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Inventory Management System for the case study of a Cement Distributor

Manuel Soto-DelaVega[1], Jenifer Vásquez, PhD[1], and Carlos Eduardo Fuquene-Retamoso, PhD[2]
[1]Universidad Tecnológica de Bolívar, Colombia, mjsoto@utb.edu.co, jenvasquez@utb.edu.co
[2]Pontificia Universidad Javeriana, Colombia, cfuquene@javeriana.edu.co

Abstract*– The present article provides an in-depth analysis of the implementation of an inventory management system within a distributor, structured around three key stages: demand analysis, inventory modeling, and technological tool development. During the initial phase, individual product references underwent scrutiny, with demand projections generated using simple smoothing techniques due to the limited historical data availability, reflecting the company's recent market entry. In the subsequent phase, an Economic Order Quantity (EOQ) model was employed, underscoring its significance as a widely recognized and adaptable approach in the literature. Model parameters were fine-tuned to optimize inventory levels and minimize holding costs, resulting in tangible enhancements in operational efficiency and decision-making processes. Finally, a prototype of a technological tool was crafted in the concluding stage, amalgamating hardware, software, and an intuitive interface. This application facilitates streamlined inventory management, supplemented by the capability to generate insightful reports supporting strategic decision-making endeavors. Collectively, this study furnishes a comprehensive overview of the inventory management system implementation process, furnishing invaluable insights to bolster operational efficiency and competitive prowess within the distributor's market landscape.

Keywords*-- Inventory management, Demand analysis, EOQ model.

I. Introduction

Effective inventory management is a critical aspect for the operational and financial success of any company. Inventory represents the stock of goods or materials that a company holds in a non-productive state, awaiting utilization or sale. This management directly influences a company's ability to meet customer demand in a timely and efficient manner, as well as optimizing its financial resources by reducing costs associated with storage and inventory obsolescence [1].

Existing literature emphasizes the importance of implementing appropriate inventory management models to enhance operational efficiency and maintain competitiveness in the current globalized market. In this context, the development and implementation of a suitable inventory management model become a strategic priority for many organizations, regardless of their size or sector.

It is essential to recognize that inefficient inventory management is a recurring challenge in companies of all sizes, as evidenced by various studies [6]. Therefore, this project focuses on addressing this issue by proposing the application of an inventory management model that not only allows for detailed control of company assets but also significantly improves operational efficiency and responsiveness to market demands.

With the aim of illustrating the usefulness and effectiveness of this model, we will initially focus on enhancing inventory management for a cement trading company. By implementing this model in this company, we aim to demonstrate its ability to optimize internal processes, reduce costs, and improve customer satisfaction through more agile and accurate service.

II. Description of the Problem

The company where this project is being developed has a relatively short time in the market, so there are opportunities for improvement in its inventory management policies and practices to better adapt to the commercial environment. The current challenges of the company become evident when it faces the arrival of new orders that cannot be fulfilled due to insufficient inventory. This situation increases operating costs as the replenishment points are not optimized, resulting in poor supply management.

The trading company has multiple suppliers such as Argos, Ultracem, Cemex, and Cementos Progreso. Additionally, it offers multiple customer service channels, including WhatsApp, phone calls, and in-person visits, all of which follow a standardized process for data collection and delivery scheduling. A monthly graph showing the quantity of cement bags requested by customers is presented. The company acts as an intermediary between factories and customers, such as hardware stores and small to medium-scale construction sites. The company's logistics are outsourced to ensure efficiency and profitability in product delivery.

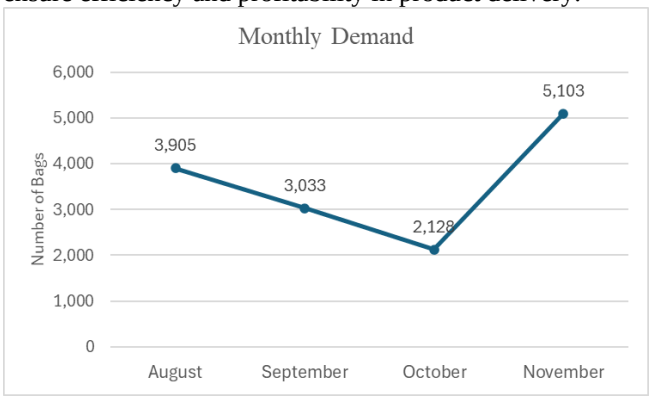

Fig. 1 Monthly Demand

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However, the current inventory management poses certain challenges. Weekly counts are conducted to decide when to replenish inventory, and the company handles various cement brands, complicating exclusivity with suppliers and inventory management. Faced with inventory shortages, the company has adopted a strategy of offering other cement brands to the customer, which reduces profitability. Additionally, the company lacks adequate demand control, resulting in uniform replenishments for all cement brands, without considering their respective individual demands. Orders to suppliers are placed through a customer service chat, but the lack of information about the specific demand for each cement reference hinders order optimization.

An analysis of sales over the past four months shows variations in demand and profits by cement brand. Cemex is the top-selling reference, highlighting the importance of understanding and effectively managing the demand for each product.

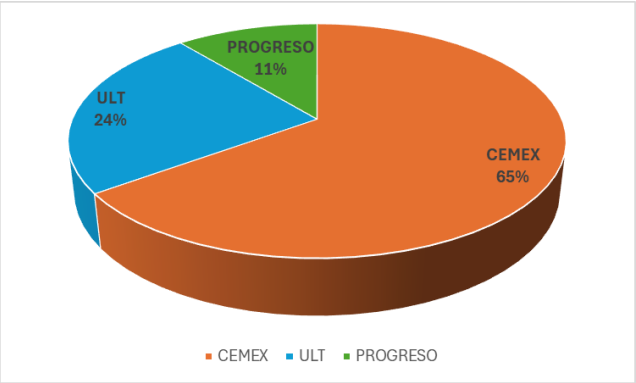


Fig. 2 Sales Analysis from August to November by Cement Brand

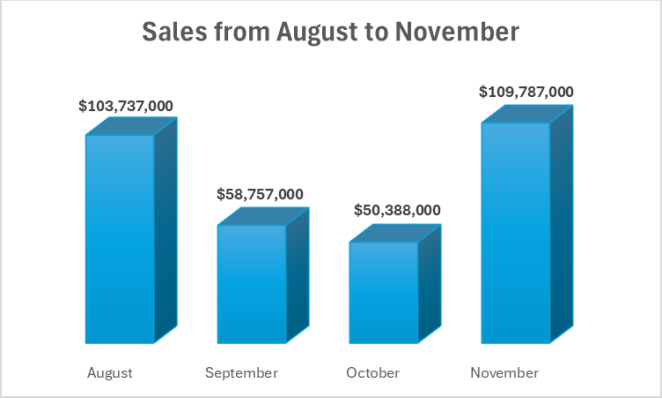


Fig. 3 Sales Analysis from August to November

III. Literature Review

Inventory management is based on planning and control to optimize operations and achieve organizational priorities. This process goes beyond cost minimization; it aims to maintain precise inventory levels to efficiently meet market demands using technologies and tools that enhance information in the supply chain [2].

Inventory management involves managing information about expected demand, available inventory levels, pending orders, and timely and adequate determination of reorder quantities. This management aligns with the company's competitive priorities and can impact its daily operations, as inventories require investment funds that could otherwise be allocated to other areas. However, product availability is crucial for sales, making effective inventory management a priority for many companies [3].

Inventory management involves a delicate balance: too much inventory can reduce profitability, while too little can affect customer confidence. Therefore, it entails making decisions that often involve sacrificing certain aspects in favor of others [1].

Regarding demand forecasting [3], it is essential for planning and setting company sales goals. The choice of forecasting method depends on factors such as the availability of historical data, the complexity of the method, and its intended application. Currently, forecasting methods are divided into qualitative and quantitative.

Qualitative methods are subjective and non-scientific, making standardization and accuracy evaluation difficult. Quantitative methods are divided into time series and causal methods. Time series methods use historical sales data to identify trends and seasonal variations if these will continue and providing accurate short-term estimates. These methods include simple moving average, weighted moving average, trend-adjusted exponential smoothing, multiplicative seasonal method, time series with seasonal and trend influences, and exponential smoothing. On the other hand, causal methods seek to identify the causes affecting sales and use statistical models such as linear regression to estimate them. Both approaches require historical sales information and have their advantages and limitations depending on the specific circumstances of the company and the market in question [5], [6].

In the state-of-the-art review, several research works were found at both national and international levels that offer different approaches to inventory management and demand forecasting. These works provide a solid foundation for the development of strategies and methodologies in the field of inventory management and demand planning.

Several studies have explored the application of inventory management models in different industries, providing valuable insights to improve efficiency and reduce costs. In the pharmaceutical industry, Silva et al. [12] implemented the EOQ model at Boticas Cristopharma S.R.L., achieving a significant reduction in inventory costs and net profit from the first month of implementation. Additionally, Mfizi et al. [7] analyzed inventory management at Rwanda Medical Supply Ltd., using ABC-VEN analysis to optimize the distribution of pharmaceutical products.

In the automotive sector, Ngadono et al. [8] and Brodetskiy et al [9] proposed the implementation of the EOQ

model to optimize inventory management, improve product deliveries, and strengthen sales. Another hand, in the food sector, Pérez-Vergara et al [10] developed an inventory management model for a food products company, using tools such as ABC analysis and reorder point calculation to optimize production and distribution. In the retail sector, Briseño-Oliveros et al. [11], applied demand forecasting techniques, ABC classification, and the EOQ model in a retail paint company, achieving increased order readiness and cost minimization.

This literature review highlights the importance of balancing inventory availability with profitability, as well as the diversity of approaches and tools used in different industries to achieve these objectives. The reviewed studies provide a solid foundation for the development of strategies and methodologies in these areas, highlighting the successful application of inventory management models in sectors such as the pharmaceutical, automotive, food, and retail industries.

III. Methodology

The conceptual design of the inventory management system for a trading company is based on a structured methodological approach that addresses the following key components:

Demand Analysis: This component involves the utilization of mathematical models and algorithms to analyze historical sales data and forecast future demand. Statistical analysis techniques are employed to identify demand patterns and trends, providing a solid foundation for decision-making in inventory management. This detailed demand analysis allows the company to better understand market fluctuations and adjust its inventory, accordingly, thereby improving responsiveness and operational efficiency.

Inventory Model: The inventory model focuses on optimizing inventory levels and minimizing associated costs. Various variables are considered, such as the cost of placing orders, the cost of holding inventory, and supplier lead time. Based on these factors, the model determines the optimal reorder point and order quantity to ensure adequate stock levels and minimize storage costs. Additionally, the model can be continuously adjusted and refined based on new data and changes in market conditions, ensuring its relevance and effectiveness over time.

Technological Tool: The inventory management system incorporates a technological tool that integrates both demand analysis and the inventory model. This tool provides an intuitive interface for data input and processing, generation of demand forecasts, and communication of alerts and notifications to the company manager. Additionally, it facilitates the visualization of key inventory and sales-related information, enabling more informed and agile decision-making. The implementation of this technological tool enhances the efficiency and accuracy of the inventory management process, while reducing the possibility of human errors and optimizing the time spent on administrative tasks.

This methodological approach is based on principles of quantitative analysis and utilizes advanced technological tools to improve the precision, efficiency, and effectiveness of inventory management in the trading company. By integrating demand analysis, the inventory model, and an advanced technological tool, the company can optimize its supply chain, reduce costs, and enhance customer satisfaction, contributing to its long-term success in the market.

IV. Results

Demand Analysis: In the first stage of the study, a comprehensive demand analysis was conducted for each product reference marketed by the company. Given the short time the trading company has been in the market, the available historical data was limited. However, simple smoothing methods were applied to project future demands based on this limited information.

Despite the scarcity of data, the analysis allowed for the identification of preliminary patterns and trends in the demand for each product. Seasonal variations and fluctuations in sales were observed throughout the study period, suggesting a dynamic response to external factors such as seasonality and changes in consumer preferences.

The simple smoothing methods applied proved to be effective in generating initial demand forecasts, providing a solid foundation for inventory planning. These models allowed for the smoothing of fluctuations in historical data and generated more stable and reliable projections for the future.

As a result of this analysis, preliminary demand estimates were obtained for each product reference, constituting a crucial first step in the inventory management process. These demand forecasts will serve as a starting point for the development of more accurate and effective inventory strategies in later stages of the study.

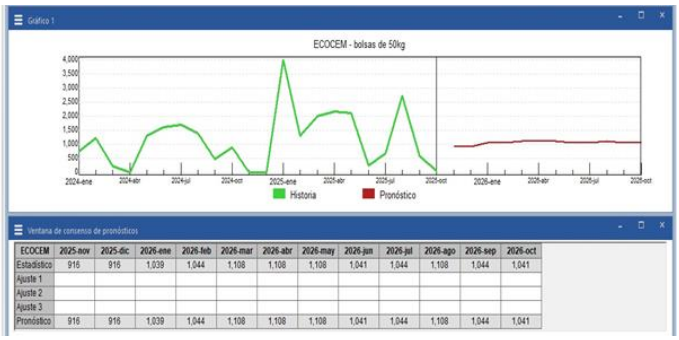


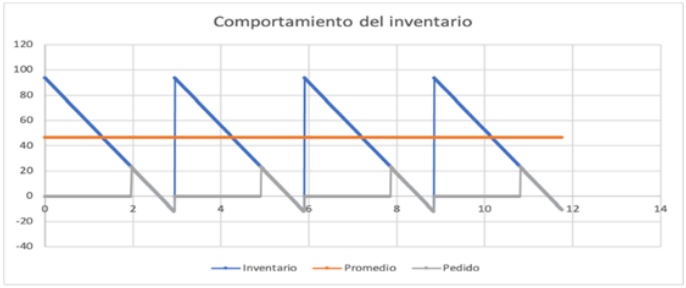
Fig. 4 Forecast Analysis

Inventory Model: In this second stage of the project, the Economic Order Quantity (EOQ) model was implemented as part of the inventory management system. This model was selected due to its widespread relevance and use in the reviewed literature, as well as its ability to optimize inventory levels and minimize associated costs.

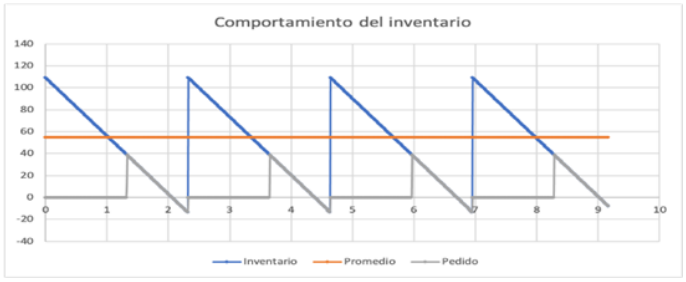
The parameters of the EOQ model, including the optimal order quantity and reorder point, were accurately calculated for each product reference. These parameters were determined considering the cost of placing orders, the cost of holding inventory, and supplier lead time, among other relevant factors.

The results obtained demonstrated that the application of the EOQ model significantly optimized the inventory levels of the trading company. A notable reduction in inventory-associated costs was observed, along with an improvement in operational efficiency. Additionally, sufficient stock levels were maintained to meet market demand, while minimizing the possibility of excess inventory or stockouts.

Optimum Amount	Q*=	123	units
Time between orders	t*=	0,07773362	months
Reorder point	q=	39	units
Effective waiting time	le=	1	day
Optimum maximum shortage	Q* - S* =	14	units
Optimal maximum inventory level	S*=	109	units



Optimum Amount	Q*=	106	units
Time between orders	t*=	0,0994512	months
Reorder point	q=	24	units
Effective waiting time	le=	1	day
Optimum maximum shortage	Q* - S* =	12	units
Optimal maximum inventory level	S*=	94	units



Optimum Amount	Q*=	118	units
Time between orders	t*=	0,086803816	months
Reorder point	q=	32	units
Effective waiting time	le=	1	day
Optimum maximum shortage	Q* - S* =	13	units
Optimal maximum inventory level	S*=	105	units

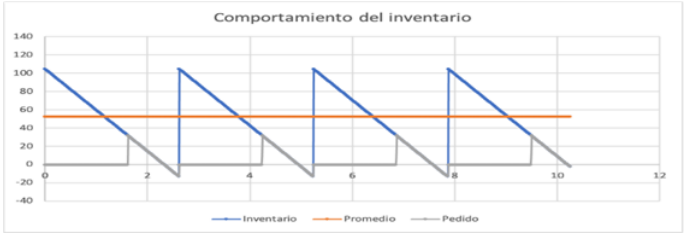


Fig. 5 Reorder Point Analysis

With the calculations, the optimal order quantity and the optimal shortages were determined. Additionally, the reorder point was calculated, which can be observed on the graph. This allows us to know how often to order to meet demand. By comparing the costs, we evaluate if the demand forecast was accurate and if the inventory management system design is achieving the objective of cost optimization, resulting in a difference of $13,781,555.

COMPANIES	PREVIOUS POLICY	PROPOSED POLICY	%
ARGOS	$6,430,060	$5,219,082	18,83%
PROGRESO	$123,410,911	$117,707,521	4.62%
ULTRACEM	$167,018,089	$163,285,050	2,24%
ECOCEM	$85,304,150	$82,170,003	2,67%
TOTAL	$382,163,210	$168,381,655	3,61%

Fig. 6 Savings with Inventory Policy

Technological Tool: Regarding the software, Microsoft Access is utilized as the database platform, and a custom application is developed to facilitate inventory tracking and generate restocking alerts. The interface is based on customized screens and forms in Microsoft Access, with dropdown menus and navigation options designed to enhance interaction, along with the implementation of real-time alerts to improve decision-making. This implementation provides the trading company with a comprehensive and user-friendly tool to efficiently manage its inventory and enhance real-time decision-making.

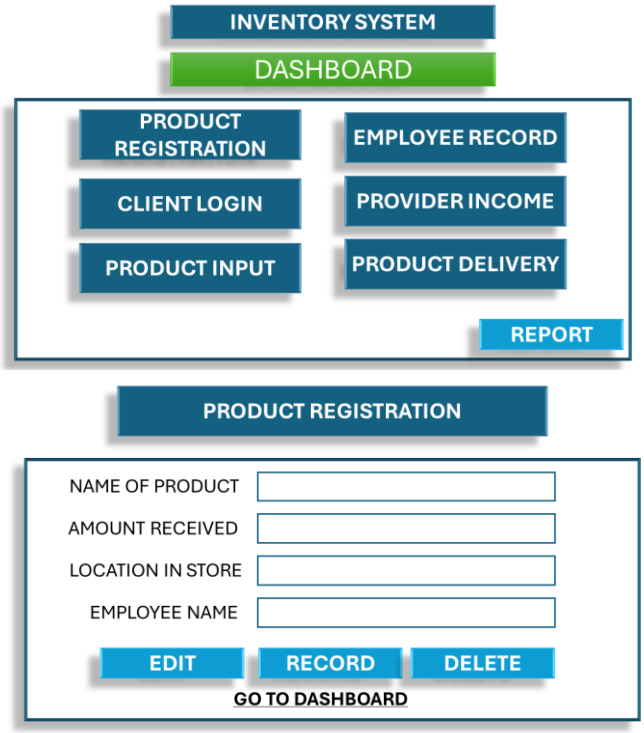


Fig. 7 Technology Tool Interface

The implemented management system consists of three essential modules: the user interface, demand forecasting, and reorder point notifications. The user interface, designed to provide an intuitive and accessible experience, stands out for its clear layout of control elements, ensuring easy navigation and meeting the "Ease of Use" requirement. On the other hand, the demand forecasting module employs advanced mathematical models to analyze historical data and trends, generating accurate forecasts that meet the "Accurate Demand Forecast" requirement. This stage connects directly with the reorder point notifications module, which monitors inventory levels and sends alerts to the manager when the established reorder point is reached. To meet the "Reorder Point Notifications" requirement, this module sends alerts based on predefined thresholds, ensuring proactive inventory management.

Each module of the management system has its specific function and requirements. The user interface focuses on providing a clear layout and intuitive interaction to meet the "Ease of Use" requirement, ensuring that users can navigate the system without difficulty. The demand forecasting module relies on advanced mathematical models to ensure accuracy in demand forecasts, meeting the "Accurate Demand Forecast" requirement. This accuracy is crucial for making informed decisions about inventory and optimizing stock levels. Additionally, the reorder point notifications module plays a crucial role in constantly monitoring inventory levels and alerting the manager when replenishment is necessary, ensuring that the company can maintain its operations without interruptions. In summary, each module of the system contributes integrally to the efficiency and optimization of inventory management in the trading company.

The application has the additional functionality of generating reports to support decision-making. These reports provide key data on inventory status, demand trends, and other relevant aspects, allowing users to access detailed information to make informed and strategic decisions.

Different types of tests were conducted to ensure proper functioning and user satisfaction. Unit tests focused on verifying the specific functions that the company needs to perform, such as calculating reorder points and generating alerts, while integrity tests focused on ensuring data consistency and correct transmission within the system. Additionally, usability tests evaluated the user interface and ease of navigation.

These testing efforts allowed ensuring that the software meets the functional and usability requirements expected by the trading company. For this purpose, specific test cases were defined for each module of the system, such as reorder point calculation, alert generation, and user interface, to verify their proper functioning and their ability to meet the needs of the end user.

IV. CONCLUSION

The development of an inventory management system for a cement trading company has proven to be a valuable investment and a crucial tool for improving operational efficiency and reducing costs. One of the main contributions of this project lies in the system's ability to optimize inventory processes and minimize associated costs. According to the results obtained, it was observed that for some products, the implementation of the new system led to significant savings, ranging from 2% to 18%. These savings mainly derive from better inventory management, which reduces costs associated with excessive storage, product obsolescence, and losses due to stockouts.

Furthermore, this project has demonstrated the utility and effectiveness of demand forecasting in inventory management. By using advanced mathematical models and forecasting algorithms, the system was able to accurately predict future demands and adjust inventory levels accordingly. This allowed the company to optimize its inventory management while simultaneously reducing risks associated with shortages or excess stock. Validations conducted during the system development process, including unit, integrity, and usability testing, confirmed the system's effectiveness and reliability in real-world environments. These validations represented a crucial step in the system implementation process, as they ensured its proper functioning and its ability to meet the needs of the end user.

The development and implementation of a customized inventory management system have allowed the cement trading company to significantly improve its operational efficiency, reduce costs, and enhance customer satisfaction. This project has underscored the importance of effective inventory management and has provided a practical and effective solution to address challenges associated with inventory management in real business environments. With the successful implementation of this system, the company is well-positioned to achieve its business objectives and continue growing in the market.

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