Inventory Policy for the Demand of Main Products: The Case of a Peruvian Grocery Store

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Abstract

The study proposed an inventory policy for its products with the highest demand based on the analysis of the application of three planning techniques, which were the silver Meal method, the minimum unit cost method and the EOQ. In addition, forecasting techniques were applied with a bimonthly historical data from the sales record that helped identify the products with the highest demand according to the ABC classification. The methodology carried out in a grocery store in Peru found that the demand behavior differed in each product; so, the standard deviation was analyzed. Then, the application of the three planning techniques was compared where a similarity in the frequency of orders and quantity between the Silver Meal and MCU was observed; on the other hand, the EOQ functioned as a preliminary step to identify a reorder point.

Keywords

Planning, inventory policy, demand forecasting, ABC method, grocery store, EOQ method, silver Meal method, MCU method, reorder point.

1. Introduction

Warehouses or grocery stores are establishments that offer household products, perishable products, among others. In other words, it is a business that is dedicated to the retail marketing of necessities; in which food and beverages predominate (Ley Peruana No. 30877, 2018).

In Peru, wineries or grocery stores represent a very important item in the retail commercial sector. In 2017, 87.6% of formal MSMEs came from trade and services activity in Peru (Ministerio de Producción 2020). In addition, the Association of Winemakers of Peru indicates that in 2020 1489 formal and informal wineries were opened in Metropolitan Lima and Callao; of which, 75% were opened in the health crisis, unfortunately 45% of these had to close due to a low sale of their merchandise (RPP Redacción 2020).

Scholars argue that small and medium-sized enterprises make decisions according to the criteria of a single person, usually intuitively (Pekuri et al. 2014). In this situation, the supply chain of an MSE can present stock breakages or

surpluses in stock volumes caused by inefficient inventory planning. On the other hand, the scarce technical training of the store manager can hinder the development and competitiveness of the business (Agustina Calderón et al. 2017).

1.1 Objectives

- Propose an inventory management policy based on demand planning.
- Present different demand forecasting methods that may be useful.
- Improve the availability of selected products.

2. Literature Review

Research on optimizing and improving the supply chain through demand planning is extensive. In general, verified information on projected demand contributes to the development of an inventory policy to increase product availability and reduce costs. However, there is a lack of verified procedures for its application in SMEs and even more so in grocery stores or retail stores.

A study carried out on a distributor of perishable products considered estimating the volume of storage for new refrigeration facilities, for which it used time series forecasting techniques such as moving average and exponential smoothing. It was concluded that statistical techniques added reliability in planning (Contreras Juárez et al. 2016).

Statistical projection techniques are useful for forecasting demand for a product; However, the behavior of historical data must be identified to identify the technique with the least standard deviation for multiple products. For example, in a company manufacturing and marketing pipes of various types, the ABC classification was used to select products according to importance and movement, then moving average and exponential smoothing were applied where appropriate to project the demand for the selected products (Méndez Giraldü & Lopez Santana 2014) . Furthermore, researchers study the viability of models for distributional demand forecasting in e-grocery. This kind of store is characterized for the transparency and traceability of the supplies; as a consequence, the stock availability of products has an strong impact on customer purchase decision and the entrepreneur has the advantage to take a better control of the service level. The study concluded than the model GAMLSS reduced the average percentage costs across all the products in the e-grocery (Ulrich et al. 2021) .

Another study carried out in a marketing company proposed the management of its inventory based on the definition of an instrument that integrated the classification of items and the forecast of demand. This study proposed a hybrid model that integrates two forecasting techniques from *machine learning*, which demonstrated better performance (Madariaga Fernández et al. 2020).

The studies that involve the forecasting of the demand must face the effectiveness and performance of the statistical technique they use, in that sense there are traditional techniques such as the moving average and exponential smoothing that require greater historical data of the product; There are also methods that integrate probabilistic models due to the scarcity of historical data such as Bayesian linear regression. For example, a study carried out at a fuel station in Colombia determined that its proposal for a multiproduct inventory model based on the forecast of a Bayesian regression optimized warehouse management, as well as the flexibility to alter the parameters or probability distributions in order to obtain more precise values (Valencia Cárdenas et al. 2015).

With the demand planning carried out, the entrepreneur has the tools to propose an efficient inventory policy. According to a study of optimization of revenues for small retail stores, there are many techniques available for controlling inventory like ABC analysis. HML analysis and economic order quantity. Besides, the application and analysis of results of more small stores will allow for create an algorithm where it will function like a support for a future software of mobile application (Sneha K V et al. 2022). Another case study in a lubricant marketing company where the projected demand was obtained, the researcher was able to propose inventory policies based on components of periodic review models (Parga-Prieto & Aranda-Pinilla 2018).

Also, the study carried out on a computer marketing store in Peru, where the inventory policy depends on demand, was reviewed, as well as an inventory model for small companies marketing technological products (Andrade Maldonado and Viacava Málaga 2021).

3. Methods

The research had an experimental and cross-sectional design since it proposes an improvement in the supply process through the management of an inventory policy for a grocery store. The study consists of four phases of analysis, which are detailed below in Table 1.

Table 1. Research design phases

N.	Research phase	Description	Tools

1	Inventory the company's products and record sales	The necessary data of the winemaker is collected to know the inventory of all its products.	Sales record through macro scheduling.
2	Classification by criterion, and by ABC methodology	The behavior of demand is analyzed for the appropriate prediction tool.	ABC methodology.
3	Make a forecast of the main products	Identify and apply the appropriate prognostic technique.	Simple average, mobile, simple exponential, holt, winters.
4	Carry out the inventory policy of type A products	Analyze and propose the appropriate inventory policy.	*Silver Meal* method, MCU method, EOQ method. Safety stock.

After the preliminary diagnosis, the first phase consisted of the collection of commercial data such as sales and products in the warehouse. This was done from a book in Excel where you found all the lines of products that can be sold in a grocery store, since the products did not exceed the amount of 100 per item, the winemaker was responsible for counting the products that were in his warehouse. Likewise, a basic Macros was provided where the winemaker recorded the sales that he made daily for two months.

The second phase consisted of the application of the ABC classification based on the data collected from sales; in this way, the demand was recorded in units and soles; in addition, the research applied the methodology for families and products. Likewise, the products with the highest demand in the winery were identified; therefore, greater rotation in the warehouse.

ABC inventory classification is a method that analyzes and classifies the company's items according to criteria such as demand, price, etc. The method is based on the 80/20 rule, which consists of identifying 20% of items with a value of 80% of the inventory, and vice versa 80% of items with a value of 20% of the inventory (Macías Acosta et al. 2019).

The third phase consisted of forecasting the demand for the main products selected by ABC, based on its sales record in the last two months. It should be noted that the winery does not have sufficient supply and each product has a different behavior in the local market, so the appropriate forecasting techniques were identified according to the standard deviation for each type A product.

Finally, the fourth phase analyzed three inventory planning methods to define the policy: the *Silver Meal* method, minimum unit cost and EOQ. Silver Meal was used to define the amount of replenishment from the average cost per period and for the average cost per unit, the MCU. On the other hand, when the cost of order preparation and storage is coincided to define the batch size, the EOQ was used. Consequently, the most appropriate policy is discussed at the product level and at the holistic level of the sample of type A products; In this way, the entrepreneur identified when and how much to buy to increase product availability.

4. Results

The products marketed by the winemaker were inventoried, a Macros was also made to record daily sales, shown a in Figure 1; the sales of the products of each family in a period of two months were identified. To make the forecast, a selection criterion was decided for products A and B, which was 20% for each; in addition, it was necessary to select products by the ABC methodology. The family of groceries was selected which is type A, since they generate more income to the grocery store, it was also identified that the lost sale of the store resulted in a minimum value, since in the area certain products were consumed; so, it was not taken as a study product.

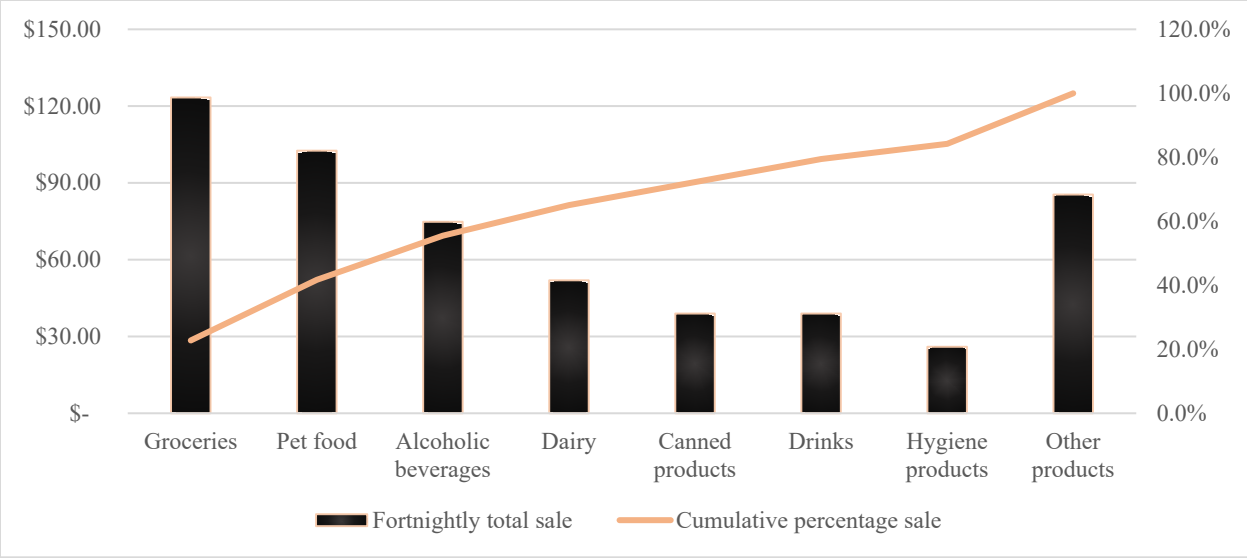

Figure 1. Product Family Pareto Chart

The grocery family has 68 products; 70% of the products with the highest sales volume were selected, the product with the highest sales value was also selected; in addition, all the techniques of time series type were applied, for which, three known techniques were applied in which the same values were considered, alpha of 0.2, beta of 0.15 and gamma of 0.12. Likewise, the MAD was used as a variable to select the type of forecast for each product, to manage the data for the inventory policy.

Figure 2 shows the result of the selected products.

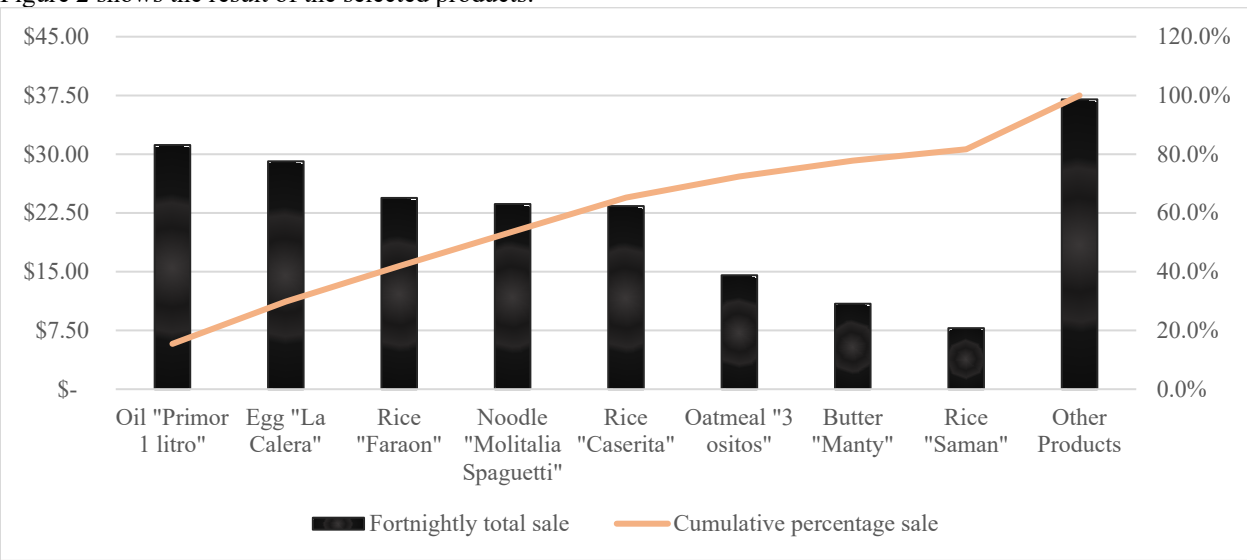

Figure 2. Cumulative Sales Chart for Grocery Family Products

The previous forecast of the selected products was made, in which the mean absolute deviation was observed when applying the different techniques; to choose the type of time series per product, the lowest MAD was determined, to validate the most appropriate sales forecast for the next four weeks; Table 2 shows the results, in which it is observed that some results do not show much numerical difference between them, despite this, the lowest value was selected; it was observed that only the product of Huevo La Calera will use a seasonal forecast, since a repetitive pattern of sales was obtained in the results; La Caserita rice used a simple moving average with a historical range of three days; in the other products the exponential technique was selected, since the sales of the winery were growing.

Table 2. Summary of identification of forecasting techniques

	MAD Simple Average	MAD Moving Average	MAD Exponential	MAD Holt	MAD Winters
Egg "La Calera"	3.61	3.11	2.88	4.01	1.50
Rice "Faraón"	0.95	0.86	0.76	1.11	1.08
Rice "Caserita"	0.56	0.41	0.44	0.57	0.32
Noodle "Molitalia Spaguetti"	1.17	0.93	0.94	1.33	1.16
Oil "Primor 1 Litro"	0.78	0.66	0.62	0.88	0.71
Oatmeal "Tres Ositos"	0.82	0.69	0.65	0.90	0.87

The forecast of the products was made according to the selected technique for the next three weeks, it was determined that the sales value of the following weeks does not vary too much despite selecting an exponential technique in some products. On the one hand, the graphs cannot be compared in volume since the units vary, the results are shown in Figure 3**.** On the other hand, it was observed that the weekly sale tends to be linear, this managed to facilitate the construction of the inventory policy.

Table 3 shows the forecast of the products of type A for the next three weeks in the respective units.

Table 3. Weekly forecast of type A products

Forecast	Egg "La calera" (unt)	Rice "Faraón" (Kg)	Rice "Caserita" (Kg)	Noodle "Molitalia" (unt)	Oil "Primor 1 litro" (unt)	Oatmeal "Tres ositos" (unt)
Week 1	73.0	16.90	7.41	9.17	5.87	4.80
Week 2	79.3	18.20	9.08	13.00	6.47	5.60
Week 3	76.5	17.40	10.22	13.67	6.67	4.60

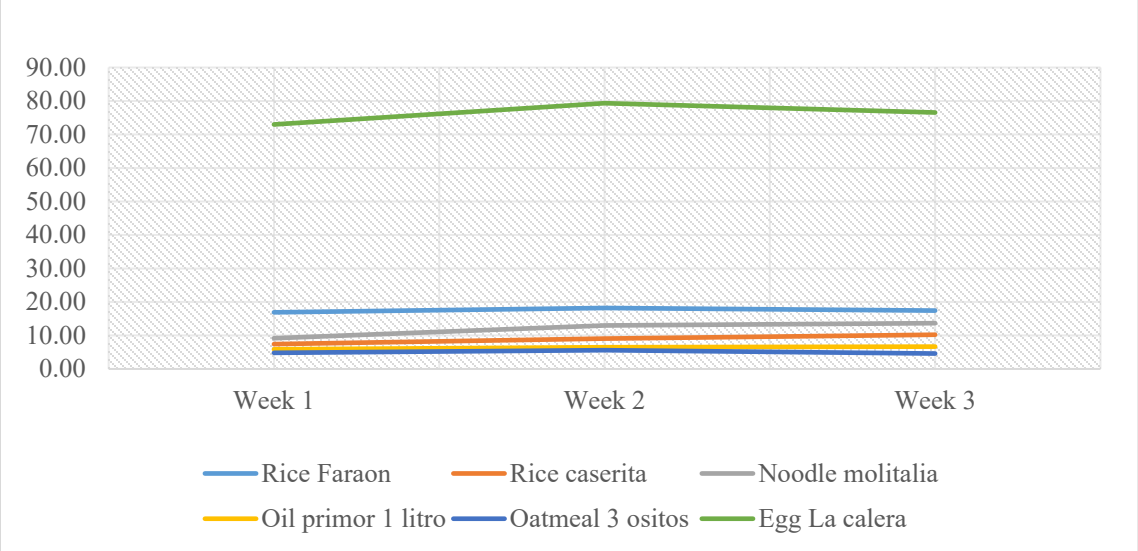

Figure 3. Graphical summary of sales forecast for Type A products.

Three techniques were used to determine inventory policy, two of them use a growth point as an indicator; The result that was developed indicates different days of purchase for the products; The restriction of suppliers to supply or place orders was considered. The different techniques were compared, to choose the appropriate policy, also considered the minimum volume of purchase of the products, in bag of 49kg, in boxes of 20 units and in packages of 12 units.

5. Discussion of results

The results obtained for the approach of the inventory policy of the products with the highest demand for a grocery warehouse exposed the feasibility and flexibility of the methodology applied and exposed above. It was also noted that limited daily sales record information may limit the optimal approach to inventory policy; However, the analysis carried out was validated by experts and was defined as an initial and useful proposal for the entrepreneur.

The first phase, which consisted of the sales record, was supported by an Excel workbook with Macros programming and the easy adaptation and handling of the tool by the winemaker was verified. Although the macro programming tool lacked sophisticated functions such as the Weka software where the multiple variables that influenced the forecasting of a research data record were selected (Madariaga Fernández et al. 2020), the entrepreneur was able to receive the necessary, feasible and economical tool for their registration and forecasting purposes.

For the application of the ABC classification in the second phase, a double analysis was carried out to segment and identify the products with the highest demand in the warehouse, based on the three-week sales record in June. In this way, as observed in Figure 2, the grocery family was identified as type A, where six mass consumption products as indicated in Figure 3 will be subject to study: in other words, demand behavior.

In addition to determining the products with the highest turnover, the ABC classification made it possible to assign an identification code for a specific product; In this way, the classification of the products was more specific in quantity, brand, and description. Then it was defined that six items: the Primor oil of one liter, the egg the lime, the Pharaoh rice, the Molitalia noodles of 500 gr., the Caserita rice and the oats Three bears of 250 gr. accumulate almost 80% of the sales made in three weeks. The nature of the business of a grocery store differs from a wholesale distributor due to the volume of sale and the unit of sale of each product as observed in the study of a Colombian company where multiple products of variable demand are marketed that in addition to sales analyzes the movement and importance (Méndez Giraldü and Lopez Santana 2014).

In the third phase, the comparison of the standard deviations of the forecasting techniques for each of the six products was carried out, where it was found that the apparent constant nature of sale in a winery differs by the type of product; then, as observed in Table 2, half of the products with the highest demand have a lower MAD with the exponential smoothing method; These products presented a behavior with little variability and few historical data; on the other hand, other methods were identified such as Winters and moving average that adapted to the La Carela egg and Caserita rice respectively, which presented a seasonal behavior.

Table 3 showed the specific sales forecast for each product in weeks, where a value of 0.6 was estimated for the error in one of its perishable products; compared to the work carried out for the forecast of perishable products of a Spanish distributor that handled for the evaluation of daily error a value of approximately 7 (Contreras Juárez et al. 2016). This difference could have several reasons such as the volume of sales in the historical record, the period of analysis or the random nature of the product.

In the last phase, three planning techniques were applied to analyze the most suitable policy for the grocery store.

P1 – Egg "La Calera"

The most suitable inventory policy for eggs is the purchase of 154 units or 4 egg packs through the EOQ method, by which the acquisition was planned on days 1 and 14. This could be summarized as the purchase of 4 egg packs every two weeks.

1. P2 – Rice "Faraón"

The most suitable inventory policy for Faraón rice is the purchase of 13 kilos of rice through the EOQ method, through which the acquisition was planned on days 1 and 16. This could be summarized as the purchase of 13 kilos of rice in each week.

2. P3 - Rice "Caserita"

The most appropriate inventory policy for Caserita rice is the purchase of 21 kilos of rice through the EOQ method, through which the acquisition was proposed on days 1 and 16. However, it was possible to purchase a bag of 42 kilos of rice for the month.

3. P4-Noodle "Molitalia"

The most appropriate inventory policy for Molitalia noodles is the purchase of 30 units through the EOQ method, through which the acquisition was proposed on days 1 and 15. This could be summarized as the purchase of packages of 10 units of noodles each week.

4. P5-Oil "Primor 1 litro"

The most appropriate inventory policy for one-liter oil is the purchase of 22 units through the EOQ method, through which the acquisition was proposed on days 1 and 18. This could be summarized as the purchase of 3 boxes of 7 units of oil of one liter each month.

5. P6-Oatmeal "Tres Ositos"

The most appropriate inventory policy for Tres Ositos oats is the purchase of 26 units through the EOQ method, through which the acquisition was proposed on days 1. This could be summarized as the purchase of 1 pack of 12 units of oatmeal every two weeks.

Table 4 shows the results of the techniques applied for the six selected products.

Table 4. Type A Product Inventory Policy Summary

	P1 - Egg "La Carela"			P2 - Rice "Faraón"			P3 - Rice "Caserita"			P4 - Noodle "Molitalia"			P5 – Oil "Primor 1 Litro"			P6 - Oatmeal "Tres Ositos"		
Day	Silver Meal	MCU	EOQ	Silver Meal	MCU	EOQ	Silver Meal	MCU	EOQ	Silver Meal	MCU	EOQ	Silver Meal	MCU	EOQ	Silver Meal	MCU	EOQ
1	45	45	154	10	10	40	4	6	21	9	7	30	5	6	22	4	4	26
2																		
3																		
4							4									6	5	
5				10	10			4			10		3					
6	71	53												7				
7										17							4	
8							5						6					
9				10	10			5			7					5		
10		72																
11							5							7			4	
12	54										12		4					
13				10	10											4		
14			154					6		10								
15							5					30					4	
16	33	60				40			21				5					
17				10	10						10			7		5		
18							6	6		8					22			
19	37												4				3	
20				10														
21																		

6. Conclusion

The inventory policy was satisfactorily constructed; when applying the techniques presented after applying the techniques such as Silver Meal or the MCU in an annual range or in a time ballast, the minimum cost indicator can extend or reduce the number of days, this can happen on holidays or holidays, also, the EOQ technique indicates a high volume of sales, which prevents accumulating the purchase quantity since there is a storage limit due to the space of the warehouse, in conclusion, the inventory policy must be carried out with a monthly or quarterly anticipation for the products sold. Likewise, the application of an inventory policy generates a growth potential in the volume of sales, being the cost of this method accessible to the winemakers, in addition, the methodology used in the study can be replicated, to carry out the inventory policy of all products and build a systematized network for food inventory.

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