



Universidad Popular Autónoma del Estado de Puebla

Vicerrectoría de Posgrados e Investigación

Posgrados en Ingeniería y Negocios

Maestría en Logística y Dirección de la Cadena de Suministro

Forecasting demand improvement for replenishment in a retail
painting company

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Agosto, 2020



UPAEP – Secretaría General

Dirección General de Apoyos Académicos

Dirección del Centro de Recursos para el Aprendizaje y la Investigación.

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Se aprueba el Trabajo Terminal llamado:

Forecasting demand improvement for replenishment in a retail
painting company

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Agosto, 2020

RESUMEN

El presente caso de estudio se desarrolló en una empresa comercializadora de pintura al por menor; el objetivo principal es alcanzar un mayor flujo de efectivo para asegurar el cumplimiento de la demanda con un nivel de servicio del 95%. Actualmente, la cadena de suministro se enfrenta a múltiples competidores por lo que las empresas familiares tienen que mejorar los procesos logísticos para permanecer en los mercados locales, nacionales e internacionales. A través de la clasificación ABC, se catalogó el portafolio de productos para elegir aquellos de mayor impacto. Las técnicas de pronóstico pueden proporcionar datos con mayor precisión en la preparación de los pedidos. Para esta investigación, es funcional un modelo estacional, ya que la demanda tiende a tener un comportamiento similar año tras año y mes tras mes. El modelo de demanda estacional se utilizó para encontrar productos específicos que podrían no ser aptos para pedidos de cantidades mínimas que podrían exceder la demanda prevista. Por otra parte, el modelo clásico de EOQ considera el valor del inventario y la previsión de la demanda, lo que demuestra que el rendimiento de la cadena de suministro podría mejorar considerablemente. Por lo tanto, una estimación precisa puede reducir los costos de inventario en cada uno de los periodos por lo menos en un 14%, satisfaciendo la demanda de los clientes. El modelo EOQ debe aplicarse a todos los productos para reducir la inversión en existencias de movimiento lento y mejorar el inventario para aquellos productos de alta demanda que pueden generar flexibilidad para adaptarse a la complejidad del mercado y satisfacer las expectativas de los clientes. Como un estudio futuro, la empresa puede desarrollar una estrategia para reducir el inventario no rotativo con más precisión, teniendo conocimiento de qué y cuándo venderán productos específicos

ABSTRACT

This case study was developed in a retail painting company; the main objective is to reach a higher cash flow for assuring the fulfilment of the demand with a 95% service level. Currently, supply chain faces to multiples competitors so familiar business have to improve the logistics processes for remaining in local, national and international markets. Through the ABC-classification, the product portfolio was classified for choosing the products with more significative impact. Forecasts techniques may obtain data with higher accuracy in the order preparation. For this research, a seasonal model is functional, since the demand tends to have a similar behaviour year by year and month by month. Seasonal demand model was used to find specific products that might not fit for ordering minimum quantities which might exceed the forecasted demand. On the other hand, classic EOQ model considers the value of the inventory and demand forecast, which demonstrates that the performance of the supply chain could improve considerably. Therefore, an accurate estimate can reduce inventory costs in each of the periods, satisfying customer demand, by at least 14%. EOQ model should apply to all products for reducing the investment in slow-moving stock and improving the inventory for those highly demanded products which can generate flexibility to embrace market complexity and meet customer expectations. As a future study, the company can develop a strategy to reduce non-rotating inventory with more accurately, what and when they will sell specific products.

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CAPÍTULO I. INTRODUCCIÓN

1.1. Breve descripción de la compañía

La empresa por estudiar fue fundada en 1980 y desde sus inicios se ha dedicado a la venta al menudeo de pinturas de la marca líder en el mercado nacional; iniciando operaciones con una sucursal, pero a la fecha está conformada por una red de 5 sucursales ubicadas en el estado de Tlaxcala. Su proveeduría, al ser una marca concesionada está basada en un solo proveedor que le suministra más de 1500 números de partes diferentes. El mercado principal de es arquitectónico.

Se trata de una empresa familiar, ya que independientemente de su tamaño es considerada como empresa familiar si: la mayoría de las acciones con derecho a voto están en posesión de la persona física que fundó la compañía, en posesión de la persona o personas físicas que han adquirido la empresa, o en manos de sus cónyuges, padres, hijos o descendientes de éstos. La posesión de la mayoría de las acciones con derecho a voto puede ser por vía directa o indirecta. Al menos un representante de la familia está involucrado en el gobierno y la administración de la compañía. Las empresas cotizadas se consideran familiares si la persona que fundó o adquirió la compañía o sus familias o descendientes poseen al menos el 25% del derecho a voto conferido por su porcentaje de capital social (Tápies, 2011).

1.2. Planteamiento del problema

El método actual de aprovisionamiento de las tiendas se realiza de forma empírica basado principalmente en la capacidad de sus almacenes y no en un pronóstico de ventas. Esto ha ocasionado que a lo largo de los años se tenga una gran cantidad de material obsoleto o de lento movimiento, que continúa comprándose al no considerar la tasa de demanda de dichos productos.

De igual forma se ha observado que en ocasiones, no únicamente se ha llegado a tener un sobre inventario de material que se encuentra estático por periodos prolongados de tiempo. Sino también, en aquellos puntos donde se tienen picos de demanda han llegado a experimentarse desabastos de material con alta rotación al estar utilizando el espacio para aquellos materiales con menor movimiento.

Se tiene la sospecha de que el comportamiento de la demanda para los materiales de mayor rotación es estacional en ciertas temporadas definidas, con patrones repetitivos observados a lo largo del tiempo. Sin embargo, no existe una medida para contrarrestar este efecto o un plan de reabastecimiento adecuado para lograr un nivel de servicio estable sin incurrir en costos logísticos por expeditados, de forma similar se han incurrido en costos de almacenamiento innecesarios para mantener aquellos materiales de baja demanda.

Es aquí donde nace la necesidad de buscar una forma de pronosticar la demanda que considere todas las fluctuaciones y periodos estacionales para cada una de las familias de productos, siendo el alcance para aquellos materiales con mayor impacto valor-uso.

Un fuerte argumento para que la compañía optara por abrir sus puertas para la realización de este análisis es que han observado una falta de liquidez para adquirir los productos necesarios para solventar proyectos específicos, ya que su capital está detenido en inventarios con baja rotación, representando una pérdida de ventas no definido por la empresa, pero suficiente para detonar la necesidad de un análisis profundo de alternativas en los métodos de compra actuales.

1.3. Justificación

Tal como se describe en el planteamiento del problema, la empresa comienza a observar déficits en su flujo de efectivo, al no contar con una estrategia de aprovisionamiento que le permita cumplir la meta establecida de 95% de nivel de servicio para sus productos principales.

Dada la necesidad de conocer cuáles son aquellos productos con mayor impacto en los ingresos, se optará por desarrollar la metodología ABC para determinar los materiales principales y enfocar los esfuerzos de mejora en el abastecimiento de estos y generar un mayor flujo de efectivo para la organización. Como enfoque inicial, se pretende

atender a los productos en la categoría A, aunque la metodología desarrollada podrá ser replicada en el resto de las clasificaciones.

Derivado de los entrenamientos que ha recibido el personal que elabora los requerimientos de material, se considera la metodología EOQ como pieza clave dentro de dicho proceso. Dentro del presente estudio se realizará el análisis detallado y comparación de resultados en términos de valor del inventario y costos de almacenaje, entre la metodología EOQ y métodos de pronósticos basados en series de tiempo, con la finalidad de determinar cual es la mejor alternativa para esta compañía.

Debido al crecimiento que ha tenido la empresa en años recientes, se considera pertinente el actualizar las prácticas de planeación de materiales empleadas desde la concepción de la empresa, misma que en sus inicios únicamente contaba con una sucursal. Esto permitía realizar una planeación enfocada en un punto de venta, sin considerar los factores de demanda específicos de las nuevas sucursales que han sido adquiridas a lo largo del tiempo, volviendo esta actividad cada día más compleja ya que demanda una visión estratégica sobre las operaciones del conglomerado.

1.4. Objetivo general

Brindar a la organización una herramienta que permita generar una proyección de la demanda. Esta estimación podrá ser utilizada para generar una estrategia de abastecimiento que permita mantener el nivel de servicio establecido por la empresa, sin incurrir en gastos innecesarios y a su vez incrementar el flujo de efectivo, manteniendo la competitividad en el mercado que se desarrolla.

1.5. Objetivos específicos

- Definir el problema, con la finalidad de determinar cual será aquella información requerida en el planteamiento de la mejora,
- Realizar la recolección de las ventas históricas que permita tener una visión sobre el comportamiento de las ventas en periodos anteriores y concretar una estrategia adecuada para el caso específico,
- Proporcionar a la empresa una visión de los productos principales en los cuales se enfocará la primera fase entregable del proyecto, que generará un impacto significativo en la reducción de costos,
- Conocer el comportamiento de las ventas a nivel SKU, para aplicar diferentes métodos de pronóstico eligiendo el que tenga un menor error porcentual absoluto medio,
- Comparar los resultados obtenidos a través del pronóstico de ventas que mejor se adapte al comportamiento de la demanda, con la metodología EOQ para seleccionar de ambas estrategias la que represente los menores costos totales asociados.

1.6. Preguntas de investigación

- ¿Qué estrategias de aprovisionamiento es posible desarrollar para satisfacer la demanda a un nivel de servicio deseado, sin incurrir en costos logísticos y de almacenaje excesivos?
- ¿Cómo se pueden catalogar los productos de una forma estratégica para identificar los que otorgan un mayor beneficio económico a la empresa?
- ¿De qué manera se puede medir la efectividad de los principales métodos de pronóstico considerando las fluctuaciones naturales de la demanda?
- ¿Cuál sería una forma objetiva para comparar los resultados arrojados por una estrategia de abastecimiento basada en pronósticos en contraste a la metodología EOQ?
- Seleccionado la metodología de aprovisionamiento que mejor se ajuste a la operación de la compañía, ¿cuál podría ser el porcentaje de ahorro en costos asociados entre las metodologías analizadas?

1.7. Beneficios

La empresa obtendrá una metodología de abastecimiento que le permita obtener ahorros en comparación con su proceso de adquisición de mercancías actual, considerándose también los costos logísticos asociados a esta actividad.

El modelo propuesto podrá ser replicado para todos los productos de la empresa, sin importar su clasificación ABC.

Los ahorros generados con la propuesta desarrollada brindarán flexibilidad en flujo de efectivo a la compañía para poder participar en proyectos que demanden capacidad de financiamiento en materiales que no se tienen en inventario de forma regular. Según información proporcionada por los directivos de la organización, en la actualidad la compañía no puede participar de dichos proyectos por la falta de liquidez que detonan los inventarios de baja rotación.

Como beneficio intrínseco a la mejora, se podrá mantener el nivel de servicio establecido por la organización ya que se proponen inventarios de seguridad para los principales productos y estos, a su vez, consideran la fluctuación en la demanda a través del tiempo.

1.8. Limitaciones

La principal limitante del presente proyecto es que únicamente se estudia a detalle el grupo de productos clasificados como categoría A.

De igual forma, al ser una pequeña empresa familiar, se considera la limitante de personal capacitado para el seguimiento apropiado de las mejoras propuestas.

El impacto no se verá reflejado de forma inmediata ya que este dependerá de la velocidad en que se logren reducir los inventarios de material de lento movimiento que se encuentran en almacén al momento de la realización de la presente propuesta.

Debido a que cada sucursal realiza sus requerimientos de forma individual, se corre el de adquirir cantidades no requeridas de materiales de baja rotación debido a los tamaños mínimos de lote que ofrece el proveedor y que pueden ser superiores a la demanda que se proyectó para dichos números de parte. Esta situación se puede replicar a través de las diferentes sucursales de la empresa, para diferentes productos lo cuál mermará el resultado proyectado para el ahorro total en costos.

CAPÍTULO II. ARTICULO PUBLICADO

Publicado en: Acta logistica – International Scientific Journal about Logistics

Volume: 6 2019 Issue: 4 Pages: 155-164 ISSN 1339-5629

FORECASTING DEMAND IMPROVEMENT FOR REPLENISHMENT IN A RETAIL PAINTING COMPANY

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[doi:10.22306/al.v6i4.143](https://doi.org/10.22306/al.v6i4.143)

Received: 26 Nov. 2019 | Accepted: 23 Dec. 2019

doi:10.22306/al.v6i4.143

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Keywords: forecast, MAPE, service level, economic order quantity, inventory management

Abstract: This case study was developed in a retail painting company; the main objective is to reach a higher cash flow for assuring the fulfilment of the demand with a 95% service level. Currently, supply chain faces to multiples competitors so familiar business have to improve the logistics processes for remaining in local, national and international markets. Through the ABC-classification, the product portfolio was classified for choosing the products with more significative impact. Forecasts techniques may obtain data with higher accuracy in the order preparation. For this research, a seasonal model is functional, since the demand tends to have a similar behaviour year by year and month by month. Seasonal demand model was used to find specific products that might not fit for ordering minimum quantities which might exceed the forecasted demand. On the other hand, classic EOQ model considers the value of the inventory and demand forecast, which demonstrates that the performance of the supply chain could improve considerably. Therefore, an accurate estimate can reduce inventory costs in each of the periods, satisfying customer demand, by at least 14%. EOQ model should apply to all products for reducing the investment in slow-moving stock and improving the inventory for those highly demanded products which can generate flexibility to embrace market complexity and meet customer expectations. As a future study, the company can develop a strategy to reduce non-rotating inventory with more accurately, what and when they will sell specific products.

1 Introduction

This case study was developed a retail store of paintings because of; currently; consumers prefer buying from retailers because their trust is a sensible expectation [1]. Hence family firms are supposed to be more trustworthy compared to their nonfamily counterparts [2-4]. Therefore, family firms may obtain a strategic advantage based on policies and practices that cause them to appear to be more long-term oriented, credible, and reliable [5]. Capitalisation plays an essential role in the success of family firms [6-8]. Consequently, supply chain managers have to adapt their strategies to minimise inventories and maximise sales for facing their competitors [9]. It is crucial that calculates demand forecasts for decision-making that satisfy customer needs without having an excessive inventory to have a higher cash flow. For it, the company's portfolio products should segment through the ABC methodology, which acknowledges, which products are the most representative in terms of value-use.

ABC classification can help industrial marketers in three ways: costs estimate of products with significant

differences specifications, proposing which product specifications may adjust in negotiations, and indicating the change company operations to reduce the cost that will allow satisfying customer [10]. Therefore, accurate and robust classification of items is required to manage a large number of products. ABC analysis, which is based on Pareto's principle, requires a single criterion, annual usage value (cost). Few items, which contribute a considerable amount of yearly usage value, are considered as A-class items and which provide very less amount of annual usage value, are considered as C class and B class. However, most of the companies store thousands of products and often they are not correctly categorised.

Additionally, ABC classification does not consider lead-time, inventory cost, commonality, obsolescence, substitutability, number of requests for an item per year, number of purchase orders per year, purchase order size of an item, scarcity, durability, repairability, stock ability, demand distribution and stock-out penalty cost, among others things [11]. To achieve supply chain competitiveness, having accurate data is a crucial factor

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[12]. However, supply chain managers cannot guarantee the accuracy of the forecasts [9] because the demand uncertainty and fickle consumers which unwilling to wait for replenishment if a product is momentarily unavailable [13,14]. Therefore, many supply chain managers rely on large inventory holdings as buffers to reduce the risk of product unavailability [15], which is not only costly but also generates inefficiencies throughout the supply chain.

Based on the case study company policies, materials should be ordered weekly. Therefore, supply chain management (SCM) supports to manage inter-company material, information, and financial flows to collectively enhance productivity, performance, and profitability [16,17]. Low costs across the supply chain, in addition to appropriate customer service levels, is seen as a crucial success factor [18]. Inventory management plays a vital role in obtaining a competitive advantage. Hence the main objective of inventory management practices is to have the requirements at the right time, in the right place with minimum cost. This proposal methodology reduces inventories, predict the demand for all A, B, and C classification SKUs, for each of the months and in turn have money available to invest on those materials with higher rotation or other special needs that arise.

2 Background

The proper management of assets held within an organization can be studied through inventory management models that is the reason for research and in-depth analysis, as they constitute an essential item on the financial statements of any company. Optimizing the operation and management of these assets to achieve the fulfilment of its function without incurring excessive expenses is the objective of using these models and management tools.

The three key questions inventory management attempts to answer are i) How often should the inventory be reviewed? ii) When should an order be placed? iii) What size should the order be? [19].

The most common objectives when applying a management model are [20]:

- Minimize costs incurred by inventory management;
- Maximization of economic benefits, speaking of savings;
- Maximization of internal rate of return on inventory investment;
- Determine a feasible solution for better inventory management;
- Ensure flexibility in handling;

Faced with variations in demand and delays, organizations decide to work with safety stocks; this allows them to maintain the level of service that is vital to their operation [21].

Chikan [22] talks about a paradigm shift in business on different topics, as shown in the below table (Table 1).

Table 1 New paradigms in inventory management

FIELD	PARADIGM
Economy of services	The requirements of today's customers are not merely to buy products, but to obtain solutions to their problems. Companies must offer the exact combination of products and services.
E-Economy	ICTs can achieve a level of integration in the activities, increasing availability, speed of action, and reaction.
Network economies	Competition is now between networks, so cooperation and competition are now interrelated. Achieving long-term relationships and strategic alliances.
An economy based on knowledge	Achieve competitive advantage through experience. Companies need more and better information based on more sophisticated decision processes.
Responsible economy	The actors within the economy are obliged to consider not only their interests but with all their surroundings.
Global economy	Decision-makers should consider the global economy when investing, buying, or selling, as competitors, customers, and partners can come from anywhere.

The new paradigm is that inventories should now be an integral part of the value chain and in close relationship with other functions of the organization, thus becoming a strategic tool that achieves economic benefit and customer satisfaction, and their performance measures should be based on their contribution to finding better solutions for the consumer than those offered by competitors [22,20]. Customers expect immediate gratification from suppliers regarding their requirements, just as they have them with their customers or suppliers, but as Walker [23] states, they do not consider a different sourcing pattern. Therefore, it is necessary to make a sourcing plan that ensures the satisfaction of the requirements of retail customers. Regarding the analysis of demand, according to Howleg [24], the first step is to understand that there will be a difference between the real demand for materials and what is called artificial demand generated from organizational decisions. It is taken from the information that is available from customers, as well as the needs of the company itself, to know the demand from a forecast based on the behaviour of customer demand.

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Walker [23] believes that perfect compliance is one in which the right product can be delivered at the right price, time and quantity, meeting the stipulated quality standards. So, it is essential to start focusing on making consistent, reliable deliveries that achieve perfect compliance. Howleg [24] states that because customer demands are unstable and highly variable, companies are required to have a safety stock. Dwivedi and Butcher [25] point out that proper management of information is of paramount importance, as it can be used to optimize supply chain relationships, avoiding internal and external problems. Eagle [26], mentions that while forecasting, it should be considered accuracy of approximately 80%, with variability that can have up to 40% additional, which as a result, will generate unbalanced inventories and prone to customer service gaps. Selecting from a variety of forecasting methods, the one with the highest accuracy plays a crucial role in the satisfaction of the company's customers.

2.1 ABC classification and EOQ model

For the present demand analysis, the ABC inventory classification technique is used, which is defined as an inventory control method based on the principle discovered by Pareto, who observed that 20% of the Italian population owned 80% of the land used, and later found that this principle could be applied to the economy [27]. The ABC methodology divides the company's sales into A for those SKUs which represent 15-20% of the inventory and whose profit to the company's revenue is close to 80%; the B classification is for those products that are in stock with 30-35% of the volume and represent 15% of the profits, and finally the C class is for 50% of the items in inventory that contribute to 5% of the sales [28].

The classic EOQ concept equation 1 is born from the minimum intersection of the costs of maintaining the inventory with ordering costs; in this way, it can be

assumed that it is an optimal value of units to be requested at the minimum possible cost [29].

$$Q^* = \sqrt{\frac{2(D)(C_o)}{Ch}} \quad (1)$$

Where:

Q^* = economic order quantity,

D = forecasted demand in the planning horizon,

C_o = ordering cost per unit in the planning horizon,

Ch = holding cost per unit in the planning horizon.

Given that the company studied is a retailer, the allowable costs will be proportional to the total income, which must be considered in its finances, thinking that if the cost is less than the permissible point, it is a profit, or it would otherwise represent a loss [30].

3 Research methodology

This research was developed in different phases (figure 1):

- Problem statement which describes the actual situation and needs of improvement in the logistics process,
- information was collected on 52 weeks of sales in the company's product portfolio within five branches,
- ABC analysis to determine those products which represent approximately 80% of the SKUs,
- Demand forecast of A classification items looking for a maximum error of 10%,
- Inventory management, all active products in the portfolio must be kept in inventory, playing a key factor being able to determine a stock level that balances the level of service with the costs of inventory and associated with maintaining it, without impacting the company's cash flow,
- Results analysis for making-decision.

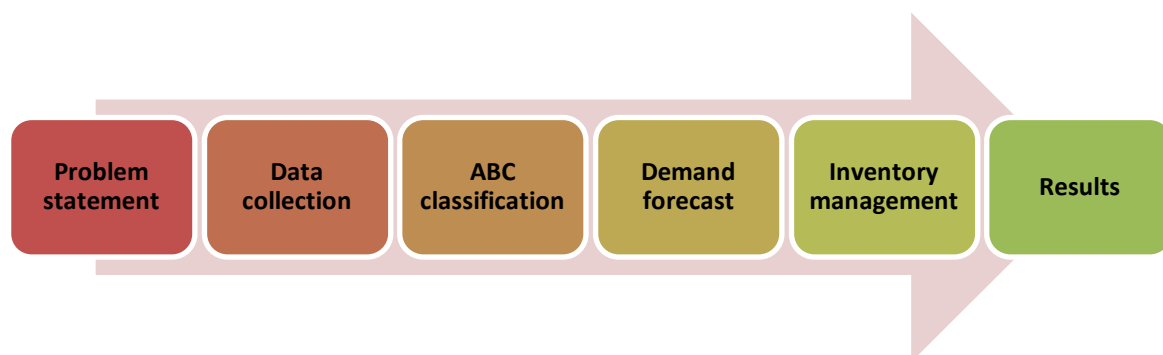


Figure 1 Phases of case study

4 Case study

4.1 Problem statement

The case study was conducted in a family business of paintings which has many deficiencies due to lack of knowledge for decision-making of owners who are managers of the company. One of the main constraints

faced is resistance to changes in strategies, due to the belief that current methods are functioning well, and it is not worth generate higher risk. Hence any improvement represents one of the biggest challenges so that the company has higher cash flow with lower inventory and maintaining the service level that has been handled since

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the beginning of the company. In the same way, there is the limitation of available working capital, since the reduced workforce and resources do not allow innovations to be made to the process for improvement projects to be developed. Furthermore, the company has excess inventory which generates high unnecessary holding costs that represent a constraint in terms of cash flow and space.

According with a company record, lost sales have reached 5% of yearly revenue due to shortages in high rotation items for the lack of financial capacity to pursue spot projects because of the elevated value of non-moving inventory. Another important implication is for certain B or C classification products its expiration dates exceed demand which causes additional fees for disposal of dangerous goods. Additionally, the inexistence of an accurate demand forecast and inventory planning strategy are impacting service level. Based on talks with the directors of the company, it is becoming more often that customers do not find the products approximately 5% of the times which is the company's allowance maximum value to keep a strong relationship with their clients

(service level target of 95%). The purpose of this case study is applied ABC classification, forecasting techniques and EOQ model for increasing the cash flow monthly and service level.

4.2 Data collection

The data collection consisted of retrieving sales history from the company's ERP from the last twelve months. However, the data showed high variation, so that the sampling period was extended by thirty-six months. This sales history allowed to observe correlation and seasonality among similar periods over the years (Figure 2).

An A-class product was randomly selected to present a chart that describes the behaviour of the demand, it was observed that not all products have the same seasonality, however correlation between months over the years is pretty similar. From below chart, month 12 is the forecasted value as at the time of the development of the paper.

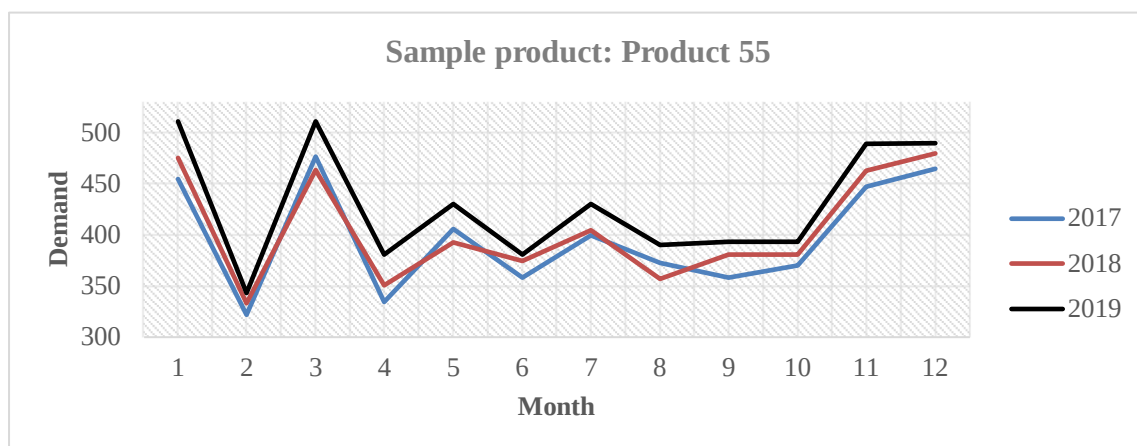


Figure 2 Monthly seasonality over the years

4.3 ABC classification

The total portfolio of the company consists of more than 1500 SKUs, which are necessary to keep in inventory and ensure service level. The higher value and rotation of a product, the more contribution on the sales it has and therefore it has a better ranking in the ABC. It was found that only 56 SKUs fit A-class category, representing close to 75% of total sales, in contrast to the C-class products which represent more than 50% of the portfolio and only worth 5% of sales. Because of the significant impact on revenue of A-class products which are the main focus for applying techniques that improvement the processes logistics for increasing the levels service.

4.4 Forecasting

Once the analysis of the forecasts with traditional methods of time series (linear regression, simple exponential smoothing, Holt-Winters method, simple moving average, weighted and centred) was carried out, it was concluded that none of the models presented results that could approximate the demand of the products, having high errors than the objective established of 10% (Table 2). The centred moving average had the lowest average percentage error (MAPE 26%), without reaching the desired value (10%). However, this method consists of taking a group of observed values, calculating the average, and using it as a forecast for the following period only [32].

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Table 1 MAPE results for time series forecasts for A-class products

PRODUCT	LINEAR REGRESSION	SIMPLE MOVING AVERAGE	CENTRED MOVING AVERAGE	WEIGHTED MOVING AVERAGE	SIMPLE EXPONENTIAL SMOOTHING	HOLT-WINTERS
1,...,56	36%	39%	26%	40%	39%	37%

For a forecast to be considered adequate, it is essential to remember that the value of the MAPE must be no more than 10%, the same value that was established as the objective for the analysis developed. Due to the 56 products of A classification show correlation and seasonality as well as external factors that intervene and motivate customers to buy certain products. For the demand of 52 weeks was applied a seasonal forecast that knowing the market trend in recent years will make it possible to adjust the amount of material that will be required in each of the months for the following periods.

Within a seasonal forecast, it is vital to consider three critical components which are: first the level, which allows separating the seasonality of the base values of the estimates. In the second place, seasonality, which will modify the values for the seasonal variations that are shown in the estimates and, finally, the tendency value that will allow adjusting the estimate to the variations or propensities through time [33].

Once the demand per month has been consolidated over the last three years, the average demand is calculated for each of the months during the period stipulated by equation 2. Subsequently, the seasonality index is obtained for each month (equation 3). Afterwards, estimate the annual demand for the year to be forecast as the product of equation 4 by equation 5. And finally, obtain the product of equation 5 by equation 3, with this, it is possible to know the forecast of seasonal sales.

$$P_i = \frac{\sum_{j=1}^m D_i}{m} \quad (2)$$

$$S_{index} = \frac{\frac{1}{n} \sum_{j=1}^m D_{ij}}{\frac{1}{n} \sum_{j=1}^m D_i} \quad (3)$$

$$T_i = \frac{D_j}{D_{j-1}} \quad (4)$$

$$D_{monthly} = \frac{D_j}{n} \quad (5)$$

Where:

P = Average demand in the sampled period,

D = Demand in the planning horizon,

S_{index} = Seasonality index for each of the periods in the planning horizon,

T = Projected tendency year over year,

$i = 1, 2, \dots, n$ (months),

$j = 1, 2, \dots, m$ (years).

It is observed that in the months where there are demand peaks, the index is equation 3 is greater than value 1 during the months of lower sales concerning the forecast average, equation 3 will have a value less than 1, which is the factor between the seasonality compared with the average demand historical data for period i for each of the items (Table 3).

MAPE for the A-class sample of 56 products yields a value of 9.18%, so that meets the objective of 10% error in 53 of 56 articles studied, which will allow replicating the model to the category A products within the company's portfolio with an accuracy in demand forecast of at least 90% (Figure 3), this result is considered highly reliable [34]. Table 4 shows the demand forecast.

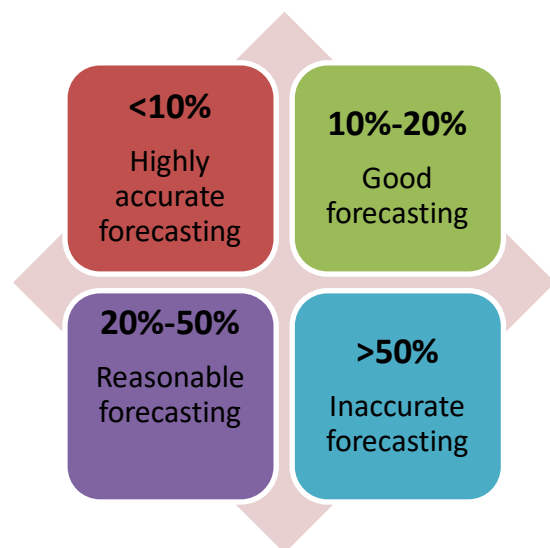


Figure 3 MAPE evaluation criteria

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Table 3 MAPE results for seasonal forecasts of A class SKUs

ITEM	PERIOD										MAPE
	1	2	3	4	5	6	7	8	9	10	
PRODUCT 1	0.05	0.06	0.03	0.05	0.02	0.08	0.04	0.08	0.05	0.04	5.12%
PRODUCT 2	0.04	0.04	0.14	0.15	0.08	0.04	0.17	0.11	0.00	0.16	9.39%
PRODUCT 3	0.04	0.04	0.04	0.13	0.04	0.21	0.20	0.06	0.06	0.04	8.72%
PRODUCT 4	0.04	0.04	0.04	0.12	0.04	0.06	0.10	0.03	0.04	0.21	7.36%
PRODUCT 5	0.13	0.11	0.09	0.07	0.03	0.14	0.09	0.07	0.04	0.04	8.37%
PRODUCT 6	0.04	0.06	0.07	0.05	0.05	0.04	0.15	0.13	0.13	0.07	7.87%
PRODUCT 7	0.14	0.04	0.20	0.01	0.00	0.04	0.24	0.09	0.04	0.15	9.69%
PRODUCT 8	0.12	0.09	0.09	0.16	0.04	0.11	0.06	0.04	0.04	0.04	7.96%
PRODUCT 9	0.07	0.39	0.33	0.14	0.04	0.24	0.04	0.11	0.90	0.14	24.20%
PRODUCT 10	0.02	0.16	0.03	0.08	0.04	0.23	0.07	0.15	0.02	0.03	8.32%
PRODUCT 11	0.16	0.04	0.09	0.15	0.04	0.04	0.11	0.10	0.01	0.17	9.16%
PRODUCT 12	0.10	0.17	0.04	0.04	0.13	0.03	0.02	0.18	0.04	0.04	8.12%
PRODUCT 13	0.04	0.04	0.04	0.13	0.04	0.10	0.04	0.04	0.06	0.04	5.95%
PRODUCT 14	0.09	0.00	0.06	0.10	0.01	0.04	0.01	0.29	0.19	0.09	8.71%
PRODUCT 15	0.10	0.04	0.06	0.13	0.04	0.04	0.12	0.15	0.01	0.09	7.82%
PRODUCT 16	0.12	0.10	0.09	0.17	0.04	0.04	0.06	0.12	0.04	0.07	8.49%
PRODUCT 17	0.04	0.04	0.04	0.36	0.10	0.04	0.04	0.21	0.04	0.04	9.70%
PRODUCT 18	0.10	0.10	0.13	0.17	0.10	0.04	0.10	0.04	0.03	0.10	9.23%
PRODUCT 19	0.08	0.24	0.03	0.14	0.04	0.08	0.03	0.04	0.04	0.06	8.00%
PRODUCT 20	0.24	0.13	0.13	0.04	0.04	0.16	0.04	0.10	0.04	0.06	9.99%
PRODUCT 21	0.10	0.04	0.16	0.17	0.01	0.13	0.03	0.10	0.10	0.01	8.60%
PRODUCT 22	0.11	0.04	0.04	0.04	0.17	0.04	0.04	0.33	0.04	0.04	9.17%
PRODUCT 23	0.04	0.13	0.04	0.04	0.21	0.13	0.21	0.04	0.04	0.04	9.37%
PRODUCT 24	0.16	0.09	0.07	0.00	0.08	0.02	0.17	0.01	0.15	0.04	8.04%
PRODUCT 25	0.03	0.06	0.11	0.16	0.18	0.10	0.05	0.14	0.08	0.03	9.46%
PRODUCT 26	0.15	0.13	0.13	0.08	0.02	0.04	0.06	0.02	0.01	0.06	7.11%
PRODUCT 27	0.10	0.16	0.08	0.02	0.11	0.11	0.19	0.06	0.05	0.04	9.16%
PRODUCT 28	0.04	0.13	0.08	0.08	0.17	0.13	0.01	0.16	0.04	0.06	9.15%
PRODUCT 29	0.04	0.00	0.04	0.08	0.09	0.43	0.05	0.08	0.03	0.06	9.05%
PRODUCT 30	0.20	0.01	0.07	0.08	0.06	0.05	0.05	0.12	0.11	0.09	8.49%
PRODUCT 31	0.16	0.09	0.08	0.04	0.02	0.12	0.10	0.17	0.07	0.14	9.96%
PRODUCT 32	0.16	0.15	0.10	0.10	0.21	0.00	0.02	0.16	0.02	0.08	9.96%
PRODUCT 33	0.12	0.03	0.00	0.02	0.06	0.04	0.00	0.04	0.06	0.53	9.05%
PRODUCT 34	0.13	0.15	0.10	0.10	0.04	0.01	0.06	0.11	0.01	0.01	7.38%
PRODUCT 35	0.02	0.06	0.13	0.02	0.08	0.15	0.11	0.13	0.19	0.04	9.40%
PRODUCT 36	0.17	0.05	0.05	0.01	0.09	0.03	0.14	0.14	0.15	0.11	9.45%
PRODUCT 37	0.02	0.04	0.11	0.10	0.19	0.02	0.03	0.21	0.07	0.04	8.41%
PRODUCT 38	0.17	0.04	0.06	0.06	0.02	0.10	0.12	0.14	0.21	0.02	9.47%
PRODUCT 39	0.07	0.10	0.12	0.11	0.13	0.10	0.03	0.01	0.12	0.04	8.35%
PRODUCT 40	0.11	0.01	0.17	0.04	0.10	0.11	0.15	0.09	0.10	0.04	9.26%
PRODUCT 41	0.03	0.05	0.13	0.03	0.07	0.09	0.07	0.12	0.14	0.10	8.31%
PRODUCT 42	0.13	0.01	0.14	0.09	0.00	0.18	0.03	0.05	0.01	0.00	6.40%
PRODUCT 43	0.20	0.01	0.09	0.23	0.11	0.05	0.14	0.01	0.10	0.09	10.25%
PRODUCT 44	0.04	0.10	0.14	0.04	0.11	0.06	0.07	0.14	0.09	0.12	9.17%
PRODUCT 45	0.01	0.09	0.07	0.26	0.27	0.08	0.06	0.04	0.02	0.05	9.28%
PRODUCT 46	0.27	0.05	0.19	0.22	0.04	0.03	0.02	0.04	0.08	0.04	9.91%
PRODUCT 47	0.21	0.07	0.07	0.07	0.20	0.01	0.00	0.07	0.08	0.07	8.61%
PRODUCT 48	0.26	0.10	0.15	0.12	0.06	0.08	0.04	0.02	0.01	0.06	8.91%
PRODUCT 49	0.08	0.04	0.14	0.03	0.23	0.05	0.05	0.08	0.03	0.16	8.96%
PRODUCT 50	0.05	0.02	0.03	0.01	0.22	0.03	0.39	0.02	0.05	0.07	8.93%
PRODUCT 51	0.07	0.03	0.02	0.05	0.01	0.09	0.20	0.13	0.09	0.12	8.12%
PRODUCT 52	0.04	0.32	0.12	0.10	0.10	0.06	0.03	0.03	0.00	0.07	8.75%
PRODUCT 53	0.02	0.09	0.00	0.18	0.08	0.12	0.13	0.06	0.15	0.08	9.20%
PRODUCT 54	0.10	0.12	0.19	0.01	0.13	0.04	0.13	0.03	0.24	0.00	9.92%
PRODUCT 55	0.10	0.03	0.08	0.00	0.08	0.02	0.01	0.14	0.25	0.08	7.94%
PRODUCT 56	0.04	0.02	0.15	0.35	0.09	0.13	0.01	0.07	0.14	0.02	10.17%
											9.18%

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4.5 Inventory management

For the analysis of the classical EOQ indicated in equation 1. The following relevant costs are considered. The cost of keeping each unit in inventory (Ch) is 5% of the selling price ($price$), the cost to order (Co) is \$3.75 for each unit requested and the level of service that has been considered for products in classification A of 95% according to equation 6 due to the importance, they represent for the company.

$$z_{score}(0.95) = 1.644854 \quad (6)$$

Likewise, the total cost incurred in such products will be considered (Table 4), which will allow the comparison of EOQ about the forecasts generated which are considering the seasonality of the products on an annual basis. Comparing the costs incurred when using the EOQ model (Equation 8) and the seasonal forecast (Equation 9), the inventory value is 14% lower, this demonstrates the effectiveness of an adequate estimate for increasing cash flow. The assumption of using seasonal forecasts considers a weekly order that covers the demand adjusted to this period based on the projected monthly demand. To absorb any variations that may exist is also considered a safety stock (Equation 7), taking into account service level (Equation 6) and delivery time.

$$SS = (\sigma)(z)\sqrt{L} \quad (7)$$

$$TC_{EOQ} = \left(\frac{D}{Q}\right)(Co) + \left(\frac{Q}{2}\right)(Ch) + \left(\frac{Q}{2}\right)(Price) \quad (8)$$

$$TC_{FCST} = \left(\frac{D_{fcst}}{2*4_{wk}}\right)(Co) + \left(\frac{D_{fcst}}{2*4_{wk}}\right)(Ch) + \left(\frac{D_{fcst}}{2*4_{wk}}\right)(Price) \quad (9)$$

Where:

SS = Safety stock,

σ = Standard deviation within the sampled values,

L = Lead time of each product,

TC_{EOQ} = Total costs related to a classical economic order quantity considering inventory value,

D = Forecasted demand for the whole planning horizon,

Q = Economic order quantity,

Co = Ordering cost for each product,

Ch = Holding cost within planning horizon,

$Price$ = Selling price for each product,

TC_{FCST} = Total cost associated with the proposed forecasting model,

D_{fcst} = Period specific forecasted demand.

5 Result and discussion

For the case study, it was found that traditional time series forecasting methods are not optimal due to the so variable nature of the demand in the products. Being that

the closest model is the centred moving average, with an error greater than 25%, so its application is not viable because its accuracy is only reasonable (Figure 2), directly affecting the level of service sought by the company. Although 20% MAPE is considered a good result [34], for the company's indicators, this is an inadequate value that would not satisfy the needs of its customers, as well as the value of inventory in each period. On the other hand, the implementation of forecast techniques that consider the seasonality of demand offers a highly accurate forecast. Calculating demand forecast with error minimum will help meet the objectives of the company without sacrificing service level.

It is observed that despite increasing the number of orders and changing the economic lot size, the savings in terms of inventory value continue to exceed the cost of ordering material. It combined with the lack of minimum order size for most of the products and having only one supplier, favours the implementation of this improvement. Importance of apply forecast methods, ABC classification and EOQ model is demonstrated that the total costs associated can be reduced. It is crucial to complement classical models with case-specific variables, such as in this scenario, the selling price had a key role in replenishment decisions. Before this study, the cost of materials was overlooked by the company, resulting in non-healthy stock levels for products with low demand. Beginning with the ABC classification, something new for the company, stakeholders will have the capability to focus their efforts to make sure the top products are always available for their customers and, in contrast, they will be able to carefully follow up those materials that do not have an added value and decide whether it necessary to keep them in inventory.

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Table 4 Total costs comparison

PRODUCT	Annual forecast (pieces)	Monthly σ (pieces)	Monthly demand (pieces)	Unit price (MXP)	SS (pieces)	Q* (pieces)	# of orders with EOQ	TC EOQ (MXP)	Monthly forecast (pieces)	TC Forecast (MXP)
PRODUCT 1	280	10.74	23	1,533.00	6	5	56	4,253.32	29	5,876.18
PRODUCT 2	268	8.97	22	1,533.00	6	5	54	4,244.32	15	3,039.40
PRODUCT 3	43	2.19	4	1,533.00	2	2	22	1,697.95	4	810.51
PRODUCT 4	52	3.89	4	1,533.00	3	2	26	1,714.84	9	1,823.64
PRODUCT 5	89	5.89	7	1,533.00	4	3	30	2,537.23	11	2,228.90
PRODUCT 6	151	7.53	13	2,173.00	5	3	50	3,627.56	25	7,175.60
PRODUCT 7	60	3.02	5	1,993.00	2	2	30	2,215.14	2	526.57
PRODUCT 8	135	5.99	11	1,945.50	4	3	45	3,247.54	19	4,883.45
PRODUCT 9	57	1.85	5	1,473.00	2	2	29	1,660.92	4	778.86
PRODUCT 10	298	5.05	25	1,071.00	6	6	50	3,576.00	28	3,967.67
PRODUCT 11	156	5.23	13	2,173.00	6	3	52	3,633.82	14	4,018.34
PRODUCT 12	54	3.61	5	2,173.00	3	2	27	2,393.77	4	1,148.10
PRODUCT 13	41	1.75	3	2,173.00	1	2	21	2,369.38	6	1,722.14
PRODUCT 14	129	6.61	11	2,173.00	4	3	43	3,600.04	28	8,036.67
PRODUCT 15	126	4.35	11	2,385.00	3	3	42	3,931.76	13	4,094.75
PRODUCT 16	100	4.27	8	2,385.00	3	2	50	2,703.74	11	3,464.79
PRODUCT 17	34	2.22	3	2,385.00	3	1	34	1,385.65	4	1,259.92
PRODUCT 18	50	1.79	4	2,385.00	1	2	25	2,609.92	3	944.94
PRODUCT 19	62	2.54	5	2,385.00	2	2	31	2,632.44	9	2,834.83
PRODUCT 20	37	1.80	3	1,993.00	2	2	19	2,171.98	2	526.57
PRODUCT 21	62	2.25	5	1,993.00	2	2	31	2,218.89	5	1,316.44
PRODUCT 22	39	1.19	3	2,185.00	1	2	20	2,378.28	5	1,443.03
PRODUCT 23	28	3.10	2	2,283.00	2	1	28	1,309.33	1	301.53
PRODUCT 24	392	19.14	33	352.50	11	12	33	2,353.85	45	2,112.91
PRODUCT 25	318	13.08	27	352.50	8	11	29	2,153.81	33	1,549.47
PRODUCT 26	209	13.69	17	352.50	8	9	23	1,760.59	21	986.02
PRODUCT 27	404	13.50	34	497.50	8	11	37	3,024.49	41	2,709.07
PRODUCT 28	105	5.74	9	617.00	4	5	21	1,706.10	16	1,309.33
PRODUCT 29	363	8.99	30	243.50	6	14	26	1,895.50	33	1,075.13
PRODUCT 30	477	7.72	40	148.50	5	21	23	1,730.20	43	862.23
PRODUCT 31	370	13.46	31	497.50	8	10	37	2,763.09	49	3,237.66
PRODUCT 32	212	5.40	18	497.50	4	8	27	2,198.84	30	1,982.24
PRODUCT 33	158	6.26	13	497.50	4	7	23	1,921.67	23	1,519.72
PRODUCT 34	185	10.71	15	497.50	6	7	26	1,936.15	21	1,387.57
PRODUCT 35	368	17.33	31	497.50	10	10	37	2,762.34	65	4,294.86
PRODUCT 36	170	6.24	14	542.50	4	7	24	2,094.26	26	1,872.23
PRODUCT 37	216	8.06	18	542.50	5	7	31	2,118.92	29	2,088.26
PRODUCT 38	134	4.88	11	542.50	3	6	22	1,800.77	19	1,368.17
PRODUCT 39	113	6.30	9	542.50	4	5	23	1,515.61	20	1,440.18
PRODUCT 40	266	14.34	22	542.50	9	8	33	2,414.06	23	1,656.21
PRODUCT 41	161	8.23	13	454.00	5	7	23	1,762.66	12	724.06
PRODUCT 42	1810	82.80	151	31.50	47	89	20	1,555.12	104	480.80
PRODUCT 43	3041	41.49	253	35.50	24	108	28	2,128.04	195	1,004.35
PRODUCT 44	192	12.11	16	320.00	7	9	21	1,599.21	11	469.35
PRODUCT 45	254	9.31	21	320.00	6	10	25	1,783.27	22	938.69
PRODUCT 46	172	6.51	14	320.00	4	9	19	1,590.87	14	597.35
PRODUCT 47	693	23.75	58	138.50	14	26	27	1,999.50	77	1,442.46
PRODUCT 48	410	13.71	34	151.00	8	19	22	1,594.33	45	917.17
PRODUCT 49	340	9.90	28	2,404.99	12	4	85	5,393.37	7	2,223.32
PRODUCT 50	1524	51.51	127	520.00	29	20	76	5,771.80	99	6,835.15
PRODUCT 51	2446	68.47	204	51.00	39	81	30	2,292.36	180	1,295.02
PRODUCT 52	1607	88.93	134	58.00	50	62	26	1,994.10	115	933.53
PRODUCT 53	2698	38.08	225	40.00	22	96	28	2,131.01	201	1,154.53
PRODUCT 54	178	7.12	15	398.00	4	8	22	1,763.01	19	1,006.12
PRODUCT 55	5261	126.84	438	133.00	142	73	72	5,391.80	351	6,320.78
PRODUCT 56	356	34.71	30	509.00	20	10	36	2,818.49	10	675.91
								139,833.03		120,692.68

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6 Conclusions

The time series methods are applicable for products where their demand is stable, with small variations or tendencies to high or low. Nevertheless, for those products in which demand can be variable as in the case of a retail company. It is necessary to analyse the historical sales for choosing an adequate technique that achieve a MAPE less than 10%, so it is a highly reliable forecast and complementing it with the safety stock. It will allow the company to comply with its service policy of 95%, without the need to have an excess of inventory or risks of lost sales. EOQ model does not consider lower inventory costs, demand fluctuations and special-order policies similar. This model involves costs across the entire planning horizon without analysing specific periods within it, which can reduce the cash flow of the company in specific periods, by not considering those low demand in specific periods and risking having shortages in those periods where demand increases.

Therefore, an accurate forecast can reduce inventory costs in each of the periods, satisfying customer demand, by at least 14% against the classic EOQ methodology. EOQ model should apply to all products for reducing the investment in slow-moving stock and improving the inventory for those highly demanded products which can generate flexibility to embrace market complexity and meet customer expectations in terms of quicker response to spot projects. It is also expected to strengthen the company's qualification to create a partnership between professional contractors to make them choose this company as the first option in their projects due to its high service level. As a future study, it is intended to help the company to develop a strategy to reduce non-rotating inventory knowing more accurately what and when they will sell specific products. This inventory management proposal might be complemented with a marketing campaign to enhance profit results and ultimately improve cash flow.

Another important future study should be consolidated product receptions in one single receiving location to distribute to all the company branches. Instead of having individual inventories, there might be a central location to replenish the stores in a frequent basis, considering the optimisation of the distribution costs associated to this further study, which would be a new variable added to the board. Seasonal demand model must be considered to find specific products that might not fit the proposed methodology since some of them have to be ordered in minimum quantities that might exceed the forecasted demand. For these exceptions, a different inventory management technique should be studied in future research.

Acknowledgement

This article was supported by the Ph.D. Patricia Cano Olivos as part of the Logistics and Supply Chain Management Master Program.

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