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Caso de Estudio en una Organización sin Fines de Lucro.

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Hacia la Mejora del Manejo de Inventarios: Un Caso de Estudio en una Organización sin Fines de Lucro

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Improving Inventory Management: A Case-Study in a Non-Profit Organization

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Abstract

Nowadays, companies around the world, even non-profit ones should keep control of their operations and make improvement efforts in order to remain competitive in a highly demanding market. One of the relevant operations within an organization is the supply chain management, where a significant portion of total costs is associated, specifically the ones relating to inventory management. This paper presents a case of study focused on the inventory management of a nonprofit organization, particularly in one of the bookstores that belong to this organization located throughout Latin America. The actual system and policies for inventory management are analyzed along with the purchasing decisions. A root cause analysis of the principal problems in inventory management is presented, followed by an improvement plan. This plan is compounded by two stages: first, a centralized system for the control of inventories is implemented using available technology combined with Statistic Control Charts; second, a technical forecasting method is employed to help in the decision making process of purchasing. And an inventory management policy is proposed, with a particular focus on the key items sold by the bookstore. Results were validated through interviews with the actors of the process.

Keywords
Inventory Management, Bookstore, Control Chart, Latin America, Forecasting

1. Introduction

Policies for inventory management refer typically to three questions: 1) how often the inventory should be revised, 2) when to place a new order, and 3) how much to order [1]. However, significant differences are observed when addressing raw material inventory or finished goods inventory [1]. The present work will take in account finished goods inventory management of a bookstore, which is part of a nonprofit organization called Lazos de Amor Mariano.

The organization faces two complications when dealing with inventory management. First, the estimation of the demand is not part of the strategic planning of the organization. Second, in the last years, there have been errors every month in the review of inventories, due to mismatches between the physical inventory and the digital one. Therefore, two problems are evident in the management of the inventories in the bookstore. The first problem, responds to purchasing the right quantities of the items, at the right time, in order to be able to satisfy the customer demand and minimize annual total costs. Meanwhile, the second problem corresponds to the non-defined procedures used for revising the finished goods inventory that is held in the bookstore. The first problem results in lost sales for the bookstore, whereas the second problem translates to an inefficient management of the assets in the organization. After all, both problems result in less revenue for the bookstore. Moreover, the organization actually has approximately eight thousand dollars held in inventory; which is a lot, considering the size of the bookstore. This value represents 19% of all the sales and 61% of the revenues of the bookstore, in the last year.

The main purpose of this paper is to analyze the actual procedures and indicators of the bookstore in order to propose, and implement improvement initiatives to the processes of estimating demand, inventory management, and reviewing the inventories. First, the study will start with an extensive literature review of what has been done when considering the best policies for inventory management, finishing with an approach of Latin America and inventory management in bookstores. Then, it will apply a methodology providing a brief introduction of the same about the tools used and how the data was collected. Third, the study will describe the analysis made for the estimation of the demand process, inventory management, and inventory reviewing; proposing best methodologies and procedures. The main tools implemented in the study include a technical forecast for estimating the demand, an inventory management model and a statistical control chart for the inventory reviewing. The main contribution of this paper is presenting a case study analysis within inventory management, using quality control, forecasting and inventory management tools, in order to, estimate the demand, manage the inventory and review the stocks in a non-profit organization with economical and human limited resources. Also, the Solver tool of Excel was used to find the best constants in the forecast model, minimizing its error, by combining linear programing with a forecast model. Moreover, an inventory management policy is proposed giving criteria about how much to order, and when to place an order minimizing the total annual cost. Finally, a statistical control chart is proposed for reviewing inventories, which will allow the organization to have a better management of the assets and a higher liquidity.

2. Problem Statement

The non-profitable organization "Lazos de Amor Mariano" is facing three main problems when referring to inventory management in its bookstore, these problems were discovered after a meeting held with the managers of the bookstore. First, lead times when delivering orders to customers in other cities of Ecuador take from 10 days to 14 days. Second, there is not a technical model for estimating the demand; the purchases are done based only in the experience of the managers. Third, month-to-month, there is a significant mismatch between the digital inventory and the physical one. Between all the problems two were chosen for this case study: the problem for estimating the demand and creating a purchase policy, and the mismatch of inventories. The demand problem drifts in lost sales because customers not always find what they are looking for; consequently the purchase is not made. On the other hand, the mismatch of the inventory results in a mishandling of the finances in the organization; because there is lot of money saved in stock instead of having a better liquidity. Due to the large amount of items the bookstore manages, the case study will focus in only two items, which represent 60% of the total revenues to the organization, the item LV-15 "Totus Tuus", and the item LO-38 "Sin oración no hay salvación". After proposing a forecast, a purchase model and a tool for reviewing inventories, the inventory management improves considerably.

3. Literature Review

3.1 Importance of Inventory Management

Nowadays, for any company having products available for their customer is as crucial as developing the product itself [2]. As Lee and Chung [3] exposed in their study, fulfilling the customers' needs by managing inventory properly has become one of the most important operations activities among companies, and a source of profit. Noticeably, making the product available for purchasing is directly aligned to the profit of any organization. Following Michalski [4], if a purpose of a firm is to maximize its value, inventory management should also contribute to that goal. Achieving this is not so complicated because, as Pong and Mitchel [5] proved, there exists a positive relation between financial performances of an organization and the improvement of inventory; and at the same time, they emphasized that performance also depends on a successful implementation of inventory control. Based on the 17^{th} Annual State of Logistics Report [6], logistics cost as a percentage of the United States gross domestic product has grown to 9,5%, which is over $1 trillion spent in logistics, with approximately 33% of this cost attributed to the cost of holding inventory.

Therefore, taking care of inventory management is one of the most important concerns that a firm has in order to be profitable and remain competitive in the market. For this reason, in the industry, many of the strategic decisions involve inventory, specifically in the manufacturing sector and in retailers [7]. As Rivera, et.al showed [8], the activity of managing inventory has become a key differentiation and a competitive advantage among companies around the world; because, an appropriate structure of inventory management and policies not only affect inventory holding costs, but also the whole supply chain costs and the customer service quality, as Hanczar exposed [9]. The cost of holding inventory in the United Sates represents over $0,33 trillion. This fact was validated by McCormak [10], when he demonstrated that inventory management of raw materials, work in process, and finished goods could affect significantly the totality of the supply chain costs and performance.

Finally, taking in to account the study by Michalski [4], it is important to state that the decisions made in the sphere of inventory management are a compromise between costs of inventory and the risk of having an over stock. These costs involve: price per unit, holding inventory costs, costs of ordering, and purchasing costs [11]. These inventory decisions are mainly based on the time and quantity of order, cost of holding inventories and other things that help decide the ordering policy [7].

Large amounts of stored products in warehouses can reduce firms' efficiency and increment costs [23].

3.2 The Approach of Time Series Forecasts

One of the most used approaches for solving the inventory management problem is forecasting through time series; because this is the base for determining the inventory level. As Hai et al. exposed [12], it is very important to forecast the market changes in order to maintain an inventory level that is able to satisfy completely customers demand. Basic time series forecast methods are based on statistics and probabilities theories [33]. One of these is the exponential smoothing method; that is attributed to Brown [34]. This forecast method is currently one of the most popular approaches. Also, Brown [34] introduced the importance of the analysis of errors when using a time series forecast method. However, the interest in using a forecast to estimate the demand or the changes in the market started just in the XX century [35-38]. Nowadays, forecasting plays a central role when it comes to efficient inventory management, providing valuable information about expected future directions [39] in order to reach two main objectives: minimize inventory holding costs, and avoid missed sales [40]. Moreover, Fildes and Beard [41] found that a better accuracy in forecasts leads to worthwhile savings for the firm. On the other hand, large forecast errors end up in high stock levels and poor customer service. It is important to take in account what Lee and Everett [42] explored about the cost impact of forecast errors. They [42] came upon the fact that higher forecast errors might not always result in higher total costs. The impact of the forecast error is given by the structure of the firm; if the firm has a more complicated structure, the impact of the forecast will be higher [42]. However, it is indisputable that forecasts are really important when it comes to an effective inventory management.

Doganis et al. [39] presented a framework for inventory management in the supply chain based on a forecasting method combined with a Model Predictive Control (MPC). They [39] used linear and nonlinear forecasting, showing that higher forecasting accuracy leads to improvements in control performance. Mascle and Gosse [40] minimize inventory holding costs, and avoid missed sales by setting up a sales forecast and integrating this information to the inventory management process of a huge quantity of different products. Mascle and Gosse [40] developed an exponential smoothing forecast, finding out that historic data is crucial to the accuracy of the forecast. However, Kurawarwala and Matsuo [43] developed a model for products that exhibit seasonality, which can be used to forecast sales in absence of sales history. They [43] used the knowledge of total life-cycle sales, and the attributes of the shape of the curve to generate short and mid-term forecasts. Meanwhile, Winters [44] presented an exponentially weighted moving average forecast, for predicting the sales in a shop, which manages thousands of products. His results [44] showed that using coefficients in a moving average gives better accuracy and less variation than a traditional moving average forecast. Furthermore, Nahmias [11] extended the forecasting methods taking in account information of lost sales to estimate the demand of future periods, making use of probabilities theories. Moreover, Ye [45] used forecasts to estimate the cost of crude oil and decide the inventory levels of petroleum.

In addition, Downing et al. [46] presented a study based on inventory planning using forecasting, for the maintenance of Chinook helicopters in Boeing enterprises. Dowing and his team demonstrated that in this case, it is better to examine the demand pattern of each component separately, than the whole demand together. Furthermore, Tiacci and Saetta [47], evaluated both demand forecasting methods and stock control policies dealing with multiple suppliers, varying demand, and multiple items. Their results showed that when deciding among multiple forecasting methods; the choice based on simulation would differ from the one made on traditional measures of errors. Additionally, Toktay and Wein [48] proposed a forecast based on a stock policy, providing insights of the interaction between: safety stock, production capacity, planning horizon, and forecast quality; concluding that variation of demand depends more of the capacity buffer than the inventory buffer. Finally, Korpela and Markuu [49] used an approach to estimate demand using a forecast that takes in account quantitative and qualitative variables. The proposed model [49] gives the opportunity to use criteria by more than one person; it documents the whole procedure, runs a sensitivity analysis, and can be communicated to other people for a consensus.

3.3 Different Approaches for Solving the Demand Problem

Dong and his team [12] exposed that basically two problems make inventory management complicated: delays and uncertainties. As Vidal mentioned [13], two typical issues derive from these problems: the over stock or the stock out of products: “We always have more of something that is not sold and lot of stock out of something that customers required”. Betts [14] found that, to deal with these problems inventory managers generally held safety stock in order to satisfy demand that cannot be met in a current period. However, the size of the safety stock; depended on the interest that a manager had: maintaining a particular level of service or minimizing inventory-holding costs [14]. According to Ketkar and his team [7] the rationale for maintaining an inventory level is to be able to manage variation in price change, take advantage of the economies of scale, and manage uncertain changes in the supply and the demand to avoid lost sales and backorders [15]. On the other hand, Betts [15] demonstrated that economic and practical worries show that it is not feasible to hold sufficient stock to guarantee a 100% level of service. Additionally, the problem of inventory lot sizing has been studied and integrated with carrier selection or supplier selection and procurement, to minimize the total logistic and inventory holding costs [16-19]. For this purpose Ketkar [7] and his team exposed that the most critical and important decision, is the development of efficient order policies. Chase, Nicholas, and Jacobs [20] defined, inventory system management as a group of policies that maintain and control inventory levels, by setting standards of when to replenish and send orders.

Aimed at setting the best inventory policies and levels of inventory, many authors used simulation-based models as a popular approach. Zheng, Gosavi and Lin [21] used a simulation based on the newspaper vendor problem approximating this one to a Markov Chain simulation, for best replenishment quantities. Furthermore, Betts [15] developed a simulation model based in Markov Chain that is able to set directly an inventory service level with a high degree of accuracy. Another approach, using a shortfall distribution, is given by Betts [14] to estimate stochastic demand. Dong et al. [12] found that the Predictive Control Model can effectively control the inventory restricted to an uncertain and dynamic demand. Finally, Abuhilhal, Rabadi, and Sousa-Poza [22] proposed a model for choosing the more cost-effective inventory control system based on simulation experiments; a reduction of at least 17% in the total costs was achieved. A different approach, using factor analysis was carried out by Liang [23], she concluded that introducing quantity and frequency as factors in the model achieved an accuracy of 66.3%.

Another popular approach for solving the problem of inventory management is the use of operation research to determine the levels of inventory and minimize costs. Purohit et al. [24], using integer linear programming developed a model that considers ordering cost, holding inventory cost, and purchasing cost to minimize the total inventory cost. Also, Purohit et al. [24] encountered that cycle service level and the variation of demand affect directly the total cost. Additionally, Lee et al. use a mixed integer linear programing model to address the problem of inventory management on an oil refinery [25]; and found out that there exists economic potential trade-offs involved in the optimization. Furthermore, Coelho and Laporte [26] developed an optimized target-level model, based on a mixed-integer linear program problem, which yields a less costly solution than a classical order up policy.

Other popular approaches for the inventory management problem are the classical algorithms [27], such as, Economic Order Quantity (EOQ), Period Order Quantity (POQ), least unit cost, least total cost, least period cost, and the Wagner-Whitin Algorithms [28]. Samak and Rajhans [28] conducted an investigation that carried out an analysis of cases; according to these authors, the Wagner- Whitin algorithm gives the least total annual inventory management cost in all cases. Moreover, Padmanabham [29] introduced the backlogging criteria for these models as a function of orders already backlogged, concluding that this is a significant factor to the models of inventory which are based in the EOQ. Finally, Song et al. [30] expand the EOQ model taking in account lead times and lot size, and giving the opportunity that the buyer and the vendor negotiate and cooperate with each other.

In some consumer products the purchasing levels of the consumers may be influenced by the stock levels [29], this phenomenon is known as "stock dependent consumption rate" [31-32].

3.4 Inventory Management in Latin America

Literature about inventory management in Latin America is very scarce compared to the United States of America or Europe. In Colombia, Gutiérrez and Jaramillo [51] have made a review of the different inventory management software that exists. They [51] demonstrated that the tendency of the software now a day is the management of inventories and accountability together. Gutiérrez and Jaramillo [51] also highlighted that there are little software which propose inventory management as a strategic business decision. Additionally, Hernández, Velasco and Amaya [52] proposed a multi-level model for inventory management of medicines in a hospital, which is located in Colombia, with one central warehouse and four sales point in order to minimize costs, while maintaining the same level of service. These authors [52] used probability theories to estimate demand and coordinate the central warehouse with the four pharmacies regarding inventory levels, order quantities, and lead times. On the other hand, in Mexico, Izar, Ynzunza and Sarmiento [53] developed a model for minimizing inventory management costs based on this hybrid method, which includes lost sales and the effect of savings for purchasing larger quantities. They [53] developed policies, based on a hybrid method, for quantity of order and when to place the orders. Finally, Arango and Hasbún [54] evaluated different alternatives of forecasts deciding on which is the best one, based on the distribution and the values of the errors. The model estimates the demand, in order to make decisions about inventory management and production planning; finding out that the knowledge of the demand influences directly in inventory decisions, which can lead to significantly reduce costs.

3.5 Inventory Management in bookstores

Although there is substantial literature about inventory management, there is little research on inventory management in bookstores. Powell [55] addresses the management of book selling by taking in account the production, promotion and purchasing processes, but does not take into account inventory management. Fan et al. [56] carried out an implementation of three bottom lines (economic, environmental and social concerns) in the UBC bookstore, with positive outcomes for students and the bookstore. However, these authors do not take into account the inventory management concern. Ghemawat, Baird and Friedman [57] make an analysis between Barnes and Noble and Amazon, focusing on who is the leader in online sales and why. Raff [58] describes the changes that the book industry has had in the last years and the challenges faced, focusing in Barnes and Noble and Borders. Best et al. [59], made a case study of Barnes and Noble taking into concern leadership, decreasing profit margins, and the decline of physical book sales. Only Mirghaderi [60], has made an approach to inventory management in an Iran bookstore. Mirghaderi [60] developed a database inventory system, in order to provide more control of the inventory and also gives services and facility for staff and customers of the bookstore.

4. Methodology and Analysis

4.1 Introduction

This section describes the methodology followed in this research study to analyze and propose improvements in the inventory management in a bookstore of a non-profitable organization. First, a brief history about the organization is presented. The second section will develop the problem statement. The third section describes the data mining process and its validation in order to ensure a proper analysis and a satisfactory implementation. The sections four, five, and six will explain the different tools used in the research for: estimating the demand, knowing how much to order, and reviewing inventories in order to propose improvements for the nonprofit organization. The research will present the implementation of a forecast, an inventory management policy and a control chart. The results will be presented in a last section.

The organization Lazos de Amor Mariano was born in Medellin-Colombia, in the 16th of July of 1992. The organization currently has presence in nine countries and more than one hundred and twenty cities in South, Central and North America. In each of these cities the organization owns a bookstore. The current project is developed specifically in Lazos de Amor Marino’s bookstore in the city of Quito-Ecuador, where the organization has had presence for more than eight years. The bookstore has one warehouse, three sales points, five suppliers, and manages more than 476 items for sale. Two people manage all the processes in the bookstore, with the support of two more people for the operational activities. Nowadays, the bookstore does not have any defined policy for inventory management, order quantities or for revising the inventories between the warehouse and the sales points.

In order to have a better understanding of how the bookstore operates, two diagrams were developed: a Supplier, Inputs, Process, Output and Costumer (SIPOC) diagram [61-63] (see Figure 1), and a Value Chain [62] (see Figure 2).

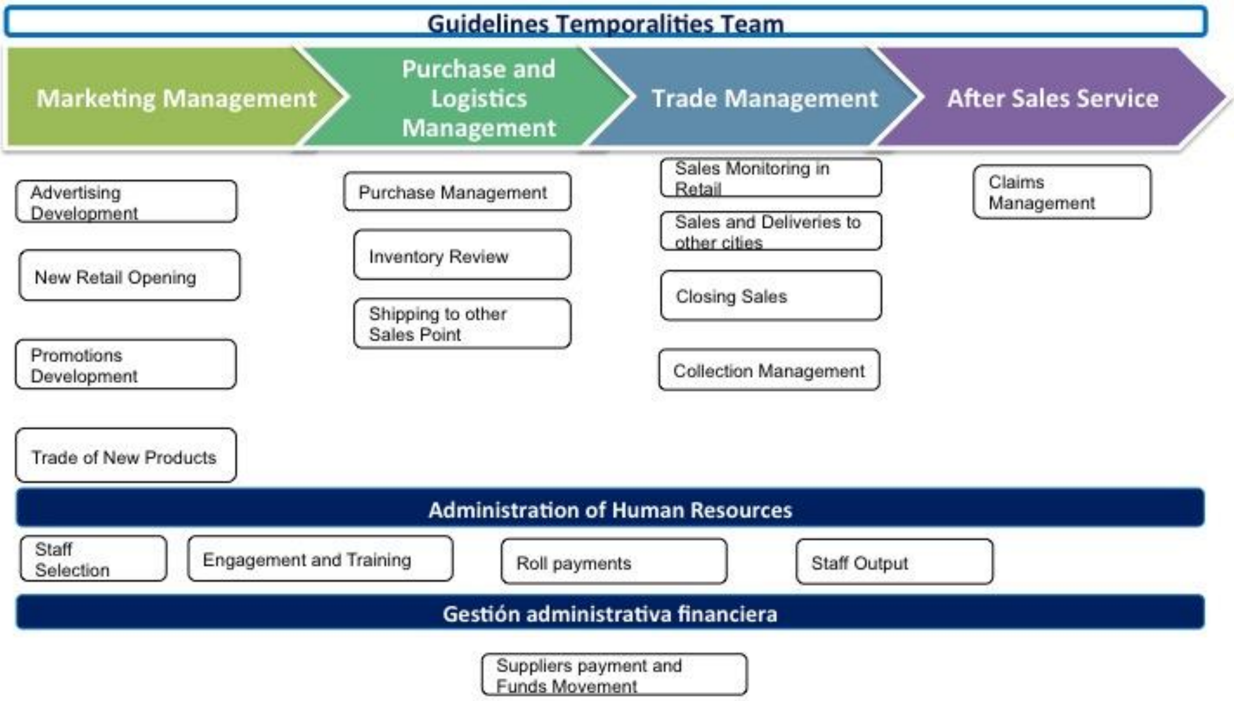

Figure 1: High Level Value Chain

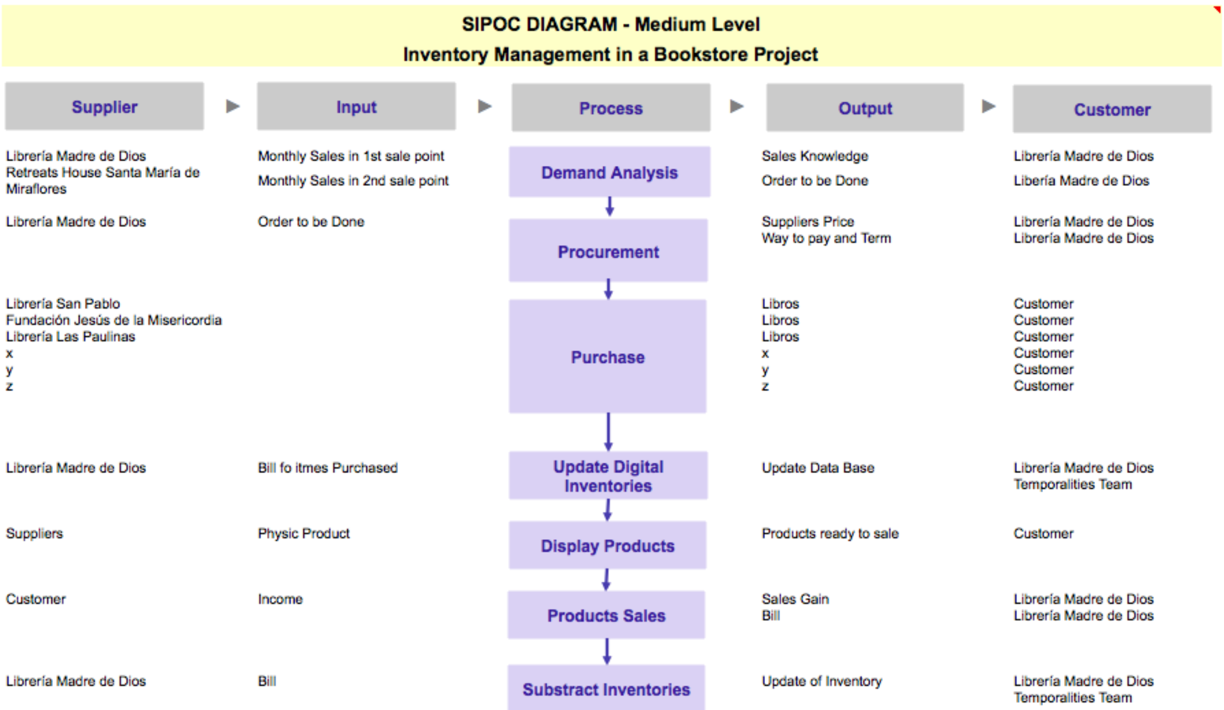

Figure 2: SIPOC Medium Level

4.2 Problem Statement

The organization is facing three problems concerning to inventory management. These problems were found when having a meeting with the managers of the bookstore:

- Demand estimation. No technical approach exists to estimate demand; when going to buy items from suppliers the procurement and purchased are done based on the experience of the people. Therefore, lost sales exist in the bookstore for not having items that customers require.
- Lead times for delivering products in other Ecuadorian cities. It takes more than a week to make the final delivery of the products to a customer, which is an excessive amount of time after taking in account the short distances from Quito to other cities.

- Mismatch in the inventory during every monthly review. When reviewing the digital inventory versus the physical inventory of the two sales points, it never matches. Furthermore, the mismatch is huge, more than one thousand dollars of inventory does not match with the physical one. This represents 29% of the average month sales in the bookstore.

In order to decide the problems in which to focus, a prioritization matrix was done [61] (see Table 1) based on economic, feasibility, impact on the organization, and alignment to the methodology proposed. Based on the prioritization matrix (see Figure 3 & Figure 4) two problems were chosen for conducting this research: the demand estimation, and the review of the inventory.

Table 1: Projects Prioritization Matrix

		Return over Investment	Client Satisfaction	Alignment with Strategy	Impact	Time	Methodology	Other Efforts in course	Resources Availability	Previous Projects	Practicality	Measure Benefits	Total
#	Peso	3	5	3		4	4	2	3	3			
1	Lead Time	3	3	3	3.0	3	4	5	1	0	2.6	5	38
2	Demand Estimation	5	4	5	4.5	5	3	1	4	0	2.9	4	52
3	Inventory Mismatch	5	5	5	5.0	5	5	4	4	0	3.8	5	94

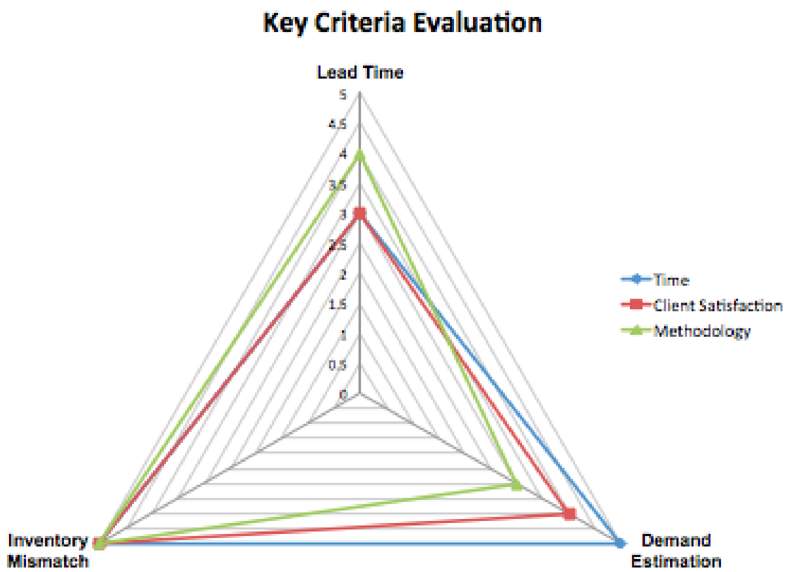

Figure 3: Key Criteria Evaluation

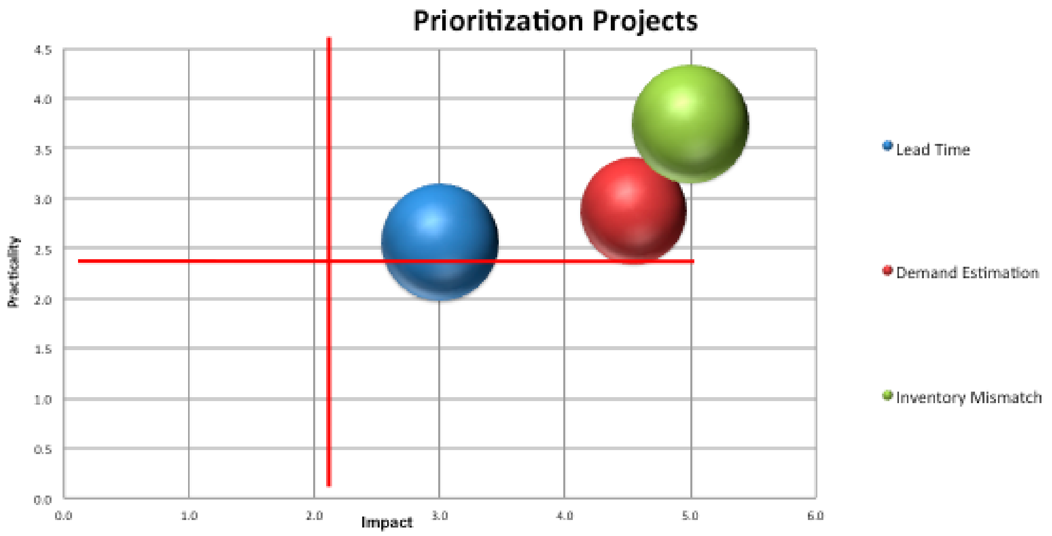

Figure 4: Prioritization Projects

Despite these two problems being defined, the bookstore manages more than 476 items, which leaves the problem little bounded. Therefore, a Pareto Chart [61,63,64] was developed for narrowing the problem to the items that provide the highest revenue to the organization (see Figure 5).

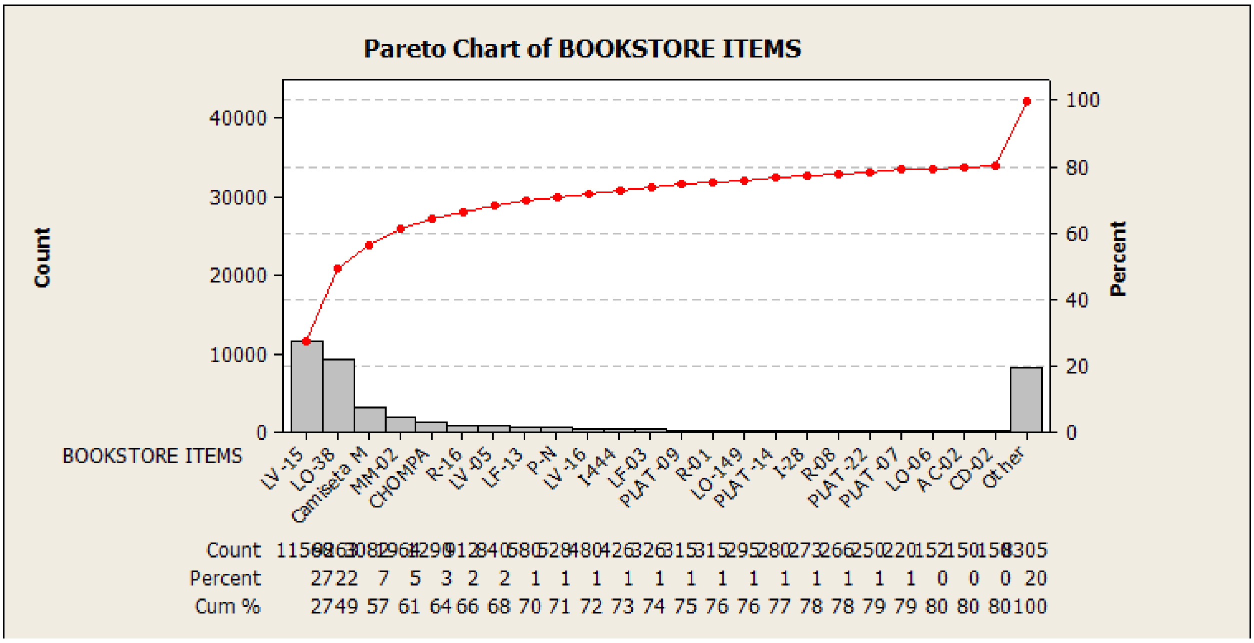

Figure 5: Pareto Chart of Items sold in Bookstore

The Pareto Chart developed by the research suggested to focused on two items that the bookstore sell, because between these two items, 60% of the annual revenues are covered. The items are two books: “Totus Tuus” and “Sin Oración no hay Salvación” with their respective codes “LV-15” and “LO-38”. Currently, the bookstore does not use any technical tools to estimate the demand; consequently the purchases are done based on the experience of the managers, which leads to lost sales because the customers do not always find what they want to buy. On the other hand, there is a mismatch of inventory between the digital data and the physical inventory. This problem results in a mishandling of the finances, because the real quantity of money that is held in the physical inventory is unknown by the managers. Both problems are directed linked to the financial profit. Therefore, by solving both problems it is expected that the inventory management will improve considerably.

4.3 Data Collection

The data analyzed corresponds to the bookstore’s total sales during the last twelve months. Data was collected from the bills corresponding to each of the last twelve months. With these data, as said before, a forecast model was proposed; then with the result of the forecast an inventory model was developed in order to establish a purchase politic. On the other hand, for the mismatch of inventory there was not quantitative data because managers did not register the monthly mismatch that came from the review of inventory. However, meetings held with managers revealed that the mismatch is truly a problem for the inventory management of the bookstore. Currently, the physical inventory held in books and other items that are sold by the bookstore exceed $ 8,000 USD and inventory does not match the virtual one stored in the database. This makes the inventory mismatch a great improvement opportunity. An analysis to implement a control chart to monitor the mismatch will be presented in a further section.

4.4 Forecasting Model

For the problem of estimating the demand, first a time series forecast model was proposed. Eight different types of forecasts were run in order to decide which had a better fit when predicting the demand of the two items analyzed (see Table 2 & Table **3**). The decision of which forecast to use was taken based on the errors of each one, following Arango and Hasbun [54]. As said before, the case study only has data for a year, that is twelve months. Therefore, the time series forecasts used are based on the Fixed Model Time Series because for using an Open Model Time Series, such as, ARIMA or Box-Jekins, following Mentzer & Moon [65] a minimum of 48 periods of data should be used. Moreover, Nahmias [33] recommend at least 72 periods of data for using an Open Model Time Series. However, this is not a problem because as Mentzer & Moon mention [65], sophisticated techniques take considerable amount of data but do not produce any better results than simpler techniques. Also, Nahmias [33] recommend the use of simple time series methods for inventory management because severe errors are minimized when using these simple methods.

Table 2: Forecast Errors for Item LV-15

	ME	MAE	MAPE	MSR
Moving Average (2)	2.8	48.5	1.183717158	3717.75
Moving Average (3)	3.666666667	42.03703704	1.064756401	2776.135802
Regression	4.73695E-15	35.05128205	0.825410626	1778.183761
Exponential Smoothing	5.017738489	26.80955467	0.60183147	1023.210677
Holt	1.975609755	15.11590456	0.336272607	428.862193
Dynamic-Holt	2.737233382	24.99823542	0.599461949	972.441477
Holt-Winters	-8.004672247	59.71910983	1.274707825	5440.379348
Winters	-22.00520377	77.56406996	1.985926679	10031.7177

Based on the analysis of the errors listed above for the methods proposed for forecasting the sales of item LV-15 (see Table **2**), the best forecast is given by the Holt Method. For this item it is logic to use a Holt Method forecast because when analyzing the demand a small trend and seasonality are shown (see Figure **6**). For the constants of the method an *alpha* of 0.6 and a *beta* of 0.2 were used. When referring to the level, the forecast gives more weight to the actual data, while when referring to the trend; it gives more weight to past data.

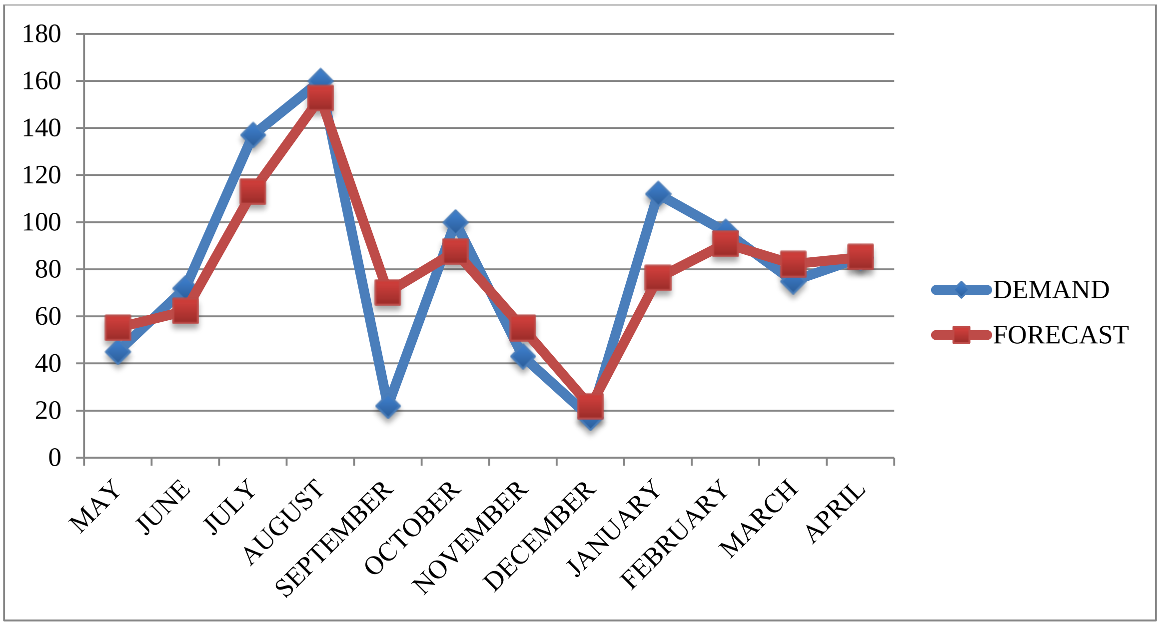

Figure 6: Graphic of the Demand and Forecast based on the Holt Method for Item LV-15

Table 3: Forecast Errors for Item: LO-38

	ME	MAE	MAPE	MSR
Moving Average (2)	64.35	85.95	2.801124551	17129.875
Moving Average (3)	89.77777778	115.8518519	4.014577595	26324.34568
Regression	0	95	9.800230855	13129.94172
Exponential Smoothing	43.00068479	56.36992406	1.79537178	7609.233243
Holt	-36.01230506	36.01230506	0.37389029	1334.779465
Dynamic-Holt	15.34489049	68.61642424	3.686937598	7555.863664
Holt-Winters	6.601380191	94.13365316	4.579264103	10396.93347
Winters	10.35967116	73.18682794	1.769693041	7959.656309

In terms of the sales item LO-38, based on the analysis of the forecasting errors for the methods proposed (see Table 3), it can be conclude that the Holt Method gives the best forecast. For this item it is logic to use a Holt Method forecast because when analyzing the demand a trend is shown (see Figure 7). For the constants of the method an *alpha* of 0.9 and a *beta* of 0.05 were used. When referring to the level, the forecast gives more weight to the actual data, while when referring to the trend, the forecast gives more weight to the past data.

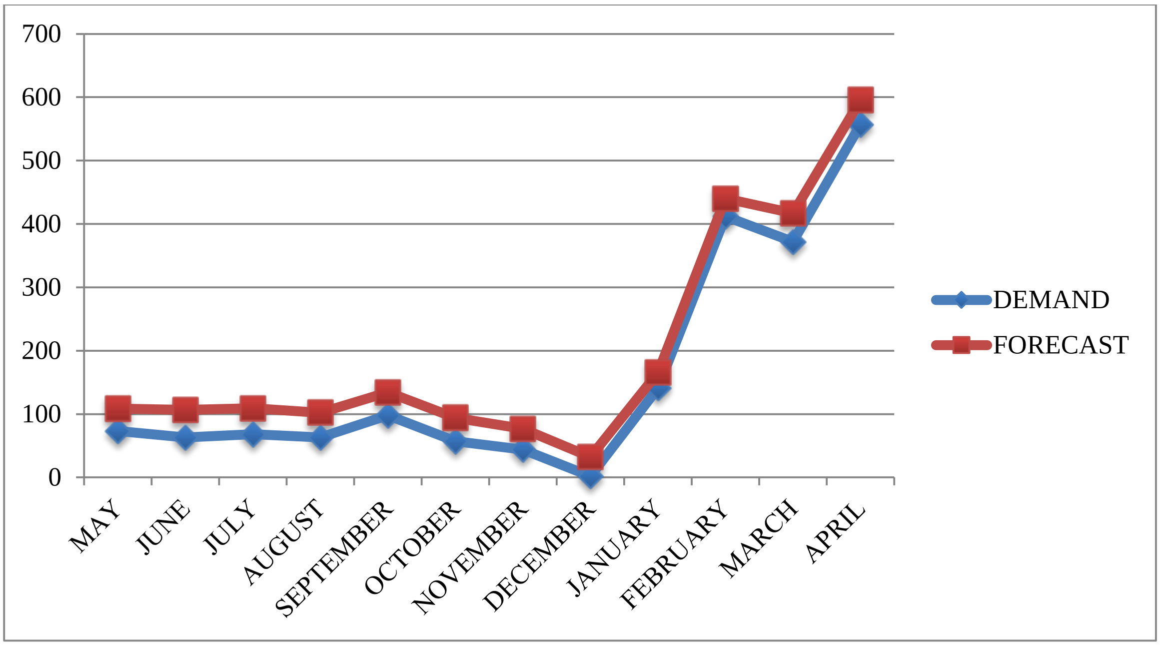

Figure 7: Graphic of Demand and Forecast based on the Holt Method for Item LO-38

4.5 Purchase Policy

With the forecast of sales of both items the case of study has enough information to develop a purchase policy in order to satisfy the previously estimated demand. It is important to take in account the following considerations that the organization has in terms of inventory management. These considerations are listed below:

- Planning Horizon: Finite
- Number of Items: Single Items
- Order Quantity: Variable
- Frequency of Review: Periodic
- Demand: Deterministic Dynamic
- Unsatisfied Demand: Not Allowed

With these considerations a model based on a Wagner Whitin Algorithm [28-29] is developed, this model is able to find the minimum annual cost via optimization. The main change the Algorithm has is that the model developed includes a safety stock, which takes into account the variation of the demand as well as the lead-time. The safety stock is calculated based on the variation of the forecasted demand, and a defined level of service of 90%. With this safety stock defined the demand is ensured to be satisfied. Also, the values obtained by the forecast were increased by 2% due to the estimated growth in sales, taking into consideration all these inputs the Wagner Within Model was run reaching a total inventory management cost of $9 378,79 for item LV-15 (see Table 4), and $7 547,69 for item LO-38 (see Table 5). These total costs include the setup cost to place an order, the unit cost of purchasing, and the inventory holding cost. Between both items the expected revenue is $ 8 868,01.

Table 4: Demand Forecasted, Orders month-to-month and Total Year Cost for Item LV-15

PERIOD	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
DEMAND	78	92	84	87	60	65	115	156	71	89	56	22
ORDER	**99**	**93**	**84**	**87**	**61**	**65**	**116**	**156**	**72**	**89**	**56**	**22**
ENDING INVENTORY	21	22	22	22	22	21	22	22	22	21	22	21

Setup Cost	$300.00
Procurement Cost/Unit	$8,500.00
Holding Inventory Cost	$578.79

Total Cycle Cost	**$9,378.79**

Table 5: Demand Forecasted, Orders month-to-month and Total Year Cost for Item LO-38

PERIOD	1	2	3	4	5	6	7	8	9	10	11	12
DEMAND	169	449	425	607	111	109	111	104	137	96	78	33
ORDER	**459**	**594**	**524**	**638**	**112**	**91**	**73**	**54**	**20**	**28**	**0**	**0**
ENDING INVENTORY	290	436	534	565	566	549	510	460	343	275	197	164

Setup Cost	$250.00
Procurement Cost/Unit	$6,482.50
Holding Inventory Cost	$815.19
Total Cycle Cost	**$7,547.69**

4.6 Control Chart for Inventory Control

For the inventory mismatch, a P control chart [67-69] was proposed in order to have a better control and management of the inventory in the bookstore. This control chart is based in the fraction nonconforming, defined as the ratio of the number of nonconforming items to the total population [67]. It is important to know that these items may have various quality characteristics examined simultaneously by the inspector [67]. As said in section 3.2, for this problem there is no quantitative data, but the use of a control chart is justified by the interviews to the managers and the money held in inventory.

When having no initial data to develop a control chart, that is, when the nonconforming *p* fraction of the process is unknown; there are two options given by the literature. First, estimate the fraction *p* from a data collection. For estimating the fraction *p*, *m* preliminary samples must be selected; each of size *n*, *m* should be at least 20 or 25 [67]. For the current research this was impossible, because one sample is obtained every week in the weekly review of inventory. Therefore, the estimation of the nonconforming fraction of the process would have been estimated 6 months later, which would have required more time, money, resources, and exceeded the scope of the present case of study. The second option when not knowing the fraction nonconforming *p* is to give a standard value of *p*, which represents a target value [67]. For the present research this option was selected, taking into account what Montgomery said: [67] in processes where the fraction nonconforming can be controlled by relatively simple process adjustments (which is the case of the review of inventories) target values of *p* may be useful. The most important consideration of taking this option is the inspectors and managers must be careful knowing that a point out of control means that the process is out of control at a target value *p* but in control at some other value of *p* [67].

With these considerations, a P control chart was proposed for the process of reviewing inventories, because as said before, value of *p* is unknown. A meeting with the managers of the bookstore was held to determine the target value of *p* for the control charts. In talking with them, they came to an agreement that the maximum mismatch should be 5% of the total population of items inspected, with this information and applying formulas the target value was found. As before, the research focused in two books, which provide 60% of the total income to the bookstore. These books are “Totus Tuus” with code LV-15 and “Sin Oración no hay Salvación” with code LO-38. For each item a control chart was proposed (see Figure **8** & Figure **9**) setting a target value of *p* based on the input of the managers. For the item LV-15 the target value was 2,9%, using sample size of 600, which was obtained based on an approximate average of the last 6 months’ stock. On the other hand, for the item LO-38 the target value of *p* was 3,3%, using a sample size of 1000, which was obtained based on an approximate average of the last 6 months’ stock.

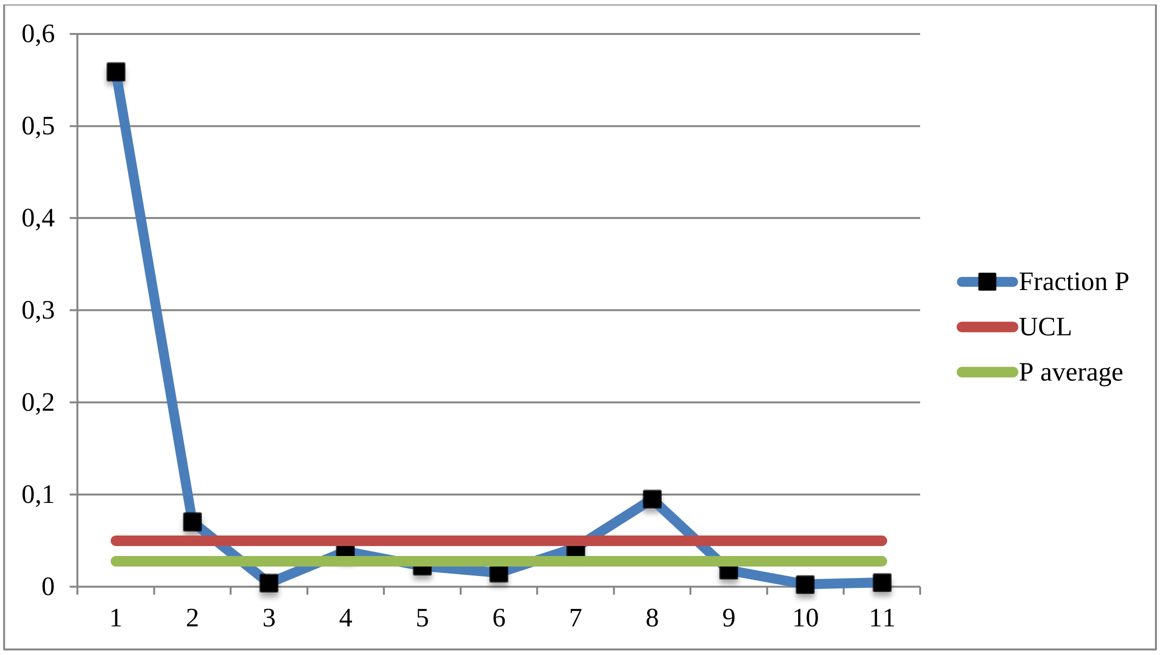

Figure 8: *P* Control Chart Item LV-15

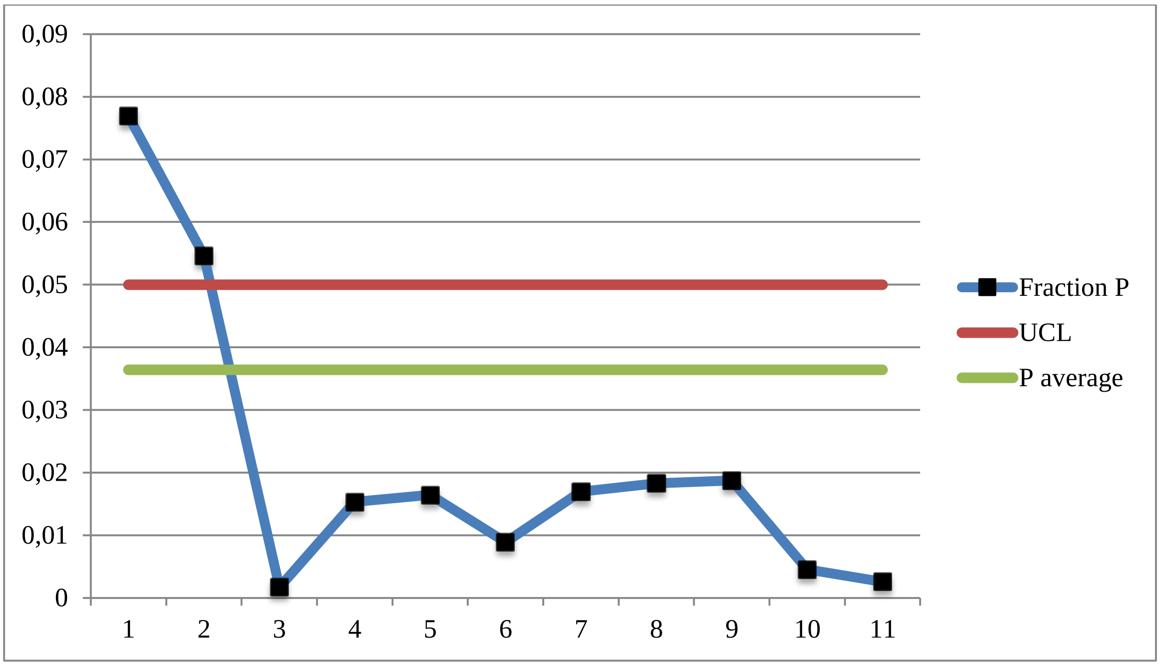

Figure 9: *P* Control Chart Item LO-38

Both Control Charts suggested that the problem of the mismatch of inventory referred to a lack of control in the process of reviewing the inventories. That is why there are points out of control in the first weeks, but when the staff noticed a more strict control was implemented they started to be more careful with the inventory management. Therefore, the charts implemented helped to have a mechanism that is able to give a more strict control in the process of reviewing inventories, and a great tool for taking decisions based on the mismatch inventory data collected.

4. Implementation and Results

This paper has applied three different tools in order to improve the inventory management in a bookstore belonging to a non-profitable organization. All the implementation has taken into account two items, which represent the 60% of the revenues of the bookstore. First, the forecast tool implemented was able to change the way the purchase decisions were taken in the bookstore. Before, all the purchases were done based on what the managers thought was going to be sold; nowadays a fixed time model series forecast [65] (Holt Method) with less than 3,5% of accuracy error is used to determine the sales in the future. Following Arango and Hasbun [54] the decision of the method used was taken bases on the minimum error. Second, an inventory management policy was developed and implemented for the two items analyzed. The past year the inventory management cost of both books ascended to an amount of $ 2 772. Thanks to the inventory policy that was implemented using the Wagner Within Algorithm, the bookstore was able to reduce the inventory management cost to $ 1 393 annually, which is greater than a 50% reduction compared to the last year. Proving what Samak and Rajhans [28] assured, the Wagner Within Algorithm is able to find the least annual costs of inventory management. Finally, the bookstore had a problem with inventory mismatch before the implementation in the reviews monthly reviews of inventory the physical inventory did not match with the one stored in the database. This problem was solved using the P control chart in order to regulate the match of inventory. Because, Pong and Mitchel [5] proved that a satisfactory inventory management must include the control of the inventories. The suggested use and implementation of the control chart has had a good result and in the last reviews of inventory, the mismatch in both items was less than 5%. A summary of the implementation and its results is presented below (see Table **6**).

Table 6: Tools Implementation Resume

	Before	*Implementation*	*Results*
Prediction Sells	Empirical	Holt Forecast Model	Accuracy Error less than 3,5%
Inventory Management	None	Wagner Within Policy	Cost reduction of $ 1 379 in inventory management
Inventory Control	Empirical Reviews	P Control Chart	Last reviews with less than 5% in mismatch

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