Inventory management: a small enterprise in the electronics sector case study

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Abstract: This work aims at developing and implementing a proposal to standardize the decision-making regarding the management of finished goods inventory in a small electronics sector company. Through this inventory management method, it is intended to improve the level of service, reducing the lack of finished goods in order fulfillment.

Keywords: Inventory management, Service level, Electronics sector.

INTRODUCTION

The efficient finished goods' inventory management represents an important factor for companies (Bucher and Meissner, 2011), especially for that look for low-cost operations (Stevenson 2014). In this scenario, the uncertainty associated with demand's forecast is an important factor for the inventory management (Giacobo and Ceretta, 2003; Bucher and Meissner, 2011), and its variation may entail low levels of customer service (Stevenson 2014). High levels of inventory can cause an increase in operational expenses. In manufacturing companies, this amount can reach until 40% of the stored items value (Ballou 2003). However, maintaining reduced inventory levels tend to reduce the customer service level, resulting in losses and damaging the company's image in the business. Thus, inventories must be managed in a balanced way to ensure a good service level to clients and profit for the enterprise (Silver et al. 1998).

Many companies use ERP (Enterprise Resource Planning) system to manage inventory, yet this practice tends to provide unsatisfactory results (Bucher and Meissner, 2011). In addition, the difficulty at the implementation of demand forecasting methods in companies (Souza et al. 2010) further contributes to the difficulty of managing inventories of finished goods. The study on inventory management is frequent in the literature. Kurawarwala and Matsuo (1996) developed a study regarding inventory management of products with short life cycle applied to the computer industry. Other studies have been conducted for inventory control of spare parts for the automotive industry suppliers (Toktay et al. 2000; Li and Kuo, 2008; Bucher and Meissner, 2011).

The aim of this paper is to develop and apply a proposal to standardize the decision-making process regarding the management of finished goods inventory in a small enterprise in the electronics sector. This study is justified by the need of small enterprises to structure the decision-making process related to production planning, inventory levels and customer service.

Currently, these decisions are intuitively taken by managers without the use of available information and a structured procedure. The available methods in the literature are too complex and with difficult operation for small enterprises; so, there is the need to adapt the available methods to reality and specific management conditions of this kind of companies.

PRODUCTION PLANNING AND CONTROL

According to Slack et al. (2009), planning and control aims to bridge the gap between supply and demand, ensuring that the processes are effective and efficient in order to attend the products and services required by customers. The planning and control of production requires changes over time. Thus, plans are divided into different levels in the planning horizon: short, medium and long term plans (Stevenson 2014).

As stated by Tubino (1999), in long term plans, it is formulated a strategic production planning as an estimate of sales, financial and productive availability. Usually this strategic planning is done by marketing and finance sectors, giving information on resources and targeted markets. The medium term plans are carried out by PPC (planning and production control) department, which develops the production master plan based on medium term demand forecasts and orders already confirmed. Yet in the short term plans, at operational level, the PPC develops the production schedule comprising inventory management, release of purchase orders, manufacturing orders, and, finally, monitoring and control of production.

Regarding the importance of demand forecast goes beyond the support to PPC. It guides the organizational strategy embracing multiple industries. Functional areas require future predictions to estimate resources, capacity and policies to be applied for a certain period (Flores and Werner, 2007; Lemos 2006); as well as the decision making related to inventory management is mainly based on demand forecast (Elsayed et al. 1994). According to Corrêa and Corrêa (2008), one of the main mistakes made by companies is to define the amount of sales needed to reach the financial goals and confound this with demand's forecast. Forecast is a methodological process that estimates a future demand based on statistical or subjective models (Queiroz and Cavalheiro, 2003). The desired demand concerns to sales goals necessary to be achieved in a given time, which may feature the commitment to overcome the forecasts and reach the goal of growth (Pires 2004).

As stated by Elsayed et al. (1994), any demand forecast follows the same logic: use past data to predict the future. To address these information there are two complementary approaches: qualitative and quantitative forecasting techniques. Qualitative techniques are subjective; admit intuition factors and experience to formulate opinions to determine the forecast. On the other hand, quantitative techniques are objective and based on historical data projected for the future (Corrêa and Corrêa, 2008). Quantitative techniques unfold itself in causal methods, which use historical data on independent variables, and time series analysis, which is based on historical data to project future demand and analyze trends and seasonality patterns (Krajewski et al. 2015). Despite the method, there will always be distortions between the actual demand and demand's forecasting, these variations are inherent to the process of estimating or making future projections (Garcia et al. 2001). The assessment of demand uncertainty is important in order to perform analysis, monitoring and measurement of errors (Donk et al. 2005).

Another important aspect to be considered in production planning and control is related to inventory management, which aims to balance the availability of costumer products and costs related to the maintenance of stocks. The challenge is to minimize these inventory costs for each level of target service (Ballou 2003). Inventory is defined as raw material, work-in-process parts and finished goods, which are in the production system during a certain time (Slack et al. 2009). Further, among the existent inventory control systems, the continuous review system (Q) and the periodic review (P) stand out as the most applied ones. According to Krajewski et al. (2015), the continuous review system makes inventory revisions continuously, in every withdrawal of stock of the product in order to define the need of placing a new purchasing order. When the inventory level reaches the replenishment point, which is the minimum level, a fixed batch quantity of the item is placed on request (Stevenson 2014). The periodic review system (P) makes the inventory review periodically and a new purchase order is placed after each review and the time between orders is fixed. Thus, only the batch size can be changed. The main advantages of periodic review system are the low cost of application (as the applications for multiple items are performed only once) and the reduction of inventory revisions (due to the fixed period).

METHOD

This study is categorized as applied research since its goal is to generate knowledge for practical application (Drejer and Gudmundsson, 2002). Additionally, this research has a quantitative approach because it uses as a source of numerical data information. The objective of this research is classified as exploratory due to fact that it provides greater familiarity with the problem and makes it more explicit (Silva and Menezes, 2005).

This study was conducted in a small enterprise of the electronic sector, more specifically, in the field of monitoring and controlling of electric power equipment. The company's current policy favors the development of new technologies and new products. The focus on innovation is supported by guidelines of the marketing sector and the R&D sector. However, because of the growth in the electronics industry related to energy, highlighted by ABINEE (2015), the company needs to improve operational planning to meet the growth of demand. The increased demand for finished goods has resulted in problems in managing the company's operations. There are frequent changes in the production master plan, which results in losses at the production processes and delays in deliveries. For this reason, this work is aimed to minimize this problem, managing the inventory system of finished goods of the company. It is proposed the development of an inventory management method applied to the presented case study.

The study's development came from the company's main problem, which is the low level of service offered to customers, resulting in lost orders due to lack of products for delivery. Thus, a cause and effect relationship was developed for each of the problems which resulted in the diagram shown in Figure 1.

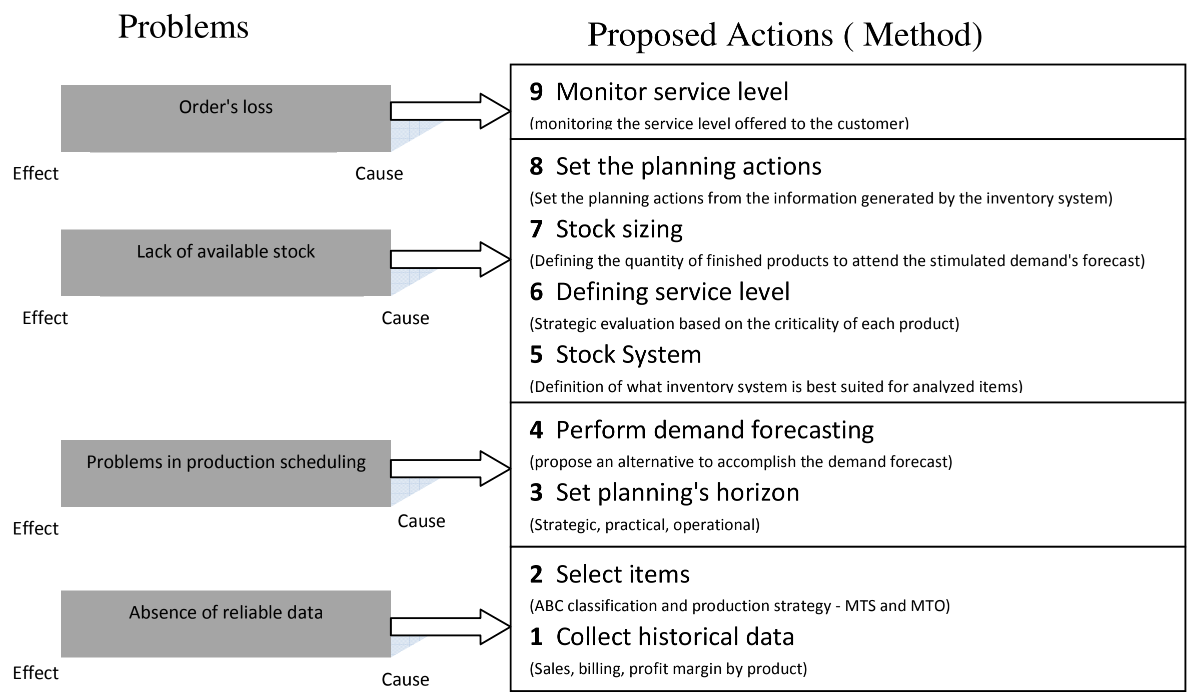

Figure 1 - Cause and effect relationship between problems and the proposed method

The development of the method was performed to minimize each of the identified problems. In this way, it was established one or more steps of the method to solve each problem identified in the cause and effect diagram. From the analysis, it was performed a method divided into stages and activities that make the procedure easily applicable. The proposed method of work is divided into 9 stages, namely: (i) collect historical data, (ii) select items, (iii) define the planning horizon, (iv) perform demand forecasting, (v) define system stock, (vi) define desired service level, (vii) scale stock, (viii) define the actions of the production planning, and (ix) monitor the level of service achieved. Figure 2 shows the steps of the proposed method.

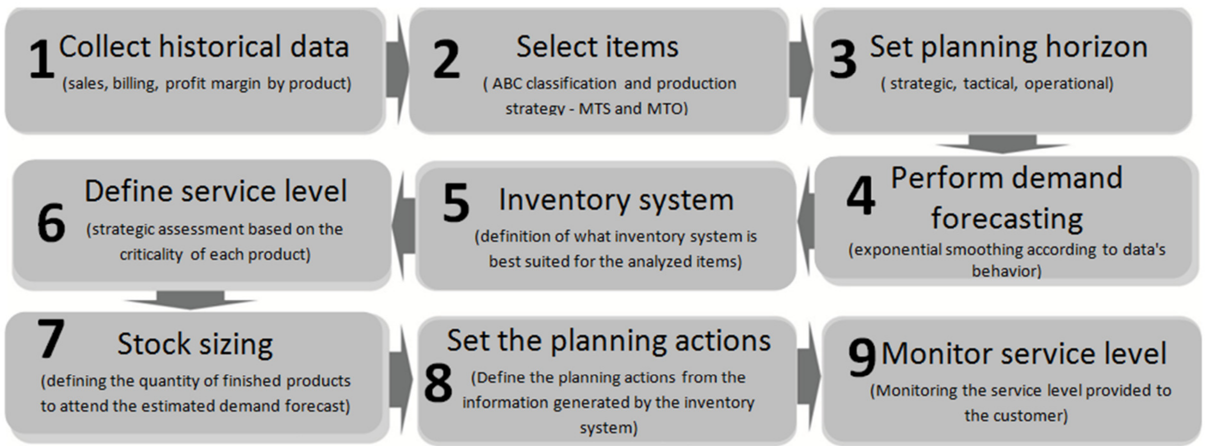

Figure 2 - Proposed method

The first step is determined to collect historical data. The fetched data among others are sales, profit and representation of profit for each sold item. The survey of such data and their presentation are crucial to realize further steps. The step of selecting the items is to identify for which products the proposed methodology will be applied. This selection is based on the types of products of production strategy (make-to-stock or make-to-order) and the ABC classification. Only products produced for stock will be analyzed (MTS); products that are customized and produced in accordance with the MTO strategy are not included in this analysis. Among the MTS products of the company, the most representative in revenues will be selected. This selection follows the Pareto criterion, selecting the products of the type "A", which typically account for about 20% of the portfolio and 80% of revenues.

In the third step it is defined the planning horizon applied to the objective of this work. The planning horizon will be proposed according to the planning level of the CFP and the activities that comprise this horizon. The planning horizon defines the forecasting methods to be used. In the step of performing demand forecast it was decided to use quantitative techniques to forecast. Among the options for historical data, the models of exponential smoothing were selected. There will be an analysis of the behavior of demand, and, according to this behavior, it is selected the most appropriate model to conduct the forecast of each product. From the demand forecasting, the stock system is set. This inventory system may be operated through a continuous or periodic review. During this step, it is also established the periodicity of review of the proposed system for sizing the finished goods inventory. The definition of service level for each product is set in accordance with the criticality level of each product. This criticality will be established in accordance with the profit margin of each product. Thus, products with a higher profit margin are expected to present higher level of service.

The stock sizing step holds the definition of inventory levels with regards to the analyzed demand forecast and the level of service. In step of defining the actions of planning, it is defined the inventory system information that will feed the production planning. Moreover, the decisions regarding the batch size of production orders and the timing of applications are also determined. Finally, the monitoring step of the service level comprises the data monitoring to verify the effectiveness of this method in order to provide feedback to production planning.

RESULTS

The source of data is the ERP software used by the company (Protheus®), in which information such as name, code, quantity, billed amount, cost of raw material, average selling price and billing were collected. The sample data included a 33-month period. The sold and invoiced amounts were verified on a monthly basis. The cost of raw material (Cost MP) represents the annual average cost of the item and the billing was a cumulative result of the period. From the collection of such data, it was possible to calculate the average profit and price of each item. This information was gathered for 73 different products, as shown in Figure 3.

Year	Product	Code		Amount	Cost MP	Revenues	Medium Price	Profit	Margin	Profit*Amount
2011	P-600	7920050	MTS	70	$ 100,24	$ 95.967,87	$ 1.370,97	$ 1.270,73	1268%	$ 88.951,05
2011	P-600	7920094	MTS	78	$ 189,52	$ 89.906,95	$ 1.152,65	$ 963,14	508%	$ 75.124,59
2011	Smart Cap 200 - 12	7810016	MTS	492	$ 31,30	$ 78.431,11	$ 159,41	$ 128,11	409%	$ 63.031,27
2011	Power Cap 485	7840005	MTS	64	$ 57,60	$ 61.720,80	$ 964,39	$ 906,79	1574%	$ 58.034,36
2011	Smart Cap 485 - 12	7900001	MTS	137	$ 48,43	$ 50.105,09	$ 365,73	$ 317,30	655%	$ 43.469,95
2011	P-300	7920040	MTS	233	$ 90,06	$ 63.854,95	$ 274,06	$ 183,99	204%	$ 42.870,23
2011	Smart Cap 200 - 06	7810019	MTS	318	$ 30,20	$ 42.055,54	$ 132,25	$ 102,05	338%	$ 32.451,54

Figure 3 - Summary of collected data

For products selection, 39 products were chosen according to the presented criteria of MTS strategy. Among these, the 20% most profitable products are shown in Figure 4, which account for 7 items and are equivalent to 41% of total sales of the company with the MTS strategy.

Product	Code	Strategy	Profit*Amount
P-600	7920050	MTS	$ 88.951,05
P-600	7920094	MTS	$ 75.124,59
Smart Cap 200 - 12	7810016	MTS	$ 63.031,27
Power Cap 485	7840005	MTS	$ 58.034,36
Smart Cap 485 - 12	7900001	MTS	$ 43.469,95
P-300	7920040	MTS	$ 42.870,23
Smart Cap 200 - 06	7810019	MTS	$ 32.451,54

Figure 4 - Selected products

As the method includes operational level activities such as production planning, inventory management, scheduling and production orders, the planning horizon was defined as a short term view, providing a 3-month forecast and monthly time intervals (time buckets). Further, historical data are analyzed graphically, helping identify patterns, trends and seasonality in time series. The selection of better demand forecasting method requires an analysis of the behavior of the time series that can be represented by the following patterns: average seasonality, cyclical and trend (Makridakis et al. 1998). The patterns in the time series obtained for the product are shown in Figure 5.

A few products, such as “7920094” and “7920040”, have a very limited amount of data, since they have been launched in the market less than two years before the analysis. Moreover, all products demonstrate an irregular demand, also called "lumpy", characterized by high levels of variability, showing a row of peak demand periods of low demand or nule. The irregular pattern of demand occurs in cases that demand is intermittent, with a high degree of uncertainty and particularly difficult to predict (Lemos 2006). In order to establish a demand forecast, this work follows the recommendation of the company's management, obtaining demand forecast from the past 12 months. Although there are more robust methods for conducting forecasts for this kind of demand, this work does not include in its objectives the modeling of time series data. The selected products have a characteristic of low amount of units sold and the company does not have a reliable system for continuous monitoring of stock levels. Also, the products monitored have irregular demand. Because of these characteristics, it was decided to use a system periodic review for inventory management.

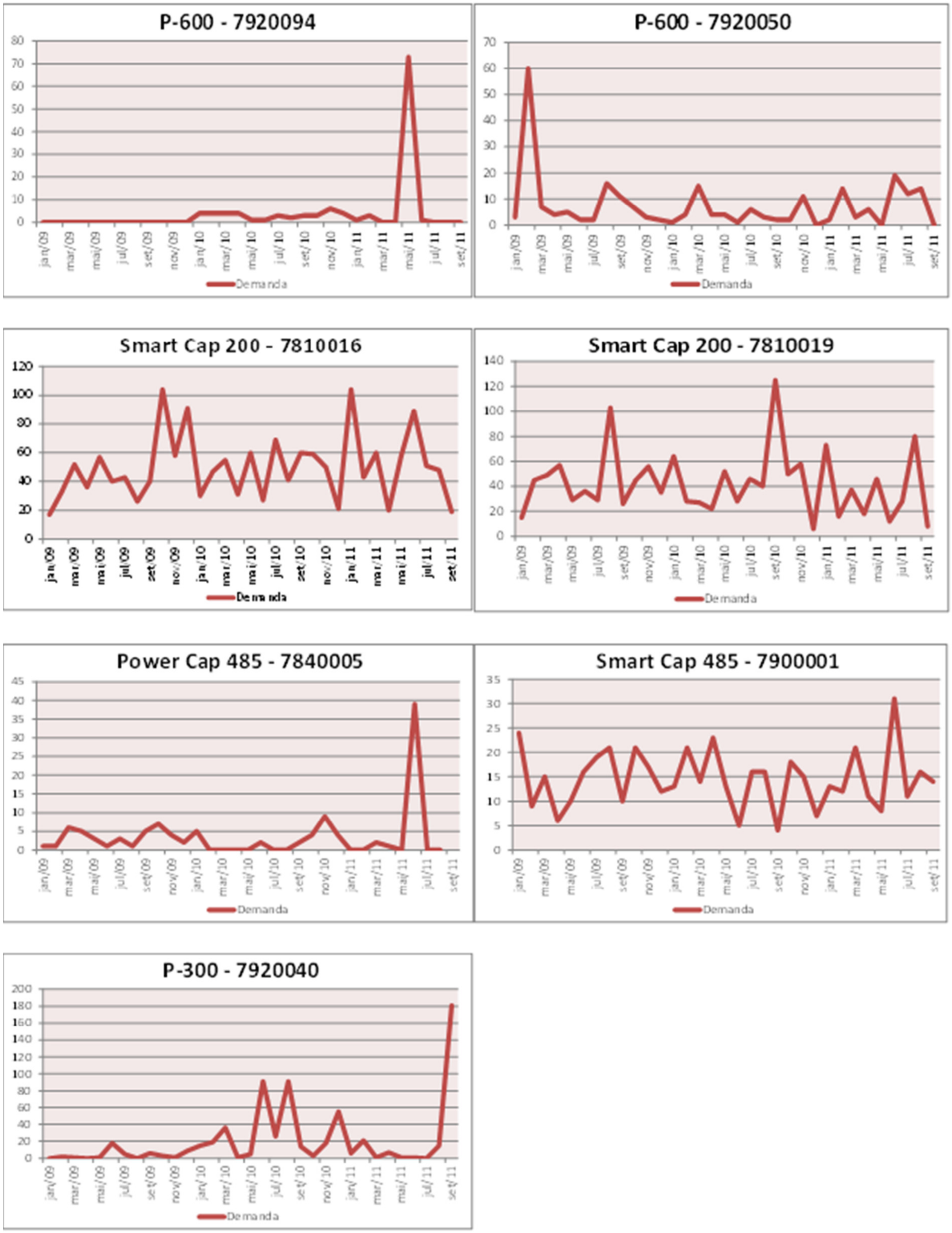

Figure 5 - Analysis of the seven products' time series

To develop this system, it was necessary to estimate the revision interval (P) desired, the lead time of products and information. The MTS products have its production schedule for periods of greater slack in the production system. The definition of service level has been established as the criticality of each product, this was measured by two variables: profitability and sales strategy. From these two criteria was established a scale of 1 to 5 for each factor, where one means poor criticality of the variable and 5 high criticality. Figure 6 shows the criteria for drawing up the criticality of the products. From the classification of the product on the criticality of profit and the strategy is calculated criticality of the product. This criticality is given by the multiplication result between the criticality of profit and strategy, and the obtained value defines the level of service shown in Figure 7.

Profit's criticality	Legend
1	Up to 300 of profit
2	From 300 to 600%
3	From 600 to 900%
4	From 900 to 1200%
5	Above 1200%

Strategy criticaly	Legend
1	Product with more than 5 years in the market
2	From 5 to 2 years
3	Products with less than 2 years
4	Products with less than 2 years + software
5	New Products

Figure 6 - Criteria criticality

Product's criticality	Service level
From 1 to 5	90%
From 6 to 16	95%
From 17 to 25	98%

Figure 7 - Analysis of the seven products' time series

From the calculations proposed it was possible to calculate the level of service desired for each of the products. Among the selected products, the following service levels have been identified:

- Product 7920050 - 20 criticality and service levels 98%;
- Product 7920094 - 08 criticality and service levels 95%;
- Product 7810016 - 02 criticality and service levels 90%;
- Product 7840005 - 10 criticality and service levels 95%;
- Product 7900001 - 03 criticality and service levels 90%;
- Product 7920040 - 04 criticality and service levels 90%; and
- Product 7810019 - 02 criticality and service levels 90%.

Figure 8 contains the values obtained in the demand forecast, the calculation of all relevant information for the inventory system and consequently the value obtained for the target level (T) of all products.

Code	Average in period (4 weeks)	Deviation in week	Service Level	Z	Period (week)	Lead Time (week)	Protection time (P+L) (week)	Demand in the protection time	Safety Stock	Stock Level
7920050	6,92	6,72	98%	2,05	4	0,5	4,5	7,79	29,27	37,06
7920094	3,25	1,42	95%	1,64	4	0,5	4,5	3,66	4,95	8,61
7810016	51,83	24,83	90%	1,28	4	0,5	4,5	58,31	67,50	125,81
7840005	5,58	2,07	95%	1,64	4	0,5	4,5	6,28	7,22	13,50
7900001	14,75	6,47	90%	1,28	4	0,5	4,5	16,59	17,58	34,18
7920040	11,83	15,46	90%	1,28	4	0,5	4,5	13,31	42,02	55,34
7810019	36,00	25,47	90%	1,28	4	0,5	4,5	40,50	69,24	109,74

Figure 8 - Stock sizing step results

After performing the previous steps, production planning is replenished every four weeks with the following information: (i) number of products in the stock and (ii) target level (T) for each product. Demand forecasts, the classification of the criticality and the design of the target stock level (T) are conducted quarterly by changing the inventory system information. From this information, the stock planning feeds into a database that is used to monitor the service level achieved for customers. This means that many times it will be checked, among the products with monitored MTS strategy, if there is a lack of finished products for delivery to customers. This monitoring helps to identify the effectiveness of the proposed process through a window of the level of service offered to the customer. However, besides the effort to keep inventories to ensure customer service, it is fundamental to address improvements to reduce inventory and, consequently, the guard costs. It is important to improve the collection of historical data and demand forecasting techniques, which may hinder the method due to lack of data.

CONCLUSIONS

This working method has not been applied in its entirety in the company, so their results could not yet be measured. However, its application has already contributed for the company to organize its decision-making process regarding the level of inventory and production scheduling. Failure complexity of the method favors its applicability in small enterprises because the method does not require the formulation of complex and difficult calculations, contributing to greater accessibility to production professionals. The high level of inventory obtained from the proposed method is explained by the variability of demand and also for the stipulated service level. But it is planned improvement actions to reduce the costs of proposed high inventory levels, such as improving data collection and demand forecasting techniques, referring to steps 1 and 4.

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