance has led to reduced waste and improved productivity. At the same time, the use of linear programming to decide the optimal allocation of resources between different types of vehicles (electric vs. hybrid vehicles) has helped to increase competitiveness in the global market. This not only improves your bottom line, but also gives you a stable position in an ever-changing market.

III. TRANSFORMING DECISION-MAKING THROUGH TECHNOLOGY

Contemporary technologies are changing the way organizations make decisions through advanced tools for data analysis and complex scenario simulation (Islam et al., 2024). Using digital technologies the efficient management of scarce resources is a strategic necessity in today's fast-changing economy as vast amounts of data are available. Therefore, in a competitive economy where market demands are rapidly changing, informed decision making and resource optimization are critical to a company's success. As a result of these innovations, managers can overcome the limitations of traditional decision-making methods (Pietronudo et al., 2022). and choose solutions based on accurate and up-to-date data. The rapid collection, storage and processing of large volumes of data is made possible thanks to advanced technologies such as artificial intelligence, data analytics and integrated information systems (Big Data Analytics and Business Intelligence) as well as complex information systems (expert systems and neural networks) (Iqbal et al., 2020). These tools help managers to spot patterns, identify anomalies and make predictions based on market trends. Economic mathematical models and modern IT solutions have been successfully adopted in various industries. In the automotive industry, Tesla has used artificial intelligence and linear programming to decide the optimal distribution of resources among various production lines.

Linear programming models are used to find ideal product quantities to maximize benefits and minimize costs in the optimal resource utilization problem. Contemporary technology modifies this process by automating data collection, integrating with optimization algorithms, and stimulating complex scenarios. A company/enterprise tracks market demand, resource costs and inventory through IoT (Internet of Things) technologies (Mashayekhy et al., 2022). The use of IoT sensors and big data analytics enables the monitoring of resource consumption and optimization of production processes to minimize waste and environmental impact. Automation of data collection is achieved with these technologies that track machine performance and resource consumption in real time. Analytical systems, taking into account available resources and capital invested, determine the ideal amount of goods that should be produced. Otherwise, a company/enterprise using an integrated ERP system decides how many raw materials to buy within budget using predictive algorithms and analysis of historical data. ERP systems are open systems (Lee et al., 2009) and manage supply chains and production plans in real time, reducing waste and increasing profit.

Companies/businesses use advanced technology to make quick and informed decisions while optimizing the use of resources. In the modern economy, this combination of decision-making and optimization increases sustainability, competitiveness and efficiency.

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IV. CONCLUSION

The study on the optimal use of resources highlights how complicated the decision-making process is in the current economic context and how important it is to integrate modern technologies with economic-mathematical methods to help optimal decision-making The ability of companies to adopt efficient IT solutions tailored to their activities is essential for their success in an economic environment characterized by limited resources, intense competition and dynamic market demands.

Economic-mathematical models, such as linear programming, are essential for resource optimization. For example, the Simplex method provides a systematic method for finding optimal solutions in situations where there are few resources and economic constraints. Companies can maximize performance, reduce costs, maximize profits, or improve the quality of products and services by integrating these methods with sophisticated algorithms and computing platforms.

Decision-making processes are being revolutionized and companies can gain a significant advantage by implementing modern technologies such as artificial intelligence (AI), big data analytics, IoT systems and integrated ERP platforms. Using these real-time tools helps organizations optimize resource allocation, make accurate predictions, and analyze large amounts of data. In addition, by improving operational efficiency, they promote sustainability and reduce waste.

In addition to efficiency, the study emphasizes the importance of sustainability. In a globalized economy, companies must prioritize not only profitability but also the social and environmental impact of their activities. Digital technologies play a key role in this, offering solutions to reduce resource consumption, minimize waste and promote a responsible business model. The study therefore concludes that companies can only maximize their economic potential and remain relevant in a changing economy by strategically integrating technology, mathematical techniques and sustainable practices. These programs improve financial results and provide a stable and competitive position in global markets.

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