Application of a Model Based on Demand Forecasting, ABC Classification and EOQ in a Gastronomic SME to Improve Inventory Turnover: Case Study in Peru

Bryan Anthony Cuba Paz*[a], Piero Enrique Bazan Cabezas†[b] and Alberto Flores-Perez[c]
Facultad de Ingenieria y Arquitectura, Universidad de Lima, Lima, Peru

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Abstract: The Small and Medium Enterprise (SME) and gastronomic sector suffered a great negative impact due to the crisis caused by the pandemic, resulting in the search for solutions to minimize costs internally in order to survive the changes of the new economic environment. Therefore, the application of a methodology consisting of demand forecasting, ABC classification and EOQ was proposed to improve inventory turnover in this sector. Several research articles were reviewed, from which the success cases and their methodologies to solve the problem were interpreted. In this case the main problem is the low inventory turnover due to inefficient demand forecasting, inadequate planning of purchases of inputs and poor prioritization of these, which generated losses to the SME studied. For the validation of the contribution, the Arena simulator was used, showing a turnover similar to that of the case study and giving positive results after the application of the contribution, empirically, improving the proposed indicators, such as; the variation of times of purchase of inputs, which increased by 8.57%, the average inventory, which decreased by 22.67%, the level of service, which improved by 5.29% and the main indicator, the inventory turnover, which improved by 40.02%.

1 INTRODUCTION

The economic crisis generated by the last pandemic affected all companies regardless of their size and sector, which caused them to make changes in their different business strategies in order to reduce their expenses, survive and adapt to changes in the economic environment (Giles, 2020). In Peru, this crisis seriously affected the SME sector, where they presented a 59.2% decrease in annual sales with respect to what was reported in 2019, registering the lowest value in recent years, resulting in 60,489 million PEN, equivalent to 8% of the Peruvian gross domestic product (GDP) in the year under study (Confederación Nacional de Instituciones Empresariales Privadas [CONFIEP], 2021). The participation of this sector has been quantitatively important within the Peruvian business sector, since it has maintained a participation of over 92.7% over the last few years.

One of the most important sectors within the Peruvian Small and Medium Enterprises (SMEs) is the gastronomic sector, which, until before the pandemic, 2019, represented 3.2% of the total Peruvian GDP, and although it has suffered a fall of 30.6%, this has been increasing since the beginning of 2021 (Sociedad de Comercio Exterior del Peru [COMEXPERU], 2022). Such is the importance of this sector that the Peruvian government made proposals for economic reactivation in the restaurant sector, where facilities were provided for the use of own or third party delivery, which led to a different behavior than usual, due to the constant variation in production (COMEXPERU, 2021).

Therefore, the key problem of the case study is the company's capacity to possess the necessary inputs for the preparation of the dishes, since, being an atypical situation, it generated losses of inputs due to poor storage, overstocking of inputs with low demand, stock breakage of the most relevant inputs, as well as inadequate inventory control and

[a] https://orcid.org/0000-0002-6301-6224
[b] https://orcid.org/0000-0002-3204-2366
[c] https://orcid.org/0000-0003-0813-0662

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purchasing management procedures. In addition, the inadequate management of the company's inventory, regardless of its size, drastically affects its annual revenue (Villón, 2021). This affects directly with the level of satisfaction provided to customers, since the requested order cannot be delivered, therefore, the perceived income is diminished. Therefore, to analyse the results of the model, indicators such as inventory turnover, average inventory, service level and variation in the quantity of input purchases were proposed. In addition, a correct control of merchandise will generate a positive impact on the growth and liquidity of the cash flow of companies, since inventories are considered a key factor in the competitiveness factors that every company, including SMEs, must manage (Serna et al., 2018). In this sense, several authors have appeared who sought to solve this problem.

On the one hand, in one of the papers studied, the inventory management of a Cuban commercial chain classified its products based on the ABC tool and analysed historical data to obtain a demand forecast, since the company did not have an efficient management model to generate orders (Bofill et al., 2017). In addition, it uses the EOQ system to obtain the order quantity while minimizing warehouse costs. It ends up with a remarkable improvement in the service level and a better utilization of the products in the warehouse. On the other hand, in a footwear trading company, the use of ABC and EOQ tools is carried out to classify according to their importance in the warehouse and to identify the order (Causado, 2015). In this case, the most important products in the warehouse are obtained as a result of the Pareto diagram. After that, a series of calculations are performed to obtain the order cost and quantities of these. In addition, the author recommends the use of software to manage the information and its application in the company under study, since it has several products with a lot of stock that take a long time to leave the warehouse and a high opportunity cost is obtained. As mentioned above, the sector in the case study presents failures in inventory management due to poor demand forecasting, lack of information in records and poor planning of warehouse management so that an improvement in its model is needed to generate effective solutions to this problem.

It was proposed to create a working model where the company's database is organized to categorize the most relevant dishes with the ABC classification. After that, a demand forecast with simple exponential smoothing was applied to forecast the next period's demand and to know the required quantity of each input used in the dishes. In addition, these inputs were then sorted by ABC classification, taking into account only products from zone A. Finally, the EOQ tool was used, which allows us to obtain the lowest possible inventory cost by using the costs of ordering and keeping these inputs in the warehouse. The decision to make this proposal was made because no other scientific article was found that uses the tools together and presents our improvement proposal for SMEs in the gastronomic sector.

2 STATE OF THE ART

2.1 Demand Forecasting

This tool has been considered by numerous researchers as fundamental in different improvement proposals, since it is a vital point for making decisions in the company on logistics issues that have repercussions on the other activities to be carried out with respect to inventory purchasing (Gonzáles,2020). In addition, it is easily integrated into the models proposed for warehouse management, which also has a high impact on the aggregate planning of companies. As can be seen in the papers reviewed, the authors highlight the added value of implementing this tool for decision making and improving the desired results (Madariaga et al., 2022).

2.2 ABC Classification

Its main objective is to classify a large number of items by grouping them into the same family, since it allows them to be grouped by different criteria that they have in common (Rivera et al, 2019). Based on this methodology for the selection of items, which has been widely used by different organizations due to its versatility of implementation regardless of the sector in which it is found, its presence and use has been seen in hospitals, clinics, insurance companies, coffee companies, hotels, education, electronic companies, among others. In this sense, as has been proven in a case study, this methodology is characterized by allowing the organization to obtain better control in warehouse management, focusing on what is most important for the company, according to their interests and minimizing costs, although, even so, there is still a resistance by companies to change in its use due to lack of knowledge of its management (Escobar et al, 2021).

2.3 EOQ (Economic Order Quantity)

This tool provides us with the optimal value of the quantity to order to avoid stock breaks and to make the management of the company's economic resources more efficient (Rodriguez et al, 2018). In addition, its main objective is to obtain the balance between fixed costs and costs related to the inventory held, so it is present in various case studies operating in different sectors, as in the case of a paper with a model based on this tool applied to the automotive sector, where it guided its warehouse managers to improve their logistics planning and ensure customer demands without generating surpluses, offering a better level of service (Contreras, et al 2019).

3 BASIS OF THE MODEL

In our case study we evidenced problems in inventory control that were repeated in different SMEs based on the literature due to the lack of tools for its management and training. Therefore, we propose an improvement proposal for storage management, taking as a guide the different proposals analyzed in papers on inventories that were implemented in SMEs. The papers studied detail their proposals based on components such as those shown in Table 1. Unlike other models applied in sectors other than restaurants, the proposed model includes demand forecasting to obtain the optimal demand for the following period, ABC classification that will improve the results expected from the categorization of supplies in the storage area and the EOQ tool for planning the purchase of those categorized in zone A.

Table 1: Comparison matrix.

Causes / Authors	Deficient inventory purchase planning	Inefficient demand planning	Incorrect decision on the importance of inputs
Madariaga F., Carlos et al (2020)		Demand forecasting – ABC Classification	Artificial Neural Network
Rodríguez L., Guillermo et al (2018)	EOQ		ABC Classification
Carreño D., Diego et al (2019)	Demand forecasting - EOQ		
Proposed Model	Demand forecasting - EOQ	Demand forecasting – ABC Classification	ABC Classification

4 PROPOSED MODEL

Based on our review of different scientific articles on our research topic, our proposal is made to improve storage management using demand forecasting, ABC classification and EOQ to increase inventory turnover and the objective indicators of the proposed model.

First we have a low inventory turnover, and the analysis of the problem is performed along with the collection of data, then we move to the phases of the model that have as name; organization, estimation, prioritization and planning, finally an analysis of the indicators in the validation, obtaining as a result an improved inventory turnover.

Figure 1: Proposed model

4.1 Components

At the beginning of the proposed contribution, we analyse the information provided in the case study with a root cause or Ishikawa diagram, in order to highlight the possible causes of the main problem. After that, the 5 Whys tool is used in different personnel of the company to validate the information, in addition to a Pareto diagram highlighting the most relevant events. After having reviewed the information and having verified it, we collected data relevant to the main axis of the problems that will be used in the following components.

In phase 0, we began with the collection of the necessary data for the use of the input tools, so we worked together with the company to obtain the required data. Among the data needed for the implementation we have; list of the restaurant's dishes; sales in units per month and cost of each dish.

In phase 1, called Organization, the categorization of all the existing dishes in the company was carried out. They are classified according to their units sold by their unit cost in the same time range. After that, we selected only the dishes categorized in zone A, which represent the 80% with the highest utilization value.

In phase 2, called Estimation, we proceeded to run the demand forecasting tool for the dishes exclusively in zone A, using the historical demand for each dish,

the type of forecast selected for our contribution is simple exponential smoothing to ensure that the forecast is the most accurate [12]. The following formula will be used;

$$Ft = Ft\text{-}1 + \propto (At\text{-}1 - Ft\text{-}1) \quad (1)$$

Ft = Average number of products sold in a given period t.
Ft-1 = Average number of products sold in a given period t-1.
At-1= Quantity of products sold in a period t-1.
$\propto$ = Smoothing coefficient between 0 and 1.

In phase 3, called Prioritization, a new categorization was carried out by disaggregating the inputs of each plate to obtain a general list of the inputs used. In this list, the ABC classification tool was used again to obtain the inputs that represent 80% of the total in order to continue with the following tool.

In phase 4, called Planning, EOQ was performed to obtain accurate data on order quantity, time between orders and reorder point, then evaluate the results with indicators in the next phase. For this we need to obtain data such as:

Q* = Optimal number of units to order (EOQ)
D = Monthly demand in units
St = Ordering Cost ($)
Ht = Cost of maintaining inventory ($)
s = Unit order cost for each order ($)
h = % of cost of holding inventory
c = Unit cost of product ($)
R = Reorder Point
Lt = Monthly Lead Time

$$Q^* = \sqrt{\frac{2D * s}{h * c}};\ N = \frac{D}{Q^*};\ T = \frac{30}{N};\ R = D * Lt \quad (2)$$

$$St = \frac{D}{Q^*} * (s);\ Ht = \frac{Q^*}{2}(h * c) \quad (3)$$

Finally, in this phase, the indicators selected for monitoring the proposed model were inspected to analyze the performance of the results found after its application, having previously carried out a previous evaluation of the same indicators at the beginning of the application of the tools, for comparison in the simulator. All this will be recorded in order to continuously improve the processes and obtain opportunities for improvement. The main indicator of this article is the inventory turnover, then we have proposed the evaluation of related indicators such as average inventory, service level and the variation of times of purchase of inputs, all shown in Table 2 with their respective formulas and uses.

Table 2: Indicators

Indicator	Formula
Inventory turnover	$\frac{Cost\ of\ sales}{Average\ Inventory}$
Average inventory	$\frac{Beginning\ Inv. + \text{Ending Inv.}}{2}$
Service Level	$\frac{Completed\ orders}{Orders\ received}$
Variation of times of purchase of supplies	$\frac{\#\ \text{purch.}\ t - \#\ purch.\ (t-1)}{\#\ purch.\ (t-1)}$

5 VALIDATION

5.1 Initial Diagnosis

The data obtained from the case study provide us with a technical gap with respect to the industry standard inventory turnover, whose value is 11.23 (Company, Sector, Industry and Market Analysis [CSI Market] 2021). The company under study has an inventory turnover level of 8.20, which generates an operating cost representing 11.21% of the company's profitability in the case study. The main reasons for this problem are: (a) overstocking due to low number of purchase times, (b) loss of sales due to lack of required inputs, (c) poor product categorization approach.

5.2 Validation Design and Comparison

The technique selected for our validation will be the simulation and it will be performed in the simulator program called Arena, since it has the advantage of representing the systems and reports in a more dynamic way, giving reports on the functionality of the system within the restrictions used. For this we use the historical data of the company as the arrival of orders, the number of dishes, the type of dishes to choose, among others. All this information was necessary for the application of the tools proposed in our contribution. These are ABC classification for both dishes and inputs, demand forecasting and EOQ. This will be done in order to corroborate the efficiency of the application of our proposal in the case study, mentioning some previous considerations for its development.

We consider in this section both the input variables, which were analyzed by the Input

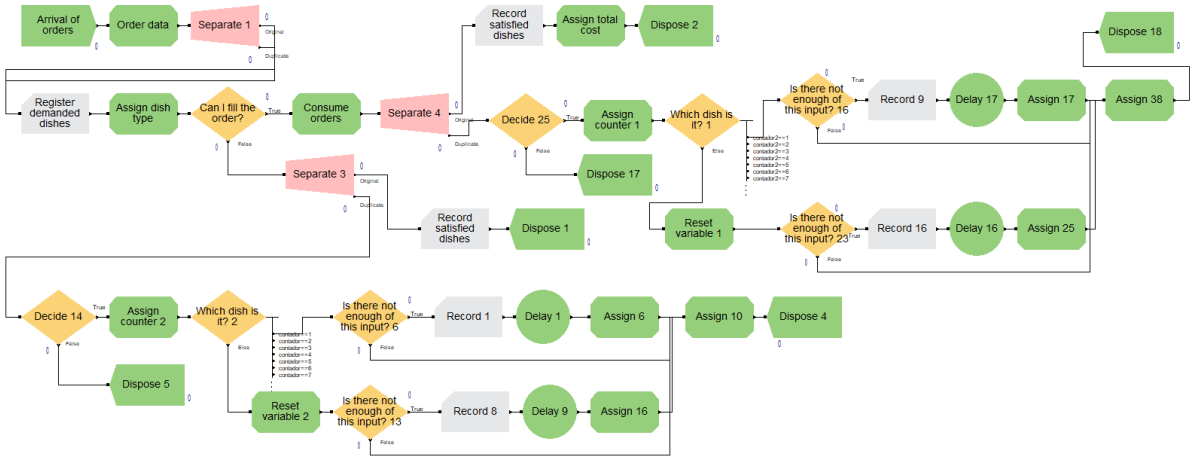

Figure 2: System representation in the Arena simulator

Analyzer, the scope of the system, the calculation of the sample size giving more confidence to the simulation results, entities and constraints, as well as, the period applicable to the simulator, improvements and recommendations. Finally, we will show the metrics of the results obtained.

5.3 Simulation of the Proposal Model

The simulation of the inventory management process for our case study begins with the entry of orders, where the amount of dishes to choose is obtained as input data; as well as the type of dish. After that, the order is generated to the kitchen for the preparation where the stock of inputs is discounted and the order is delivered to the customer. If the order is not fulfilled due to lack of supplies, an unexpected purchase order will be generated for replenishment during the course of the day. Therefore, the customer cannot be served until the required supplies are replenished and it will be considered as an unfilled order. Each day a review of the inputs is carried out, verifying the reorder point of each input, if it does not meet this condition, a purchase order is generated with a lot size determined by the company, where a one-day delay time restriction for resupplying all inputs has been taken as a restriction.

The restrictions of this simulation are based on the 10 dishes obtained within zone A of the ABC classification applied among the restaurant's dishes, since they are the ones that represent the most value and relevance for the company. In addition, it should be considered that the simulation will use only the most used inputs for the group of dishes resulting above, obtaining the 8 most relevant inputs, since an ABC classification was also performed to give more focus to these inputs, which represent 80% of the total value of inputs used in their preparation.

It was also considered that the working time is 10 hours per day in an applicable period of one month. In addition, there are two branches, one for inventory replenishment due to stock-outs and the other with planned purchase orders. After the application of the simulation, either in the current situation and in the proposed model, the results detailed in Table 3 are shown.

Table 3: Simulation results of the initial model and the proposed model.

Indicator	Units	Initial Situation	Improved situation
Inventory turnover	Times	9.12	12.77
Variation of purchases of supplies	+/- %	-	+ 8.57%
Average inventory	$	1230.14	951.27
Service Level	%	72.80%	78.09%

6 CONCLUSIONS

In the first place, we were able to improve the process of the case study by obtaining a better inventory turnover, which was our objective, and this was due to the correct implementation of the tools in the inventory management process, and all this without modifying the structure of the current process, but with a better planning of its purchasing strategies. As a result, we obtained a remarkable improvement of 40.02% of our main problem over the indicator of the current situation.

In second place, it is evident in the case study that there are SMEs that do not give greater relevance to their inventory control and the monetary loss that this represents, since the main causes of their low turnover can be solved by obtaining a positive economic impact on the company's capital.

Thirdly, the application of the improvement proposal is effective in different scenarios according to the simulations made, which demonstrates the robustness of our proposal, which could be replicated in other related or similar areas.

Finally, tools such as ABC classification allowed us to categorize a large number of items, which facilitated the prioritization of these items and allowed a better quality of data for the demand forecast. In this way, the EOQ tool was executed, with which we obtained the quantity to be purchased per lot, the amount of re-order, as well as the exact time to generate the order. However, more research should be done on the use of EOQ with products with expiration dates and it should be coupled to the model to achieve a greater impact on inventory turnover and on the company's future planning with respect to its inventories.

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