

Reduce Slow Moving Inventory of Convenience Stores: A Case Study

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Abstract

Traditional inventory models do not take into account various circumstances that are unique to a retail setting. The purpose of this study is to high light one such issue, namely, inventory management of slow moving items. The impact of all these decisions led the company to hold inventory levels of about 30 days on average with replenishment cycles of seven days. This work describes the efforts of the company to decrease inventory levels through the application of concepts associated to the forecasting and the impact of pack sizes for slow moving items. Results of the pilot studies of implementing the suggested initiatives are provided.

Keywords

Replenishment inventory; slow moving items; display inventory; retail echelon; erratic demand

1. Introduction

According to Kotler et al., (2003), the concept of retailing includes all activities involving the sale of goods or services for individual consumption (and which it is not for commercial purposes). In other words, retailing can be seen when retailers purchase products from a dealer and sell it again to other users (Nilsson, et al., 1987). The traditional approach to retailing states that whenever a customer need arises, retailers used to serve final customers from the stored inventory that they purchased based on forecasted data. Different categories of retailing are described in Kotzab (2005). These are Non store retailing (general mail-order, specialist mail-order, electronic commerce, etc), Store based retailing (retail stores, general merchandise retail stores, supermarkets, departments stores, discount stores, etc). Other types of store based retailing that have been discussed in literature are vending machines, kiosks, catalogue show rooms and gas stations.

According to the Food Marketing Institute (FMI) and the Grocery Manufacturers of America (GMA), (2000), the convenience store (C-store) sector represented by Seven & I Holdings occupies the position 20 among the top 250 retailing institutions in the world, as shown in Table 1. In the age of retail giants like Walmart and e-retailer Amazon, how do the small, corner convenience stores and bodegas compete? Food, fuel, and fast service are paving the way, and it all comes down to that key word: “convenience.” The National Association of Convenience Stores (NACS) defines a convenience store as: “a retail business with primary emphasis on providing the public a convenient location to quickly purchase from a wide array of consumable products (predominantly food or food and motor fuels) and services. The average convenience store is a mere 2,744 square feet, yet it serves as a one-stop destination for food, refreshments, tobacco products, motor fuels, and a wide variety of other items (NACS). 7-Eleven is the leading convenience store throughout the United States and Canada, followed by Circle K and Speedway stores (<http://www.mechtron.com/blog/how-do-convenience-stores-compete/#sthash.wkHIUSEu.dpuf>).

The Mexican C-S sector was located in position 11 among the first 15 biggest world markets in year 2014 with total sales of 8500 million dollars. These sales were generated by 17,450 stores established throughout Mexico. The leading company in this sector contributed with 12,853 stores and a market share of 88% in that year. This firm will be called “The One” hereafter. One of the greatest challenges of C-stores to be competitive refers to inventory

management. This is fundamental to maintain high levels of product availability and insure customer satisfaction. This aspect represents an important weakness for “The One”. The average level of inventory in stores for “The One” is estimated in 30 days which is considered very high considering replenishment cycles of seven days.

Table 1 Summary of best world retailers

Rank	Company	Retail Revenue (US\$M)	Operational Format	# Countries of Operation
1	Wal Mart Stores, Inc.	482,130	Hypermarket, Supermarket	30
2	Cotsco Wholesale Co.	116,199	Cash & Carry Warehouse Club	10
3	The Kroger Co.	109,830	Supermarket	1
4	Schwarz Unternehmenstreuhand KG	94,448	Discount Store	26
5	Walgreen Co	89,631	Drug Store Pharmacy	10
20	Seven & Holdings Co. Ltd	50,119	Convenience Store	19

This work has the purpose of describing the efforts of “The One” to decrease the level of inventory in the stores. The document is structured as follows. The first section presents an introduction and general context. Second section describes a summary of bibliographic research relevant to the problem of interest. The following section provides a description of the general methodology followed to treat the problem. Then, the application of this methodology is given in the fourth section, followed by the fifth section of results and conclusions.

2. Literature research in C-Store item forecasting and inventory management

Retailers are often dealing with an inventory replenishment environment in which deliveries are periodically (based on a delivery schedule per store), replenishment quantities are an integer multiple of a fixed case pack size, sales follow a weekly pattern with peak sales on Friday and Saturday and shelf space per SKU is limited. In practice, a complete inventory policy must include case pack size (order quantity) and shelf capacity as decision variables. In fact, this policy should be developed considering an alignment among the previous variables. However, such alignment and optimal decisions are difficult to achieve due to the existing fragmented approach to inventory decision making in retailing (see Figure 1). Although retail operations may be responsible for setting reorder points, shelf space decisions are often made by the retailer’s merchandising and/or marketing organizations. Furthermore, case pack size is generally determined unilaterally by the supplier on the basis of pallet dimensions, truck trailer dimensions, and packing machine capabilities (Food Marketing Institute (FMI) and the Grocery Manufacturers of America (GMA) 2000). As each party attempts to optimize the decision variable under their control, their efforts will not be completely effective in achieving full alignment (optimality) among case pack size (order quantity), shelf space, and reorder point.

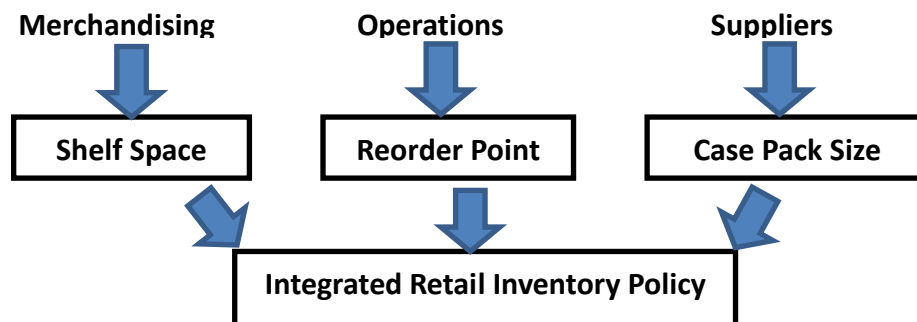


Figure 1 Retail inventory decision making elements

Donselaar et al., (2008) present a comparison of two inventory replenishment strategies in a retail environment; The Full Service (FS) strategy and the Efficient Full Service strategy. Both strategies represent an effort to integrate the

concepts of reorder point, case pack size and shelf space into a single inventory policy. In the Efficient Full Service strategy, if at a review period the inventory position, IP , is strictly below the reorder level s , we order the maximum number of case packs, Q , such that the inventory position (IP) after ordering is less than or equal to the shelf capacity V . Unless this IP is still below s , i.e., the shelf is not large enough to accommodate all units, then we order as many case packs as needed to bring the inventory position after reordering to (or just above) s . In summary: if at a review period IP is strictly less than s , the order quantity, q , becomes:

$$q = \max \left\{ \left\lfloor \frac{(V - IP)}{Q} \right\rfloor \cdot Q, \left\lceil \frac{(s - IP)}{Q} \right\rceil \cdot Q, 0 \right\} \quad \text{if } IP < s \quad (1)$$

The reorder level, s , is equal to the average forecasted demand during the review period, R , and delivery period, L , plus the safety stock, ss , for a given predetermined service level.

2.1 Forecasting and inventory management for C – F items

According to Putts (2014), a slow moving item “has a very low demand compared to the average products. Due to batch sizes the minimum order quantity of these products can be very high in comparison with the demand. This will result in ordering and storing a large quantity of products when the inventory level drops below the ordering point. A preliminary analysis has shown that for some slow moving items the minimum order quantity is enough to satisfy demand for a whole year.” Figure 2 presents an example of the demand pattern behaviour of a C – F item. In short, these items present an intermittent demand pattern with very infrequent demand arrivals and high demand variability.

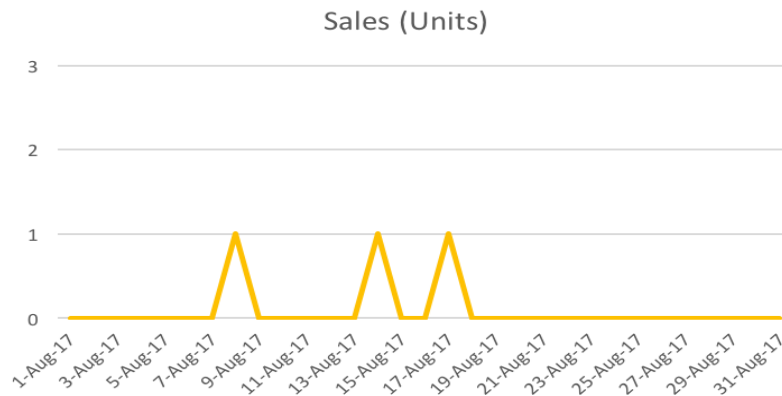


Figure 2 Illustration of the demand pattern behavior for chocolate turin

The accuracy of a forecasting method for a particular product depends on characteristics exhibited by the product’s demand history. Consequently, demand time series are sometimes divided into several discrete categories in order to assign the best forecasting method. The idea of categorizing demand patterns initially appeared in Williams (1984), who studied the classification of products by demand type, stock control policies for different categories of products, and methods of forecasting demand for the different categories of products. A new approach to this problem was suggested by Syntetos et al., (2005) (to be called SBC hereafter). SBC categorize demand based on the expected mean square error of each forecasting method under some assumptions. They compare the method suggested by Croston (1972) (hereafter CRO) and a bias-adjusted version of Croston’s method due to Syntetos et al., (1999) and hereafter referred to as SBA. From this comparison they propose the four discrete categories of demand shown in Figure 3 which they label ‘erratic’, ‘lumpy’, ‘smooth’ and ‘intermittent’.

The four quadrants are uniquely specified by two parameters p and v , where p is the average inter-demand interval and v is the squared coefficient of variation of the demand when it occurs. SBC argue that CRO should only be used for smooth demand series and that demand series from the other three quadrants are best forecast using SBA. The threshold values defining the quadrants are given as $p = 1:32$ and $v = 0:49$ respectively. Both CRO and SBA use a smoothing constant α for producing exponentially smoothed estimates of positive demands. They also both use the parameter p to denote the average inter-demand interval.

An interesting mechanism for improving the forecasting performance was recently provided by Nikolopoulos et al., (2011). This is called “An Aggregate-Disaggregate Intermittent Demand Approach (ADIDA)”. This approach is mainly based upon a non-over-lapping temporal aggregation of demand in higher level time buckets (say, from days into weeks for example). The result of the application of this tool is the reduction of zero-demand periods, having a new demand pattern showing a smoother behaviour with lower variability levels. The authors suggest the use of periods equal to the review period plus the response lead time when a company is using periodic review management inventory systems.

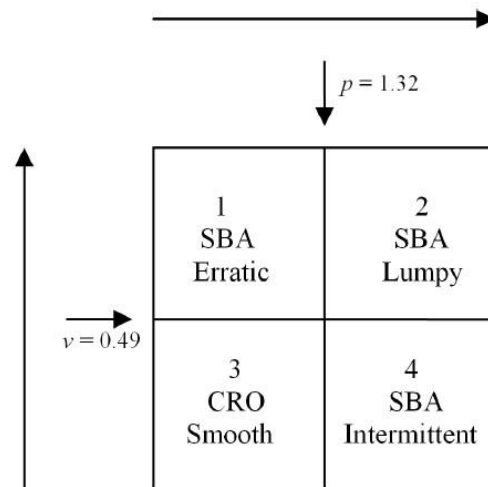


Figure 3 Illustration of intermittent demand pattern categories

2.2 Description of scheme for improving inventory level

This case study was solved using the following steps.

1. Describe the general context of the firm of concern, and its problem.
For our case, this included the study of the supply chain structure and identifying the level(s) where the problem of inventory was occurring. In addition, it was important to make a pareto analysis of the items involved and their contribution to inventory.
2. Analyze the characteristics of the demand patterns of the products of interest.
This step is intended to find areas for improvement in the relation of the demand patterns of the items to the corresponding forecasting procedures used at the time. The use of Syntetos matrix (Syntetos et al., 2005) is used for these purposes.
3. Describe the current forecasting and inventory management methodology for stores.
The parameters of the original forecasting techniques and their accuracy performance are estimated.
4. Identify areas for improvement and define improvement initiatives.
The identification of improvement options such as changing parameter values, forecasting techniques or the application of improvement schemes such as ADIDA (Nikolopoulos et al., (2011) is defined from the previous two steps. This may include simulation trials with historical demand data to assess the possible benefits.
5. Validate solutions with the application of pilot programs.
The previous benefits are validated with the implementation of pilot programs.

3. Application of Methodology

The leading C-store company, “The One”, has grown in an impressive manner during the last decade. The supply chain structure includes 16 Regional Distribution Centers (RDC) that service a total of 15, 225 store outlets as of the end of year 2016 with a market share of 88% in Mexico. “The One” has a two-echelon divergent inventory system, also known as the one warehouse and N-retailers inventory system (Axsäter, 1990).

All inventories managed in “The One” use a periodic review system. The average level of inventories per store is estimated in 30 days (see Figure 4).

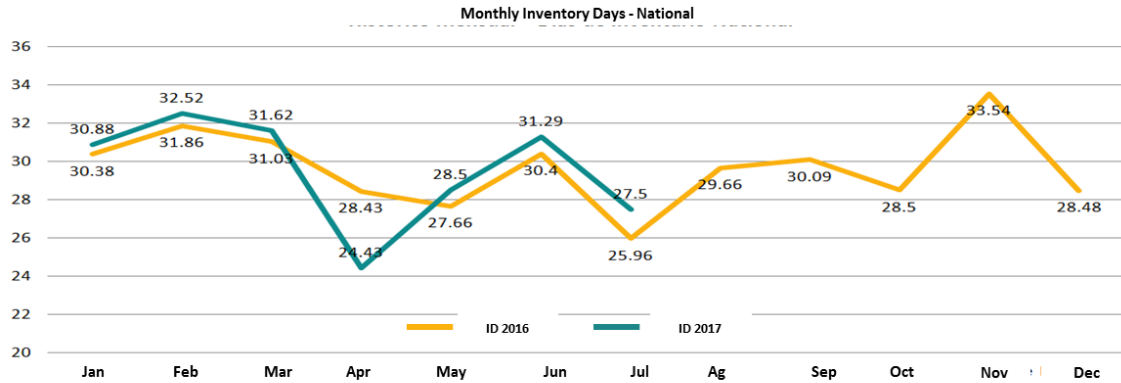


Figure 4 Monthly inventory pattern level per store

A further analysis of the importance of the different type of items is presented in Figure 5 using a Pareto analysis. Items type A and B represent 80% of the sales volume. However, their inventory levels are the lowest among the rest of the types. On the other hand, C - F items which account for the remaining 20% of sales volume are the ones with the highest levels of inventory days. These latest types of items are part of the so called slow moving items (Putts 2013). Given the results previously illustrated, the management of “The One” decided to pursue inventory reduction efforts for C – F items.

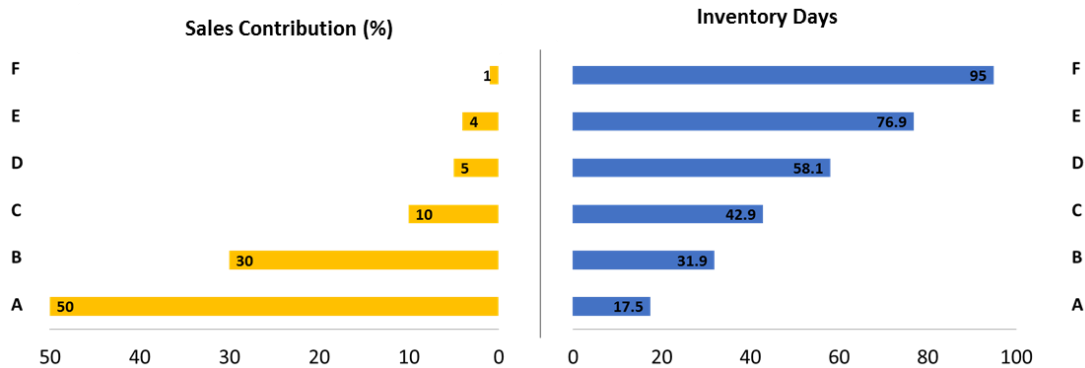


Figure 5 Level of importance of different types of items in inventory level

3.1 Description of current forecasting and inventory management schemes for C – F items

Before embarking into the description of the forecasting and inventory management schemes for items C – F, it is important to review their demand patterns behavior. For this purpose, a matrix suggested by Syntetos et al., (2005) is used. Figure 6 illustrates that the demand pattern for C – F items is intermittent and can be classified as lumpy and erratic.

Currently, the forecasting and inventory management scheme used by “The One” for handling C – F items is described as follows. The inventory management system is a periodic review order up to system. The review period is one week and the replenishment delivery frequency is twice per week. This system includes a reorder level, M, calculated as the average demand during the review period plus the delivery response time and the maximum between safety stock or the display inventory of the item. This is described by the following expression.

$$M = d*(T+L) + \text{Max} (SS, DS) \quad (2)$$

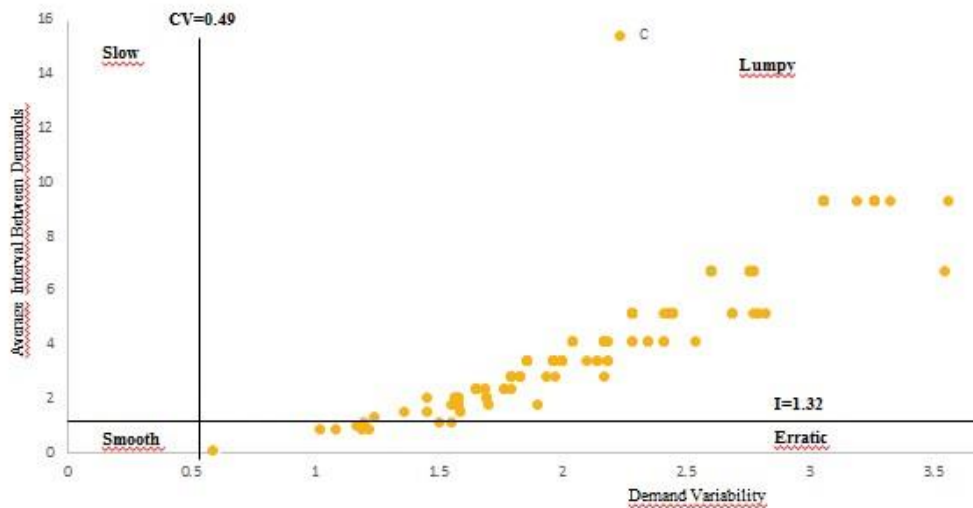


Figure 6 Classification of C – F items according to Syntetos et al., (2005)

$$DS = 0.3(d)(T+L) \quad (3)$$

Where, d represents the daily demand forecast, T stands for the review period, L is the delivery response time, SS is the safety stock and DS is the display stock of the item. Daily demand is forecasted using moving average procedures. Operatively, every time the level of available inventory position level of an sku at a given store is less than or equal to M , an order of size equal to M minus the current position is placed. Furthermore, If the item is supplied in case packs, the order size is rounded up to multiples of the case pack size. This expression is similar to the one described by equation (1). However since

$$M \geq s, \text{ then } q_{\text{OXXO}} \geq q \quad (4)$$

3.2 Identification of inventory reduction initiatives

Given the previous description of the forecasting and inventory management procedures for C – F items, the identified potential improvement initiatives are the following (1) replace the forecasting procedure from moving averages to CRO or SBA, in accordance to Syntetos et al., (2005) and the formula for determining the amount to order, q ; (2) Review the policy of setting order sizes equal to multiples of case pack sizes, and; (3) review the option of deleting items from the store catalogue.

Reviewing the forecasting procedure

From Figure 3, it was concluded that most of the C – F items have a demand pattern that is mostly lumpy and erratic. Therefore, according to Figure 6, Syntetos et al., (2005) recommend the application of the SBA forecasting procedure for this type of demand pattern. The company is currently using moving average procedures for this task. Hence, it seems that changing the method would improve forecasting precision. Furthermore, the estimation of the parameter, M , will be better with a good chance of being lower.

As previously mentioned in section 2.1, an interesting mechanism for improving the forecasting performance was recently recommended by Nikolopoulos et al., (2011). This is called “An Aggregate-Disaggregate Intermittent Demand Approach (ADIDA)”. Even though this new tool was originally suggested for intermittent demand items, it can also prove useful for non-intermittent demand items as shown by Spithourakis et al., (2011). The tool contemplates four steps; (1) Gather original data; (2) Apply a non-overlapping temporal aggregation at an aggregation level, A ; (3) Extrapolate the aggregate time series by means of a forecasting method, F , and; (4) Disaggregate aggregate forecasts back to the original time scale via a disaggregation algorithm, D .

Thus, in our case, the first step carried out was the application of the ADIDA process. Thus, a significant amount of demand data occurred from September to November of 2016 for 107 items of the Tijuana plaza was selected to apply ADIDA in a pilot program of one month. The aggregation period chosen was equal to the review period of one week. The result of this process is illustrated in Figure 7. As shown, the new demand patterns for the items modified their category making them smoother. Under this new category, it will be possible to apply the CRO technique.

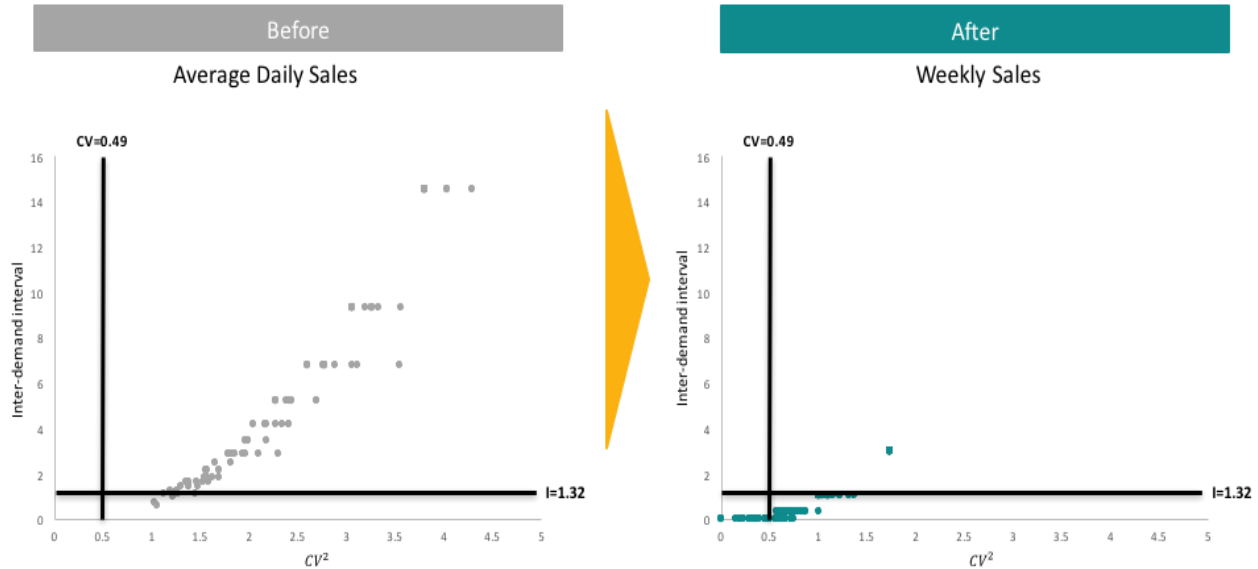


Figure 7 Illustration of the application of the ADIDA process and the CRO procedure

The initial value for the average Mean Absolute Deviation (MAD) and average Mean Square Error (MSE), before applying ADIDA and the CRO procedure were estimated as 2.01 and 5.99 respectively. After the pilot program these two measures decreased 36.3% (to 1.28) and 56.4% (to 2.61) respectively. These results imply important savings in safety stock levels.

Review policy of setting order size to multiples of case pack size

An analysis of the C - F item orders placed resulted that there was an 87% of items in excess with respect to the real requirements. Also, as shown in Table 2, the order sizes for some product families, such as water items, tobacco, candy, crackers and juices present excesses above 50% due to rounding up to their respective pack sizes.

Table 2 Illustration of excess over items pack sizes

Product Types	C-F
Edible Groceries	18%
Water Jugs	25%
Purified Water	62%
Alternative drinks	48%
Snacks	15%
Cigarretes	69%
Party Supplyes	-5%
Candies	71%
Cookies	56%
Home Hygene	7%
Personal Health and Hygine	11%
Juices	55%
General Merchandise	0%

The original rule follows the expression given in equation (1). Those C – F items with pack size will always have a q value rounded up to multiples of it. Since there is always the chance to correct potential stockout situations every replenishment cycle, it was plausible to evaluate the possibility of eliminating the last pack size of the order. Thus, equation (1) was modified to consider the previous modification provided that the Expected Stockout Cost per Replenishment Cycle is greater than or equal to the Cost of Keeping Inventory per Cycle of the Pack Size. This change seemed logical provided the low daily demand of the C – F items. The previous new rule was tested with a pilot program during two months for 20 sku´s in the Mexicali city stores. The number of orders considered in the program were 17, 808. The results provided in Table 3 indicate that about 56.4% of the orders did not require the last pack size. The orders requested 142,703 items of which 104,172 were not included, which imply an important reduction of inventory.

Table 3 Illustration of the results of the new rule for order rounding up

1	REPL_DA	INV + 1	CLAVE	Probabilid	Pronóstico	\$Stockout	\$Inventario	DECISIÓN
2	13/10/2017	4	4 Trident 20s Menta 27.2G	1.89%	0.04	-\$ 0.16	\$ 0.32	No pedir
3	18/09/2017	7	7 Chocolate Turin Baileys 3 Pack 30g	0.49%	0.31	-\$ 0.08	\$ 0.58	No pedir
4	12/10/2017	7	7 Chocolate Turin Baileys 3 Pack 30g	0.49%	0.31	-\$ 0.08	\$ 0.58	No pedir
5	04/09/2017	5	5 Trident 20s Menta 27.2G	0.95%	0.04	-\$ 0.11	\$ 0.33	No pedir
6	01/09/2017	16	16 Chocolate Turin Baileys 3 Pack 30g	0.00%	0.31	\$ -	\$ 0.58	No pedir
7	01/09/2017	6	6 Chocolate Turin Baileys 3 Pack 30g	0.78%	0.31	-\$ 0.11	\$ 0.58	No pedir
8	01/09/2017	7	7 Chocolate Turin Baileys 3 Pack 30g	0.49%	0.31	-\$ 0.08	\$ 0.58	No pedir
9	04/09/2017	7	7 Chocolate Turin Baileys 3 Pack 30g	0.49%	0.31	-\$ 0.08	\$ 0.58	No pedir
10	04/09/2017	8	8 Chocolate Turin Baileys 3 Pack 30g	0.29%	0.31	-\$ 0.06	\$ 0.58	No pedir
11	04/09/2017	8	8 Chocolate Turin Baileys 3 Pack 30g	0.29%	0.31	-\$ 0.06	\$ 0.58	No pedir
12	05/09/2017	7	7 Chocolate Turin Baileys 3 Pack 30g	0.49%	0.31	-\$ 0.08	\$ 0.58	No pedir
13	05/09/2017	5	5 Chocolate Turin Baileys 3 Pack 30g	1.71%	0.31	-\$ 0.18	\$ 0.57	No pedir
14	05/09/2017	6	6 Chocolate Turin Baileys 3 Pack 30g	0.78%	0.31	-\$ 0.11	\$ 0.58	No pedir
15	06/09/2017	5	5 Chocolate Turin Baileys 3 Pack 30g	1.71%	0.31	-\$ 0.18	\$ 0.57	No pedir
16	08/09/2017	16	16 Chocolate Turin Baileys 3 Pack 30g	0.00%	0.31	\$ -	\$ 0.58	No pedir
17	08/09/2017	5	5 Chocolate Turin Baileys 3 Pack 30g	1.71%	0.31	-\$ 0.18	\$ 0.57	No pedir

Analysis of updating store item catalogue

The last initiative considered in this effort for reducing slow moving items is the update of the store catalogue. This initiative is undertaken given that the catalogue had not been reviewed during the last 5 years. An analysis of the importance in total sales of all the items carried by the stores revealed that 47% of the (F) items accounted for only 1% of the sales. Many of them were supplied in pack sizes. This meant that less than one item was sold per month and it was necessary to store the whole pack. After an evaluation of the cost involved on keeping them in inventory, the management responsible for the project decided to make an initial and definitive deletion of 9% of the F items at national level.

3.3 Impact of the implementation of initiatives on inventory

The impact on inventory of the previously described initiatives is described in this section. Table 4 illustrates a summary of these impacts. The main contribution is given by the application of a new forecasting technique and period (from daily to weekly) for C – F items, enabled by the application of the ADIDA tool ([12]). The estimated impact of 3.2 days is based on the results of the pilot program.

Table 4 Summary of impact on total inventory days of initiatives

Initiative	Impact in days
Modification of forecasting method and of reorder point	3.2
Modification of rounding up to case pack sizes	2.5
Elimination of F items in catalogue	0.5
Total	6.2

The next most important contribution comes from the implementation of a new rule of rounding up to case pack sizes. This is estimated in 2.5 days. Finally, even though the deletion of F items of the national catalogue has a limited impact on the total inventory level, with 0.5 days, it represents the first step towards a more dynamic scheme of updating it. This exercise motivated higher management to establish an annual review of the catalogue

incorporating an economic point of view. Thus, the total improvement on the level of inventory of the stores is estimated in 6.2 days.

4. Conclusions and recommendations

The level of competitiveness of the C – store retailing sector is dependent on the level of product availability at the store. Under these circumstances, the effectiveness with which inventory management is performed becomes very important. Too much is expensive, and too little implies the appearance of more frequent stockouts.

The case of study treated in this paper deals with the management of inventories of C – F items for the leading network of C – stores in Mexico. The company was dealing with the problem of having excessive level of inventories in its stores in terms of days of inventory. An exhaustive analysis of the contribution to this excess was developed and found that the C – F categories of items were very important. Thus, three initial initiatives were designed and implemented in corresponding pilot programs; modifying the forecast procedure for the items; changing the rounding up to case pack sizes rule and; eliminating the F items from the national catalogue of the company.

The impact expected with the full implementation of the previous initiatives totals 6.2 days of inventory in the stores. This additional work is programmed to be carried out during the first semester of 2018. Further research work to be done will focus on the application of the ADIDA scheme for the forecasting of items A and B.

References

- Kotler, P. & Keller, L. K., *Marketing Management*, 12ed. Upper Saddle River, New Jersey, Prentice Hall, 2003.
- Nilsson, J. & Høst, V., *Reseller Assortment Decision Criteria*, Aarhus University Press, Denmark, 1987.
- Kotzab, H., *Retailing in the context of IT and distribution, Retailing in a SCM-Perspective*. H. Kotzab and M. Bjerre. Copenhagen, Copenhagen Business School Press, 2005.
- Deloitte, *Las Potencias Globales del Comercio Detallista*, Galaz, Yamazaki, Ruiz Urquiza, S.C., 2017.
- Food Marketing Institute (FMI) and the Grocery Manufacturers of America (GMA), *Case Pack Optimization: Supply Chain Economics of Variations in Case Pack Quantities for Consumer Packaged Goods*. Food Marketing Institute (FMI) and the Grocery Manufacturers of America (GMA), Washington, DC, 2000.
- Van Donselaar, K.H. and Broekmeulen, R.A.C.M., *Inventory replenishment in retail : the efficient full service strategy*, (BETA publicatie : working papers; Vol. 243). Eindhoven: Technische Universiteit Eindhoven, 2008.
- Puts, L.C.G.A., *Slow moving items in grocery supply chains at Sligro Food Group*”, MSc Thesis, Eindhoven University of Technology, The Netherlands, 2014.
- T. Williams, *Stock Control with Sporadic and Slow-Moving Demand*, *Journal of the Operational Research Society*, Vol. 35, pp. 939-948, 1984.
- Syntetos, A. and Boylan, J., *The Accuracy of Intermittent Demand Estimates*, *International Journal of Production Economics*, Vol. 71, pp. 303- 313, 2005.
- J. D. Croston, *Forecasting and Stock Control for Intermittent Demands*, *Operational Research Quarterly*, Vol. 23, pp. 289– 303, 1972.
- Syntetos , A. and Boylan J., *Correcting the bias of forecasts of intermittent demand*,. Presented at the 19th International Symposium on Forecasting, June 1999, Washington DC, USA, 1999.
- Nikolopoulos, K., Syntetos, A., Boylan, J.E., Petropoulos, F. and Assimakopoulos, V., *An Aggregate – Disaggregate Intermittent Demand Approach (ADIDA) to Forecasting: An Empirical Proposition and Analysis*, *Journal of the Operational Research Society*, Vol. 62, No. 3, pp. 544 – 554, 2010.
- Axsater, S., *Inventory Control*, Kluwer Academic Publisher, Boston, MA., 2000.
- Spithourakis, G., Petropoulos, F., Babai, M.Z., Nikolopoulos, K. and Assimakopoulos, V., *Improving the Performance of Popular Supply Chain Forecasting Techniques*, *Supply Chain Forum*, Vol. 12, No.4, pp. 16 – 25, 2011.

Biographies

Bernardo Villarreal is a full professor of the Department of Engineering of the Universidad de Monterrey. He holds a PhD and an MSc of Industrial Engineering from SUNY at Buffalo. He has 20 years of professional experience in strategic planning in several Mexican companies. He has taught for 20 years courses on industrial engineering and logistics in the Universidad de Monterrey, ITESM and Universidad Autónoma de Nuevo León. He

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Jesús Vazquez Hernández is a Ph.D. Professor & Business Consultor Professional with more than 15-year experience in Operations and Supply Chain Management. Proven record of success leading Supply & Demand Chain strategy projects across multi-cultural teams, implementing business solutions and process improvement, with a TLS – TOC + Lean + Six Sigma mindset. Strong people management capabilities, team leadership and cross-team collaboration approach. Key strengths in analytical thinking, problem solving and people development skills. Certified as: Project Manager Professional (PMP), Jonah degree by the Goldratt Institute regarding the Theory of Constraints (TOC), and 2 Master degrees

Estefanía Quintanilla is a CUM LAUDE Industrial Engineer graduated from Universidad de Monterrey (UEM). Her specialty is strategic planning and the operations and logistics improvement. She has participated on several projects such as The Redesign of the Supply Process of Drugs on a Medical Center and the Improvement of the routing operations of a soft drink bottling firm. Nowadays, She works at FEMSA S.A. de C.V., developing operations strategies for improving quality and productivity. Estefanía is a member of the IISE, ASQ and APICS Societies.

Mariana Herrera is a CUM LAUDE Industrial Engineer just graduated from Universidad de Monterrey (UEM). She has participated on several projects such as the Improvement of the routing operations of a leading convenience store firm. She also applied Lean Thinking principles for Improving the Productivity of several metal assembly lines for a Mexican metal mechanic company. Currently, she has started to work at a Mexican firm leader in the manufacturing of frozen and refrigerated food as a transportation and traffic analyst. Mariana is a member of the IIE and ASQ Societies.

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