Application of ABC, Slotting and EOQ to Increase Productivity in a Trading Company: An Empirical Research in Peru

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Abstract

The commercial sector has evolved since it has increased by 1.24% compared to the 2022 periods; however, automotive trade decreased by 2.16%. This behavior happened, since the economy in 2022 was affected by the continuity of social demonstrations. This research analyzes and studies the distribution and inventory management of a warehouse using the ABC, Slotting and EOQ tools to increase productivity in the dispatch area; this has a technical gap of 55% with respect to the sector, which currently has a productivity of 2.9. Through the implementation of the proposed model, it was possible to reorganize the warehouse, optimize the stock to meet the demand and achieve the target objectives, since the productivity increased by 43.79%, the operational efficiency increased by 65%, the Stock breaks were reduced by 63% and returns of wrong products decreased by 6.2%. It should be noted that the results obtained were validated by a software called Arena and an economic evaluation.

Keywords

Productivity, ABC Classification, Slotting, EOQ, warehouse

1. Introduction

Globally, the productivity of the commercial sector has contributed approximately one third of economic growth, similar to the case of East Asian middle-income countries such as Thailand. Production per worker is only 25% of that of the United States, and is slightly lower than those of Chile and Mexico; Likewise, the productivity of the country's companies is comparable to that of similar middle-income countries, such as Malaysia and South Africa, but the productivity of a company in Peru is barely 5% of the level of the world productivity frontier and it is similar to the levels registered in Colombia (5.5%) and Mexico (8.5%). Likewise, the economy of Peru has grown at a faster rate than that of more developed countries, which is why economic convergence has accelerated. During the years from 1960 to 1990, the convergence was slow and even negative in some stages. During that period, other countries, including the middle-income countries of East Asia, advanced in their convergence, leaving Peru behind. In the last decade, however, Peru's per capita income has been increasing rapidly with that of high-income countries and, although starting from a low base, it is reaching the speed of convergence of countries such as Malaysia and Thailand. But like other middle-income countries, Peru now faces the most difficult challenge of becoming a high-income country (World Bank 2015).

According to the literature review, the problem of low productivity in the dispatch area is identified, which may be due to inadequate design of the layout of facilities, low operational efficiency, lack of control indicators, returns, stock breaks, storage, among others. others. In addition, this problem was also found in other investigations; For example, that of a Peruvian company importing and trading auto parts, which had a productivity below 40% of the optimal 8 pieces/H-H, this did not allow them to meet customer satisfaction levels (León et al. 2022). On the other hand, according to (Rivera et al. 2022) the productivity of the picking process is important for the entire operation of the office and its economic performance. The aforementioned demonstrates that auto parts trading companies present inefficient processes, which is why it is necessary to propose new solutions to this problem.

From the information mentioned, not all industries and subsectors in Peru have contributed positively to overall productivity growth. For this, a case study was identified that evidences the problems of the sector for two reasons. The first, logistics reprocesses are due to the return of wrong products in the dispatch, low operational efficiency and the lack of control indicators; the second, the inefficient inventory management is attributed to the lack of ordering techniques and stock breaks. For these reasons, to solve the described problem, an improvement model was developed through the application of tools such as ABC, Slotting, and warehouse planning and management under the Economic Order Quantity (EOQ) and Reorder Point (ROP).

The reviewed articles do not show sufficient information on improvements that can be applied to increase the productivity of trading companies, especially in Peru. Therefore, the need and importance of carrying out this research arises. Said scientific article is divided into seven parts which are Summary, Introduction, Literary Review, Method, Validation, Discussion and Conclusions.

2. Literary Review

2.1 Productivity in the automotive sector

The first typology seeks to solve the problem of low productivity using different methodologies and tools to solve problems that arise in companies in the automotive sector. The authors (Edith Leon et al. 2022) managed to increase productivity in the study warehouse area by 40% by applying the SLP and 5S methodologies. On the other hand, the authors (Felix Chan & Hing Chan 2011) measured warehouse productivity performance in terms of distances traveled and order picking time, in which the study results indicate that the key to effective implementation of a storage system is to match the types of the warehouse system and the variety of items in the customer order.

2.2 Application on of the ABC Classification in warehouses

This typology suggests applying the ABC technique or tool to solve the problems that arise in companies in the commercial sector. The authors (Silva et al. 2022) sought to assign storage locations in three zones and assign the products with the highest demand to the best located zone; for this they were based on factors such as warehouse design, demand characteristics and storage policies. In addition, the authors (Jemelka et al. 2016) focused on redistributing shelves and reducing merchandise handling distances according to product rotation using the ABC method.

2.3 Slotting application in warehouses

From this typology, we sought to use the Slotting methodology to solve the problems that arise in companies in the commercial sector. The authors (Viveros et al. 2021) addressed the problem of assigning storage locations on several levels for SKU pallets, considering divisible locations on the first level to improve the picking operation and reduce travel times associated with travel routes. Likewise, the authors (Petersen et al. 2015) sought to evaluate slotting measures and storage allocation strategies with racking, travel distance, and fulfillment time to complete an order.

2.4 EOQ application in warehouses

The EOQ tool helps to have good inventory management, which is why several authors propose applying this tool to solve the problems that arise in companies in the commercial sector. According to (Heaviside et al. 2020) the Economic Order Quantity (EOQ) method helps to determine the optimal purchase frequency by determining the optimal number and frequency of purchases, then the correct inventory control is obtained. In addition, another point to take into account according to (Meileni et al. 2020) is the data processing system using the EOQ method, since it facilitates the processing of inventory data; to overcome problems in merchandise data management in the warehouse, such as running out of stock when a request from the sales department appears.

3. Method

Currently, most trading companies, due to the variety of products they offer and to tend to meet demand, require one or more storage areas in which most of the inventory of each product will be located. Due to the fact that this area generates expenses, both for rent and personnel payment, it is essential to optimize the space through a correct distribution of shelves and organization of products so that it facilitates the activities of the workers, reducing dispatch times and material disorders. Likewise, it is necessary to identify the correct management of returns of wrong products in case they occur in certain sales. To do this, the use of various models, tools and methodologies is intended to replace the conventional way, considering the most relevant needs of employees and the company. In this way, as observed in

Table 1, according to what was found in the literature, the ABC and Slotting tools are effective since they allow to classify and order the products according to their rotation and determine the best location to reduce routes; In addition, with the EOQ tool it is possible to plan optimal amounts of inventory in the warehouse.

Table 1. Comparative matrix

Components	Returns and low operational efficiency	Lack of sorting techniques	Qut of stock
Viveros, P.; González, K.; Mena, R.; Kristjanpoller, F.; Robledo, J. (2021)	Slotting.		
Dave, Y., & Sohani, N. (2019)	Slotting	ABC	
Allyson Silva; Kees Jan Roodbergen; Leandro C. Coelho; Maryam Darvish (2022)		ABC	
Michael Heaviside; Bagus Mulyawan; Tri Sutrisno (2020)			EOQ
Proposal	**Slotting**	**ABC**	**EOQ**

3.1 Proposed Model

The value of the proposal for the company focuses on the need to increase productivity in the warehouse and dispatch area through ABC, Slotting and EOQ.

With the model in Figure 1, the aim is to eliminate quantitative problems such as the high percentage of returns for wrong products, the lack of ordering techniques and high stock breaks.

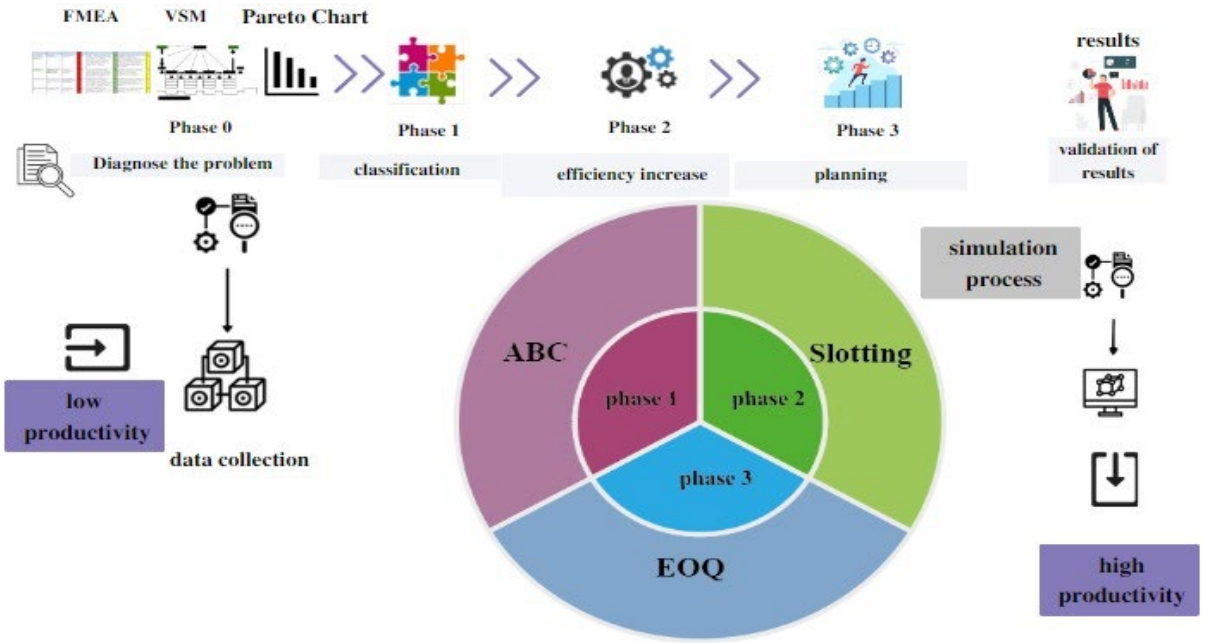

Figure 1. Contribution of tools in the improvement proposal

The improvement proposal consists of a 3-phase methodological model, the first is the classification phase, the next is the efficiency increase phase and finally is the planning phase. The following three paragraphs present the components of the proposed model based on the literature review and its different phases:

3.1.1 Phase 01 – Classification: The first activity to perform is the classification of the products in the new model using the ABC tool. This allows us to identify the different families of products and those with the highest rotation, which will facilitate the trajectory or route of the personnel in charge when dispatching the order orders.

3.1.2 Phase 02 – Increase in efficiency: Slotting is applied at this stage, it is a tool which will make it possible to make the most of the warehouse space for the merchandise that is stored and withdrawn, with this it will be possible to determine the most convenient locations to reduce picking times due to the fact that the workers They will be able to complete orders faster, while reducing the possibility of error.

3.1.3 Phase 03 – Planning: In this last component, the EOQ tool is applied to establish the correct inventory control, which implies specifying the quantity demanded in a set period of time of the products to reduce inventory costs as well as order and transportation costs. With this, it seeks to reduce high stock breaks.

3.2 Indicators

3.2.1 Productivity (P): It allows measuring the efficiency of the quantity of products dispatched per factor used, which is per unit of work or capital used.
Objective: Increase productivity by 55% in the dispatch area

$$P = \frac{Dispatched\ units}{Hours\ man}$$

Interpretation: Currently the company has a ratio of 2.9, with this investigation, it is intended to increase the value to 4.5 of productivity.

3.2.2 Dispatch operating time (DOT): It allows to identify the useful or real time of a process.
Objective: Reduce by 0.57 hours.

$$DOT = \frac{Useful\ time}{Scheduled\ time} x\ 100\%$$

Interpretation: The operating time is 2.07 hours and with the application of methodologies it is desired to minimize it to 1.5 hours.

3.2.3 Stock breaks (SQ): It allows validating the number of times that the demand was not met.
Objective: Reduce by 67%

$$SQ = \frac{Unshipped\ units}{Total\ number\ of\ units\ requested}$$

Interpretation: Currently, the company presents 118 breaks/year, so the objective is to reduce it to 39 breaks/year.

3.2.4 Returns of wrong products (PWR): It allows to determine the number of times that the products returned from the customer to the warehouse
Objective: Reduce by 6%

$$PWR = \frac{Returns\ of\ wrong\ products\ shipped}{Total\ number\ of\ orders\ served}$$

Interpretation: According to the current situation, the returns of the company present 10% of the total orders attended, of which the objective is to reduce it to 4%.

4. Validation

An integrative modeling of the pilot plans of the aforementioned tools was carried out with the purpose of corroborating the efficiency of the operation of our proposal as a whole, having previously considered some considerations for its development.

This section will mention some considerations for the development of the simulation that will be taken into account prior to its application. These include both the input variables for the input analyzer, scope of the system, the sample size calculation (runs) that guarantees its reliability, entities and restrictions and period applicable to the simulator, areas where they are going to be implemented and orders involved. in the analyzed period.

In order to have much more reliable results, the Arena software was used as a validation tool. The simulation involved all the processes that are required to serve and dispatch a purchase order. The simulation begins with the Input Analyzer, software that provides the distributions that best fit the sample data. Obtaining the optimal sample was based on 500 observations made of the dispatch process that directly involves the use of the reusable resource. From this, the optimal number of runs, which was 30, was determined.

On the other hand, for the comparison of the current model with the proposed one, a confidence level of 95% and an error of 10% were used. The current model can be seen in Figure 2 and consists of 6 main activities, in which some unnecessary ones can be observed in the dispatch process, which increase picking time. Similarly, Figure 3 represents the proposed model that contemplates an additional branch that symbolizes a supply chain periodically for greater fulfillment of dispatch orders. Once the simulation was carried out in the Software Arena, the indicators were obtained by which it is concluded that the proposed model significantly impacts the increase in the company's productivity indicator, as can be seen in Table 4.

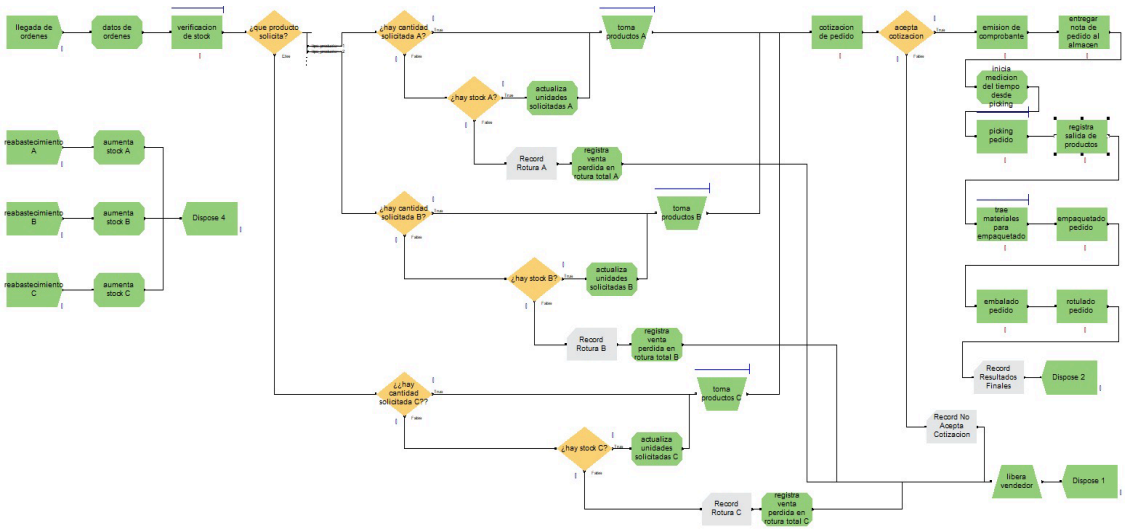

Figure 2. Model of the current situation

As can be seen and indicated above, the current model considers some unnecessary activities which are shown graphically in comparison with the model proposed below.

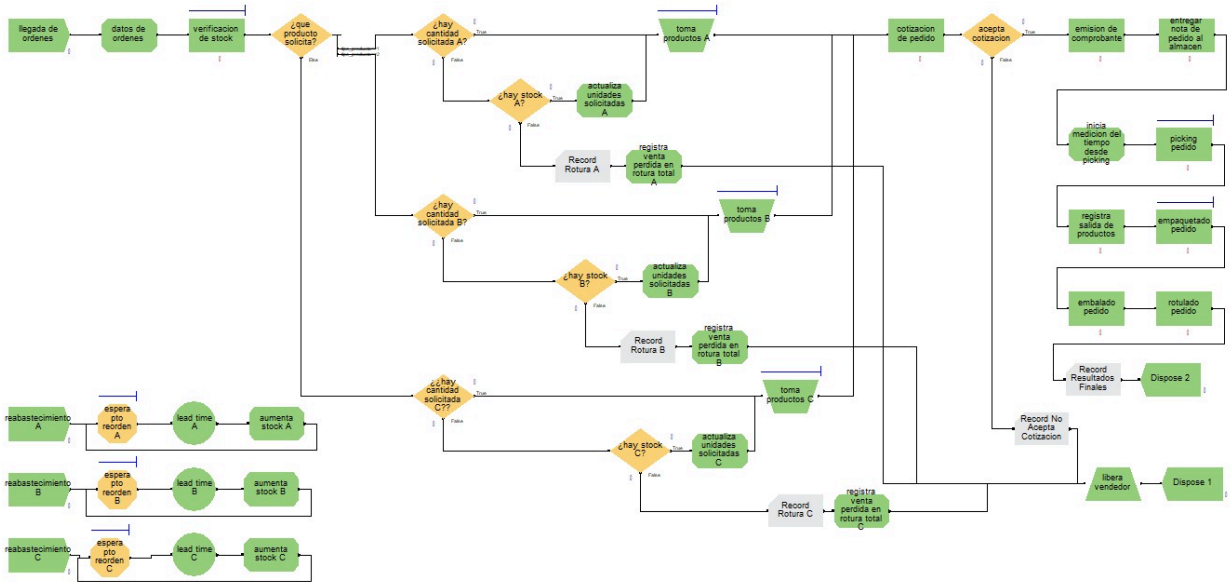

Figure 3. Model of the proposed situation

In the proposed model, due to the optimal relocations of the various areas, applying the Slotting tool, it was possible to eliminate the activity "Bring materials for packaging", reduce dispatch time (cycle time) from 162.11 minutes to 125.54 minutes per order. average and reduce the returns of wrong products of all orders served from 78 to 30 times per year. In addition, the reorder point was applied as a replenishment strategy (it allows to know, from what existing quantity, it must be ordered) which is related to the application of the EOQ (it allows to know the optimal quantity to order to meet the demand).

4.1 Economic Validation

For the economic evaluation, the total income related to the profits was calculated due to the difference in H-H used in service and dispatch and the increase in orders served aligned to the reduction of stock breaks. The calculations are shown in the following table. In addition, the total expenses that the development of the project would incur according to the proposed model were calculated; for this, a two-year project life horizon is considered.

Table 2. Economic cash flow

Year		**0**	**1**	**2**
Investment	-	39,060.00		
Income			56,354.15	56,354.15
(-)expenses			39,060.00	0.00
(-)Depreciation			0.00	0.00
(+/-)Other income/expenses			0.00	0.00
(=)Profit before taxes			**17294.15**	**56354.15**
(-)Intereses			0.00	0.00
(=)Profit before taxes			**17294.15**	**56354.15**
(-)Taxes			5101.77	16624.47
(=)Net profit			**12192.38**	**39729.68**
(+)DEPRECIATION			0.00	0.00
(+)RECOVERY OF WORKING CAPITAL				39,060.00
(-)amortization		-	S/0.00	S/0.00
(+)BALANCE BOOK VALUE				0.00
(=)Economic Cash Flow	**-**	**39,060.00**	**S/12,192.38**	**S/78,789.68**

Table 2 shows the development of the economic cash flow, data that facilitates the evaluation of the feasibility of the project. Likewise, it allows obtaining the economic indicators that are presented in table 3.

Table 3. Economics indicators

Economic indicators	Worth
VAN =	S/27,080.28
TIR =	58.49%
R B/C =	1.69
PR =	1.52

According to the values obtained, it is determined that the project is viable or profitable because the NPV is positive, the cost benefit is higher than the unit, which indicates that for each sun invested, it returns 1.69 soles and the recovery period (1.52 years). is less than the useful life of the established project (2 years).

4.2 Results metric

Below are the theoretically proposed indicators that were formulated with the aim of comparing them more accurately after simulating scenarios using the Arena software.

Table 4. Indicators for measuring the improvement project

Measurement of the improvement project								
Problem	Current	Objective	Proposed	Cause	Indicator	Current	Objective	Proposed
Low productivity in the dispatch area	**2.9**	4.5	4.17	Low operational efficiency (Picking time)	Average Order Dispatch Time	124.38 min	90 min	80.81 min
				High stock breaks	Number of times the demand was not met	118 breaks	39 breaks	44 breaks
				Returns for wrong products	Percentage of returns of wrong products	10%	4%	3.80%

As shown in Table 4, to increase productivity in the dispatch area, the ABC, Slotting and EOQ tools were applied, of which, through the Arena software, it was possible to perform the simulation and validation of Slotting and EOQ. From this, results were obtained that allowed verifying compliance with the established KPIs, which are the following:

• Through Slotting and ABC it was possible to identify the optimal layout of the warehouse areas and relocate the products according to families, with which it was possible to exceed the objective of the indicator average dispatch time of an order whose goal was 90min and the result was 80.81 min per order, this meant an increase in operational

efficiency of 10.21%; Furthermore, in accordance with the provisions, it was possible to reduce returns for erroneous products from 10% to 3.8%, thus exceeding the target by 0.2%.

• Through the effective application of the Economic Purchase Order (EOQ) strategy, a significant reduction in the frequency of stock-outs was achieved, going from 118 to 44 cases per year. It is important to highlight that, although the established goal was 39 breaks, the results obtained are remarkably close to this optimum figure. This improvement translates into greater stability in the supply of products and a firm step towards the optimization of inventory management

• By applying the ABC tool and carrying out a successful simulation that involved both the Slotting approach and the calculation of the Economic Purchase Order (EOQ), a notable increase in the productivity of the dispatch area was achieved, rising from 2.9 to 4.17. Although this value does not exactly match the target set of 4.5, it is close to the target and shows substantial progress in optimizing processes. These improvements are reflected in greater efficiency in resource management and a significant step towards operational excellence in the dispatch area.

4.3 Discussión

• The present case study resulted in the increase in the company's productivity through the application and development of the ABC, EOQ and Slotting tools, which grew from 2.9 to 4.17 representing 43.79%; however, León & Torres, in 2022, obtained closely similar results with other methodology that were 5S and SLP, managing to increase productivity by 40%.

• According to Rios et. al, 2022, managed to apply the Slotting tool in a food industry warehouse (manufacture of cellulose pulp and derivatives) with which they obtained a 19.24% reduction in operating time. With this, it is evident that the developed solution sequence suggested in this case can also be applied in other companies from different sectors

• First, regarding limitations and challenges addressed during the research process, it was noticed that there are few articles directly applied to the commercial sector of the automotive industry, on the other hand, of those selected, few included a software validation which allows to obtain data with greater precision; An example of this is the use of Python for demand forecasting. Second, regarding suggestions for future research, it is recommended to include the Lean Six Sigma methodology, which is responsible for reducing inventory errors, increasing operational efficiency, saving costs and therefore increasing the productivity of the company; To support what is indicated, the authors (Adefemi Adeudo, et al., 2023), in their evaluation, observed activities without high added value that led to a low efficiency of the process cycle of 40%, after implementation, efficiency improved up to 70%, which established an increase in productivity in all warehouse processes.

5. Conclusiones

The application of the ABC classification allowed better management and control of inventories by identifying and prioritizing products according to their relative importance in terms of value or impact on the business. Through the analysis and categorization of products based on their demand, cost and rotation, a clear segmentation was achieved that facilitated strategic decision making in inventory management, which led to a better allocation of resources, a reduction in storage costs and an optimization of stock levels.

The implementation of the slotting methodology allowed a better organization and distribution of the products in the warehouse, ensuring an optimal location of each product based on its rotation and demand. This facilitated order fulfillment efficiency and minimized the possibility of errors during the dispatch process. This not only benefited order accuracy, but also saved time and resources by minimizing the need for rework and returns. The successful implementation of this methodology has proven to be a viable solution to optimize inventory management and ensure greater accuracy in product dispatch. As a result, tangible benefits have been obtained in terms of operational efficiency.

The EOQ tool made it possible to determine the optimal order quantity that minimizes total inventory costs, considering storage costs and ordering costs. On the other hand, the Reorder Point established a critical stock threshold at which a new order must be placed to avoid stock outs. The simulation carried out in the ARENA program was a fundamental part of this study, since it allowed testing and evaluating different scenarios in a controlled environment. The simulation gave us the opportunity to adjust the parameters of the EOQ tool and the Reorder Point and observe

their impact on the efficiency of inventories. The results obtained from the simulation confirmed the effectiveness of these strategies in reducing stock-outs and improving inventory management significantly.

• In summary, it is concluded that this study supports the effectiveness of the ABC, EOQ and Slotting strategies in increasing productivity in the dispatch area and increasing utility. The successful implementation of these strategies has proven to be a viable solution to optimize inventory management, improve efficiency in dispatch processes and maximize profits.

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Biography

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