Unlocking the power of investment decision making with MATLAB: A cutting-edge method for optimizing capacities

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ABSTRACT

Purpose: The aim of this research was to present a method that would allow responding to both interests in a staggered and proportional way, in correspondence with existing financial availability.

Design/Methodology/Approach: This research shows the results of the application of a methodological proposal programmed in MATLAB, which provided a solution to the described problem.

Findings: The application was carried out in a small company, which has three fundamental products, and allowed to optimize the use of the available capital, increasing both the installed capacities and the potential demand for the products offered.

Conclusion: It is possible to define an investment strategy that, based on the existence of an amount of financial availability, alternates the investment in the limiting capacity or the commercialization actions in correspondence with what is the limitation of the organization, which can be a limitation of capacity or market. This favors a systematic increase in the utility of the organization.

Practical Implications: An analysis algorithm is developed that can serve as a guide for businessmen to design investment strategies aimed at increasing demand or capacity restrictions, as the case may be, based on financial availability and contributing to the systematic increase in the utility of the organization under study.

Contribution to Literature: A method is presented that combines the analysis of capacity restrictions with those of demand restrictions, an aspect that is generally addressed in the literature independently.

Keywords: *Capacities, Decision making, Investment, Management, Optimization, Theory of constraints.*

1. INTRODUCTION

The primary objective of companies is to generate profits, and they encounter two potential constraints in achieving this objective. The first constraint is a production capacity that is insufficient to meet demand, while the second constraint is a demand that is insufficient to utilize the full production capacity. (Faninam, Huisman, & Kort, 2023; Xu et al., 2023). The organization's current financial availability similarly limits the development of both objectives. According to Vidal (2006), this characterizes the limitless situation that an organization faces. In correspondence with the above, two basic disciplines or fundamental areas of knowledge stand out in organizations: operations management and marketing. These two areas complement each other and form part of the value chain.

The research topics reported on them in the Scopus database serve as evidence of the close relationship that exists between the two disciplines. Under the search criteria of "Operations Management" and in the areas of Business, management, and accounting, 1 938 publications are reported, and in the same way, when analysing the publications related to marketing, 103 553 are reported. The fundamental topics that are investigated in both topics are represented in Figure 1.

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As evidenced by Figure 1, within the research associated with operations management, what is related to marketing or commercialization is located as a topic of analysis, while in terms of commercialization, in the same way, what is related to production, the chain supply, and profit generation (Xu et al., 2023).

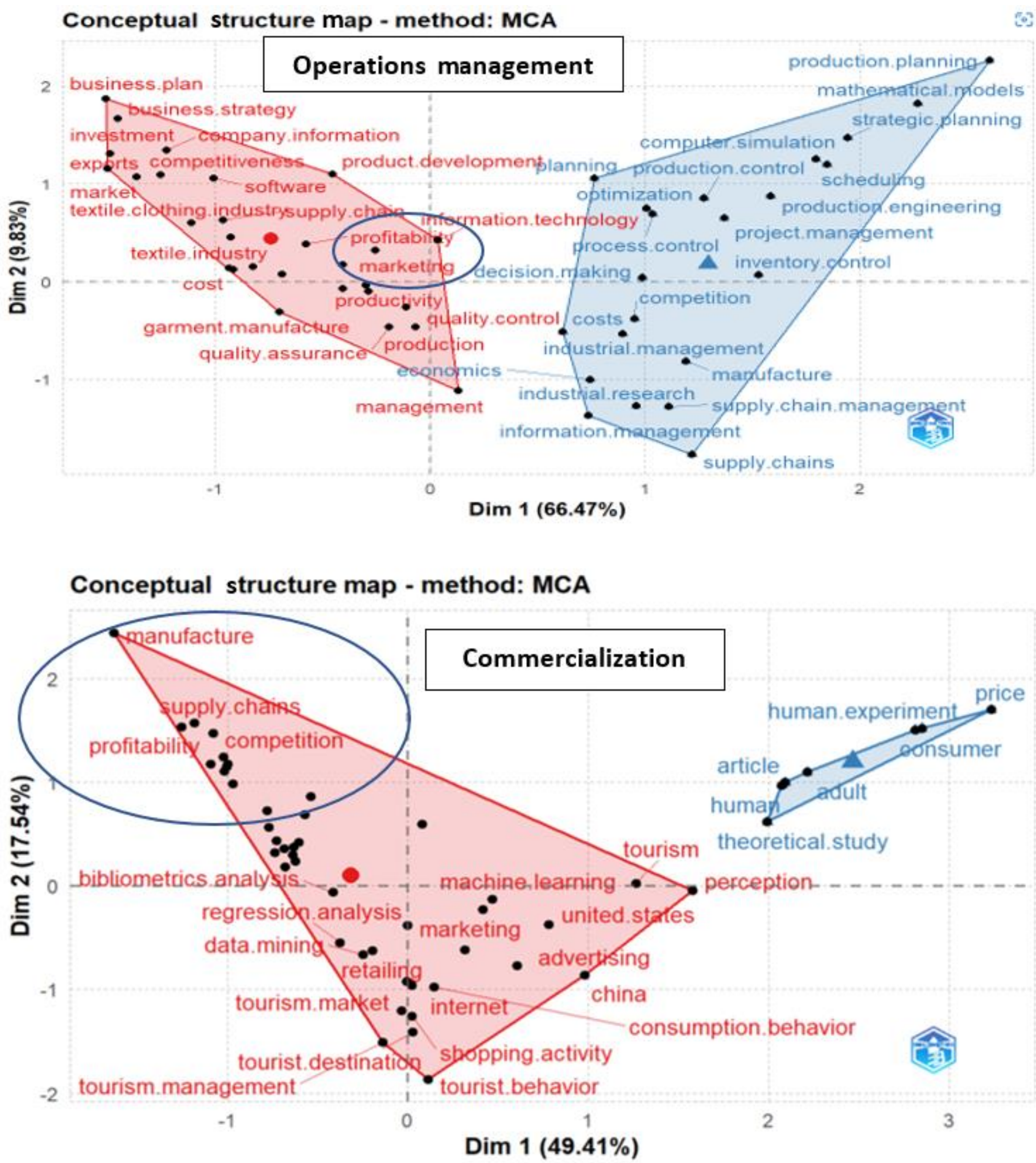

Figure 1. Keywords related to capacity management.

Note: MCA – Multiple correspondence analysis; Dim – Dimension.

Within operations research, everything related to the optimization of capabilities is a highly important issue. Operations management seeks to maximize the efficiency of production levels, which means achieving high levels

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of production with the maximum performance of resources. Marketing seeks to ensure a demand capable of assimilating everything that operations management generates.
To harmonize both goals, several proposals have been developed, usually from the perspective of operations management, but without neglecting the market perspective. Significant progress has been made in this regard. In 1984, the book "The Goal" by the authors Goldratt and Cox (2014) came to light, giving new visions to capacity studies as one of the foundations of administration and giving rise to what is now known as the Theory of Constraints. This approach has been adopted from two main perspectives: as a general philosophy of improvement, which promotes a different method of thinking (Banerjee & Mukhopadhyay, 2016), or focusing on the improvement of specific skills (Faninam et al., 2023; Panizzolo, 2016).
In general, it can be stated that the research based on the theory of constraints is diverse; some focus on the relationship between the organizations that make up the logistics chains (Azadnia, Ghorbani, & Arabzad, 2015; Puche, Ponte, Costas, Pino, & De La Fuente, 2016), and others focus on a particular organization (Panizzolo, 2016).
One of the most relevant contributions of this new theory is recognized in the fact that it promotes the coordination of all productive capacities in correspondence with market demands and considers that the latter should be the drum that sets the pace of production.
The intention of operations management should not only be to optimize the installed productive capacity but also to promote the capacity to systematically increase it. Similarly, marketing must seek to increase demand proportionally to the increase in capacities. In this context, the research question arises: How to achieve both objectives if both require a capital investment and this is limited? The objective of this research was to present a method that would allow responding to both interests in a staggered and proportional way, in correspondence with the existing financial availability.

2. LITERATURE REVIEW

The balance of operating lines is a crucial aspect of efficient and effective production in various industrial processes. Operating lines refer to the flow of materials or substances, energy, and information through different components of a system. In chemical and industrial processes, maintaining a balance of operating lines helps to ensure that the system operates within its design limits, leading to consistent product quality, improved yield, and reduced waste. The balance of operating lines can be achieved through the optimization of several parameters, including flow rates, pressure, temperature, and composition (Özceylan, Kalayci, Güngör, & Gupta, 2019; Şahin & Tural, 2023).
The authors Hamta, Ghomi, Jolai, and Shirazi (2013) indicate that “studies on balances of operating lines date back to 1955, indicating that the first scientific study on the subject was published by Salveson (1955). Since then, different approaches have been proposed to enrich line balance analyses, and many attempts have been made to reduce the wide gap between the academic discussion and the realistic situation”.
In 2018, during a bibliometric study carried out on the Web of Science by Zheng, Zhou, and Chen (2019), it was found that, until that date, there had been more than 2476 published research results aimed at optimizing production flows. These studies (Kucukkoc, Li, Karaoglan, & Zhang, 2018; Tanhaie, Rabbani, & Manavizadeh, 2020) generally seek to optimize the use of installed capacities, increase productivity, reduce cycle time, reduce the number of jobs, reduce energy consumption, reduce environmental pollution (Kalayci & Gupta, 2013), and reduce the learning cost curve (Wu, Dai, & Luo, 2018).
Even when the objective of some of these investigations is to reduce operating costs (Kazemi & Sedighi, 2013), the fundamental objective is to reduce work times or the number of positions, establishing that there is a direct relationship between the decrease in the technological cycle and the cost. Similarly, they assume a direct relationship between productivity, income, and the decrease in the cycle. These investigations assume a deterministic behaviour of the working times of the different operations, while others (Chiang, Urban, & Luo, 2016; Hamta et al., 2013) recognize a stochastic behaviour of time and establish lower and upper limits of the working times of the operations.
Failure to maintain a balance of operating lines can result in process disruptions, equipment damage, and safety hazards. For instance, a poorly balanced operating line can cause equipment to operate outside its design limits, leading to increased wear and tear and a reduced equipment lifespan. Therefore, maintaining a balance of operating lines is crucial to ensuring safe and efficient production processes, reducing operational costs, and improving product quality (Wang, Song, Shi, Zhang, & Gong, 2023). As such, it is important to implement proper

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monitoring and control systems that can detect and correct imbalances in operating lines promptly (Bin, Yong, Wenhao, & Yu, 2023; Özceylan et al., 2019; Özden & Tahsin, 2023).

The use of mathematical optimization techniques is essential in the search for optimal solutions in the optimization of productive capacities. These techniques help organizations make informed decisions regarding the allocation of resources, achieve maximum production output, and reduce costs. Mathematical optimization techniques help organizations determine the best use of resources to maximize production output and minimize costs. These techniques involve the use of mathematical models and algorithms to solve complex optimization problems. Linear programming is one of the most widely used mathematical optimization techniques in the optimization of productive capacities. It involves the use of linear functions to optimize the allocation of resources. Linear programming can help organizations determine the optimal use of resources such as labour, materials, and equipment, subject to constraints such as production capacity and budget limitations (Paul & Chowdhury, 2021).

Another mathematical optimization technique used in the optimization of productive capacities is nonlinear programming. This technique is used to optimize functions that are not linear, such as production costs, by using nonlinear equations and constraints. Nonlinear programming can help organizations optimize production processes and resources more accurately by considering non-linear relationships between production inputs and outputs.

Among the mathematical methods used in the search for optimal solutions, we can mention the ant colony algorithm (He, Peng, & Long, 2020; Lausch & Mönch, 2016). Genetic algorithms (Anel, Català, Serra, & Domenech, 2022) or particle swarm algorithms (Şahin & Kellegöz, 2019; Sridevi & Chakkravarthy, 2021) Although these have particularities that distinguish or differentiate them, they generally constitute methods that allow researchers to obtain the desired results. These methods generally assume an objective function that seeks to maximize capacity or minimize cost or time. They define a group of constraints to which they must respond and, based on a metaheuristic method, generate or find the most feasible solution.

Optimizing productive capacities involves ensuring that production processes are efficient, consistent, and cost-effective. This requires the proper balance of operating lines and the utilization of resources such as labour, materials, and equipment. When done correctly, optimizing productive capacities can lead to improved productivity, reduced waste, and increased profitability for the organization (Özden & Tahsin, 2023).

However, it is equally important to consider possible increases in demand when optimizing productive capacities. An increase in demand may require an increase in production capacity to meet customer needs. Failure to respond to such demand can result in lost sales and reduced market share. However, increasing production capacity requires investment in additional resources, such as equipment and labour, which can be costly. Thus, the organization needs to consider the existing financial availability before making any investment decisions (Mian, Sufi, & Verner, 2020; Paul & Chowdhury, 2021).

It should be noted that, with the exception of research related to the theory of constraints, no research was found that, at least explicitly, linked the optimization of production capacities to possible increases in demand and to the financial resources available in the organizations being studied.

Proper articulation between optimizing productive capacities, possible increases in demand, and financial availability can help organizations make informed decisions regarding investments in production capacity. It can also help organizations avoid over-investing or under-investing in production capacity, leading to improved financial performance. Therefore, it is crucial for organizations to consider all these factors when making production-related investment decisions.

3. MATERIALS AND METHODS

In the research that is presented, a method of improvement of the existing limit situation in the organization is developed, where the systematic increase of the capacity constraints or the existing demand in the organization is sought from the existence of financial availability. The general logic that is implemented is summarized in Figure 2.

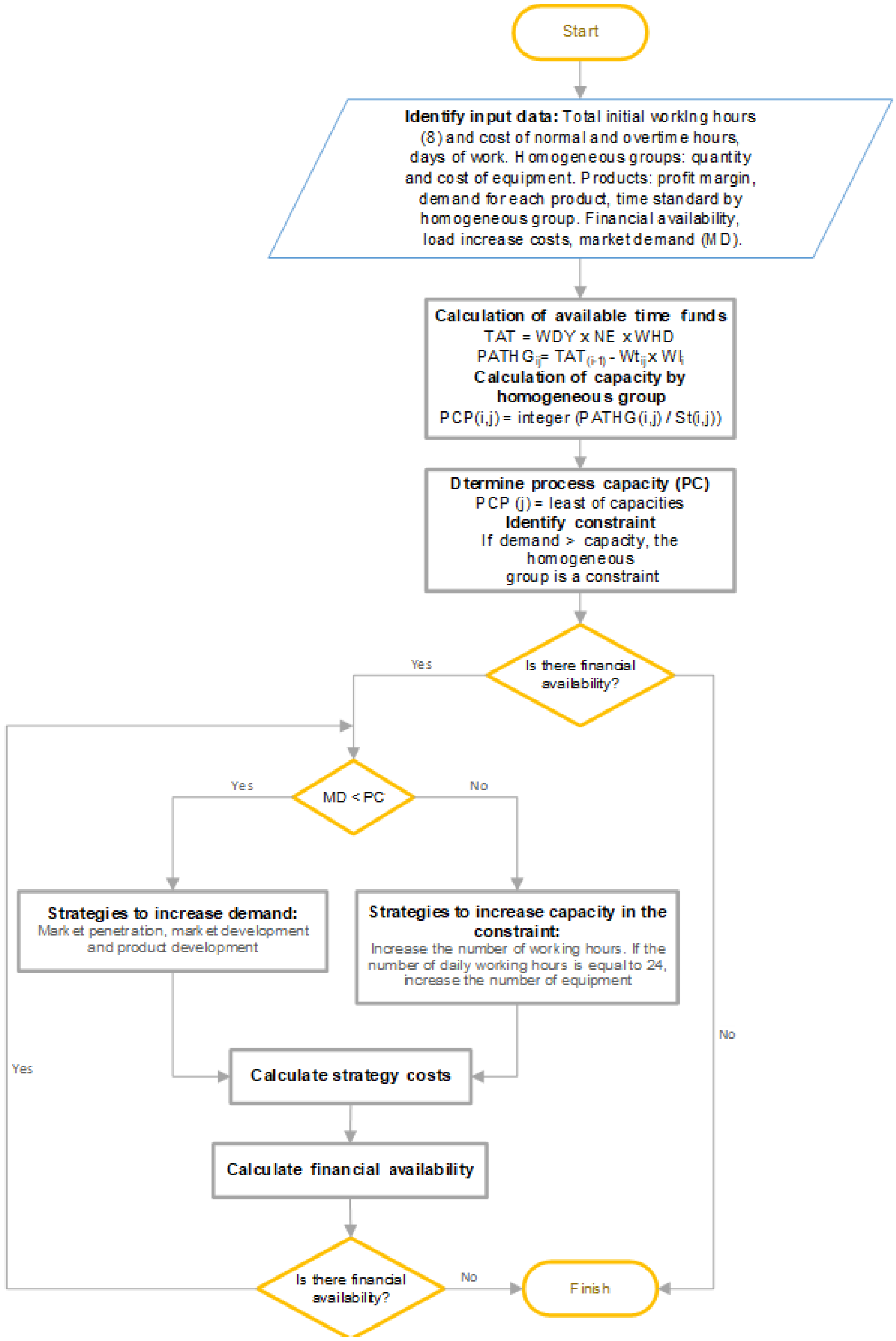

Figure 2. Algorithm of the applied procedure.

Note: The full form of abbreviations variables are defined as part of Equations 1, 2 and 3.

3.1. Definition of Input Data

It is based on establishing the basic information for the processing, which presupposes, among other aspects, knowing the following:

- Number of working days per year.
- Number of working hours per shift.

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- Cost of regular working hours and overtime.
- Quantity of equipment by homogeneous groups and their costs.
- Current demand and contribution margin for each type of product.
- Production time standards for each product in each homogeneous group.
- Estimated cost of increasing a percentage of demand.
- Financial availability for the period.

3.2. Determination of Productive Capacities

Capacity determination begins with the ordering of products according to their contribution margin. This is done to ensure that the products with the highest contribution margin have priority in the allocation of the available time.

Subsequently, the total available time fund is determined. To facilitate the analysis process, time losses due to technical requirements or fortuitous causes are not considered.

It is assumed that the organization can implement up to three work shifts, each lasting 8 hours. The determination of the total amount of available time (TAT) is carried out by Equation 1.

$$TAT = WDY * NE * WHD \tag{1}$$

Where:

TAT: Total amount of available time.

WDY: Working days per year.

NE: Number of equipment.

WHD: Working hours per day.

In light of the fact that overtime is not compensated in the same way as regular working hours, the work organization can be developed through the use of shift work or overtime.

Subsequently, the amount of productive available time per homogeneous group (PATHG) is determined through Equation 2, understanding that by homogeneous group, the total production equipment has the same characteristics and is used for the same operation.

$$PATHG_{ij} = TAT_{(i-1)} - Wt_{ij} * Wl_i \tag{2}$$

Where:

PATHGij: Amount of available time for each product i in the homogeneous group j.

Wtij: Working time for a unit of product i in the homogeneous group j.

Wli: Workload.

For the first product, the Total Amount of Available Time is considered. Once the PATHG has been established, the production capacity of each product for each homogeneous group (PCPij) is determined through Equation 3.

$$PCP_{ij} = integer\,(PATHG(i,j)/St(i,j)) \tag{3}$$

Where:

PCPij: Production capacity of each product i for each homogeneous group j.

Stij: Standard time of the product i in the homogeneous group j.

Knowing the production capacity of each product in each homogeneous group, the lowest value of the production capacities is established as the production capacity of the process of each product.

3.3. Determination of Constraints

If the production capacity of a product is less than its demand, the capacity of the homogeneous group where the demand is generated constitutes a constraint. If all the demands are satisfied, then the homogeneous groups do not constitute a constraint.

3.4. Capacity Increase Strategy

Based on the capacity constraints identified, two types of fundamental constraints are established: increase the number of working hours through overtime or work shifts, or increase the number of work teams. For both strategies, the costs of increasing capacities must be determined.

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The costs of increasing working hours must consider the cost of overtime and regular hours. The costs of increasing capacities must consider the increase in acquisition and installation, just as they must be identified if there are space constraints for the increase in the amount of equipment.

The capacity increase assessment is repeated until all capacities exceed existing demands or capacity increase costs exceed financial availability. If capacities exceed demand and there is still financial availability, the next stage proceeds. If the financial availability is exhausted, the application is finished.

3.5. Strategy for Increasing Demand

The evaluation of the rise in demand and its corresponding expenses falls under the purview of marketing personnel. This assessment is typically marked by a heightened degree of uncertainty regarding its actual worth and relies on multivariate approximations that take into account factors such as the product life cycle, extant competition, customer satisfaction levels, and the intensity and quality of communication campaigns. Of these variables, the latter is deemed the most crucial. In this sense, several authors (Tustin & Strydom, 2003) acknowledge how difficult it is to establish the real contribution of advertising actions to future demand. In this research, values estimated by specialists in the marketing activity were used as data for the analysis, adapted to the context of the organization under study, where a cost is assigned within the contribution margin of the product to the advertising actions.

Provided that financial availability allows, a financial budget is allocated until the forecast demand exceeds the minimum installed capacity. Once the installed capacity is exceeded, and as long as there is financial availability, the capacity increase strategies are repeated. The procedure described is repeated until financial resources are exhausted.

The application of the described methodology was carried out in MATLAB (version R2019a).

4. RESULTS

The methodology described was applied to a low-complexity entity with only three products and five homogeneous work groups. It was applied on a Digital Printing Press, in order to respond to the unsatisfied demand of the Santo Domingo province in Ecuador.

The products that are made are: Labels and Stickers, with a demand of 89 200 units per year; Triptyches, with a demand of 10 984 units per year; and Gigantographies, with a demand of 1056 units per year.

Table 1. Information on products and homogeneous groups.

Products	**Profit margin**	**Homogeneous groups**					
			Design	**Printing**	**Drying**	**Cutting**	**Packaging**
		Equipment	2	2	2	2	1
		Acquisition cost	500	650	120	150	80
		Demand	Time standards				
Gigantographies	4.50	1 056	0.016	0.20	0.10	0.10	0.10
Triptyches	1.34	10 984	0.057	0.09	0.05	0.04	0.13
Labels and stickers	0.66	89 200	0.040	0.033	0.04	0.04	0.12

Five different homogeneous groups are used for the production process: Design, Printing, Drying, Cutting, and Packaging. The company works 332 days a year, one shift per day. The cost of the regular hour of work is 2.21, and the extra hour is 1.77. A financial availability value of USD 15 000 was established. The data related to the equipment, the products, and the time standard of the products in the homogeneous groups are summarized in Table 1. The initial results showed the available capacity, which is summarized, in Table 2.

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Table 2. Available time and capacities by product and homogeneous group.

Products	Homogeneous groups									
	Design		Printing		Drying		Cutting		Packaging	
	Time	Production capacity	Time	Production capacity	Time	Production capacity	Time	Production capacity	Time	Production capacity
Gigantographies	53.120	332000	53.120	26560	53.120	53120	53.120	53120	26.560	26560
Triptyches	52.951	92897	51.008	56676	52.064	104128	52.064	130160	25.504	19619
Labels and stickers	46.690	116726	41.122	124614	46.572	116430	47.670	119176	11.225	9354

Table 3 shows the relationship between the demand for each product and the initial available capacity, as well as the initial profit margin to be obtained.

Table 3. Behavior of capacities, demand and total profit by product.

Products	Demand	Production capacity	Profit
Gigantographies	1 056.00	26 560.00	119520.00
Triptyches	10 984.00	19 619.00	26289.46
Labels and stickers	89 200.00	9 354.00	6173.64
Total			151983.10

Based on this initial information, strategies were designed to increase capacities until the existing demand was exceeded, which allowed for the results shown in Table 4.

An assessment carried out by the managers of the organization established an initial strategy to increase capacities: the systematic increase in working hours, initially as overtime and, if necessary, work shifts, and only proceeding to the purchase of equipment if the increase in daily working hours did not allow for covering the existing demand. The decision was arrived at through an analysis that indicated that an augmentation in equipment would result in a corresponding rise in operators' expenses per acquisition. Furthermore, the limited availability of space precluded a significant increase in equipment. A summary of the applied strategies can be seen in Figure 3.

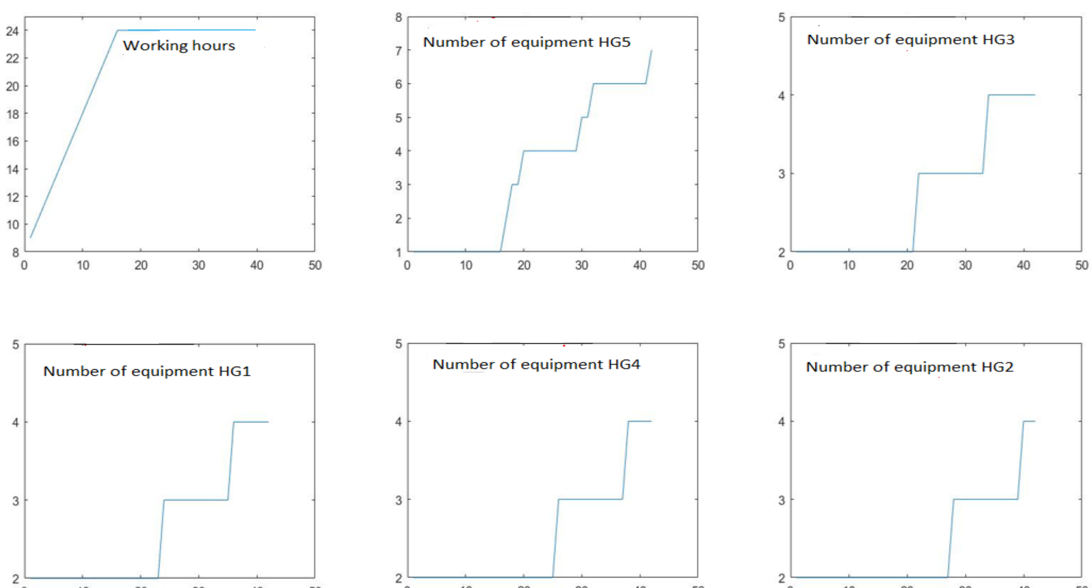

Figure 3. Strategies applied.

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In total, 42 iterations were registered until financial availability ran out. As expected, the initial strategy was to increase hours; later, it was necessary to start increasing the number of teams in homogeneous group 5, which ranged from 1 to 7 units. The rest of the homogeneous groups also increased their capacities from 2 to 4 or 5 units. Similarly, it can be seen that the increase in units in homogeneous group 5 occurred interspersed with the increase in units in other groups and in correspondence with the subsequent increase in demand.
The results associated with each iteration and their influence regarding capacities, demand, total utility, and financial availability can be seen in Figure 4.

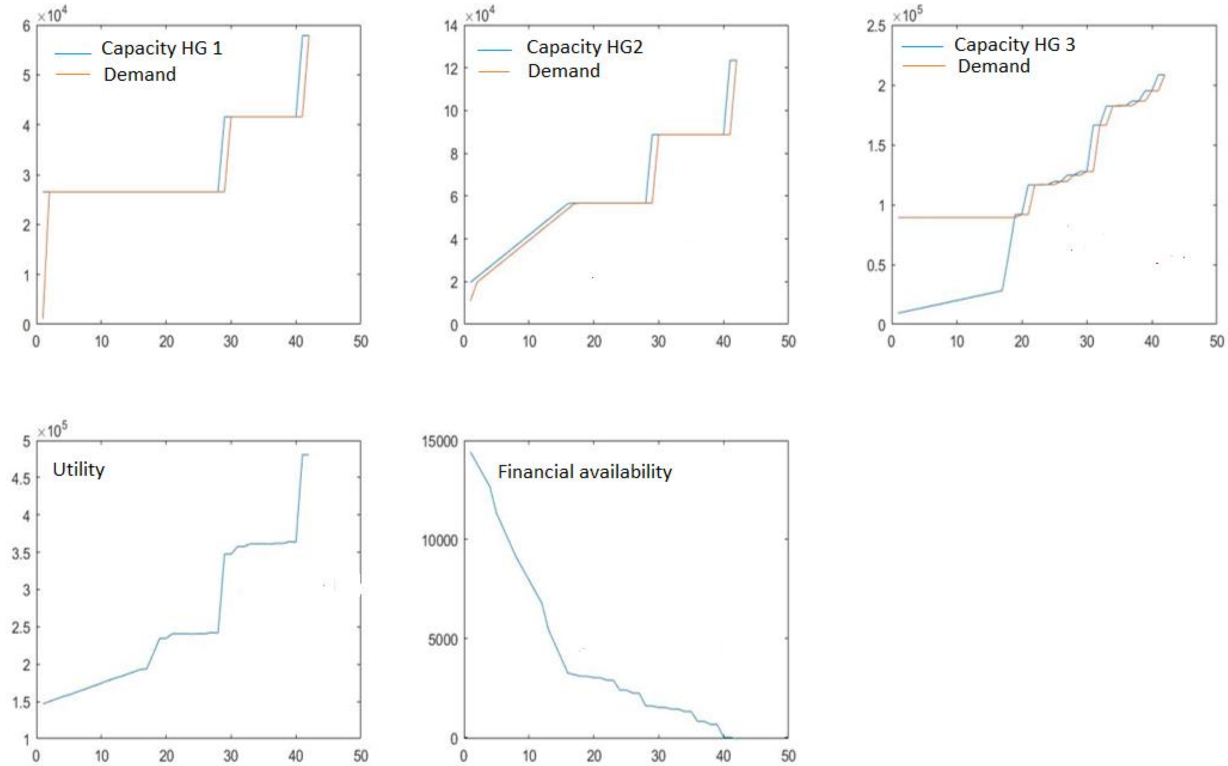

Figure 4. Representation of the contribution of the iterations in the fundamental indicators.

It can be seen that the most diverse behaviour occurs in the third product, which motivates greater variation in the profit curve. In the third product, the production capacities are lower, as is the contribution margin; both variables influence the observed result. In general, growth and a systematic balance between capacity and demand are achieved to the same extent that financial availability decreases and general utility grows. The initial and final behaviour of capacities, demand, and profits by products is summarized in Table 4.

Table 4. Variation of capacities, demand and profit by products.

Indicators	Gigantographies	Triptyches	Labels and stickers	Total
Initial capacity	1 056.00	10 984.00	89 200.00	101 240.00
Initial demand	26 560.00	19 619.00	9 354.00	55 533.00
Ultimate capacity	57 840.00	123 420.00	208 300.00	389 560.00
Ultimate demand	57 841.00	123 421.00	208 301.00	389 563.00
Initial profit	119 520.00	26 289.46	6 173.64	151 983.10
Ultimate profit	260 280.00	160 446.00	137 478.00	558 204.00
Potencial increase	140 760.00	134 156.54	131 304.36	406 220.90

With the systematic application of the proposed methodology, the organization estimates a potential increase of $ 406 220.90 in profits, which would mean that each dollar invested of the $ 15 000 available could contribute $ 27.08. Regarding this estimate, the greatest uncertainties go back to the real impact of advertising and its weight in the contribution margin, as well as the existence of a real market capable of absorbing the total demand for each product, although according to the market experts in charge of carrying out these estimates, it is possible to achieve the estimates made.

5. DISCUSSION AND CONCLUSIONS

The methodology, which is a novel contribution to the literature, will help decision-makers make an accurate and prompt decision in designing the revised production plan (Ruiz-De La Peña, Pérez-Campdesuñer, & Andrade-Molina, 2022). The utilization of the previously described approach has enabled the validation of the possibility of deploying an algorithm that not only endeavours to optimize the utilization of the installed capacities but also identifies the constraints in the process and subordinates the operations with slack capacities to the constraints. This objective aligns with the objectives of numerous prior investigations. (Chiang et al., 2016; Kazemi & Sedighi, 2013; Kucukkoc et al., 2018; Tanhaie et al., 2020; Wu et al., 2018). Rather, based on the identification of an amount of financial availability, it seeks to define investment strategies that allow the systematic improvement of the constraints to increase profits, as long as the financial availability allows it. In this sense, it should also be noted that the analysis is not limited solely to the internal management of operations based on installed capacities, but also incorporates the systematic increase in demand into the analysis.

Similarly, it should be noted that this research does not consider the possible improvements in productivity that can be implemented through the improvement of work organization or the increase in productivity through motivational actions; it is assumed that this methodology applies once these variables have been optimized. Similarly, it is assumed that the implementation of overtime work does not affect the quality of production.

MATLAB is a powerful tool for production optimization because it provides a comprehensive environment for modelling, simulation, and analysis of complex systems, including those encountered in production optimization, similar to those encountered in other investigations (Jiang, Yang, Chen, & Liang, 2021; Joya & Rougier, 2019). Overall, the use of MATLAB in production optimization is essential for achieving efficient and effective production processes. Its powerful numerical analysis capabilities, built-in visualization tools, and extensive library of pre-built functions make it an ideal choice for complex engineering problems encountered in production optimization.

Despite the above, as a limitation of this research and recommendations for future research, it should be pointed out that there is a need to continue deepening the precision of the analysis methods to account for the increase in demand forecasts and the estimation of the impact and cost of the actions. In today's dynamic business environment, it is crucial for companies to continue deepening their analytical methods for forecasting increases in demand and estimating the impact and cost of potential actions. By using advanced analytical techniques, businesses can obtain more accurate forecasts of future demand, enabling them to plan their operations, production, and resource allocation more effectively. This leads to cost-effective decision-making, helping businesses prioritize and allocate their resources based on a better understanding of the costs and benefits associated with different actions. Moreover, accurate demand forecasting and cost estimation also provide businesses with a competitive advantage over their rivals, enabling them to respond more quickly and effectively to market changes (Bin et al., 2023; Özden & Tahsin, 2023; Şahin & Tural, 2023). In this same sense, it can be recommended to incorporate the effects and costs of actions to improve work organization into the proposed methodology.

This research is likely to make significant contributions to the field of investment decision-making. By introducing a new methodology that leverages the power of MATLAB, the paper is expected to provide a cutting-edge solution for optimizing investment capacities. The proposed method could potentially enhance the accuracy and efficiency of investment decision-making processes, leading to better outcomes for investors. The investigation could also help researchers and practitioners in the finance industry gain new insights into the dynamics of investment portfolios and develop more effective strategies for managing them. Overall, the paper has the potential to significantly advance the state-of-the-art in investment decision-making and make a meaningful impact on the finance industry.

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Not applicable.

TRANSPARENCY

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

COMPETING INTERESTS

The authors declare that they have no competing interests.

AUTHORS' CONTRIBUTIONS

Conceptualization, writing – original draft R.P.; data curation, project administration and validation, G.G.; formal analysis and Writing – review & editing, A.S. and R.P.; investigation, A.S., R.P. and R.M.; methodology, R.P. and G.G.; supervision, R.M.; visualization, G.G., A.S. and R.P. All authors have read and agreed to the published version of the manuscript.

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