Impact of Increasing Replenishment Frequency on Convenience Store Inventory: A Mexican Case

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Abstract

The purpose of this work is to apply a strategy for reducing the inventory replenishment cycle time for a Mexican Convenience Store Supply Chain. This strategy is structured with the aim of reducing the store inventory level from about 30 days on average. This work describes the efforts of the company to decrease the delivery cycle time by increasing the inventory replenishment frequency in the Metropolitan Monterrey area. Results of simulation and pilot studies of implementing the suggested initiatives are provided.

Keywords
Inventory reduction, frequency of replenishment, order cycle time, logistic network reconfiguration, periodic review inventory strategy

1. Introduction
The convenience store (C- S) sector occupies the position 20 among the top 250 retailing institutions in the world (The Food Marketing Institute (FMI) and the Grocery Manufacturers of America (GMA), 2000). How do the small, corner convenience stores compete against retail giants like Walmart and e-retailer Amazon? 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 (Gerke Economics 1989). The average convenience store size is about 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).

The Mexican C-S sector with total sales of 8500 million dollars, was positioned 11th among the biggest world markets in year 2014. These revenue was generated by 17,450 stores operating 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 for The One to be competitive refers to inventory management. This is the key to maintain high levels of product availability and ensure customer satisfaction. This aspect represents an important weakness for "The One". The average level of store inventory for "The One" is estimated in slightly higher than 40 days which is considered very high considering replenishment cycles of seven days.

This work has the purpose of describing the efforts of "The One" to decrease the level of inventory in the stores by increasing their inventory replenishment frequency and reducing their order cycle time in the area of metro Monterrey. 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 inventory reduction

Retailers are often dealing with inventory replenishment environments in which deliveries are periodic (based on a delivery schedule per store). Inventory replenishment quantities are generally integer multiples of fixed case pack sizes, sales follow weekly patterns with peak sales on Friday and Saturday and shelf spaces per Stock Keeping Unit (SKU) are limited. In practice, a complete inventory policy must include case pack size (order quantity) and shelf capacity as decision variables. Therefore, this policy should consider an alignment among the previous variables. However, such alignment and optimal decisions are difficult to attain due to existing fragmented approaches to inventory decision making in retailing.

Even though retail operations may be responsible for determining reorder points, shelf space size and layout are often defined by the retailer's merchandising and/or marketing organizations. Furthermore, case pack size is unilaterally determined by the supplier on the basis of pallet dimensions, truck trailer dimensions, and packing machine capabilities (Food Marketing Institute and the Grocery Manufacturers of America, 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. Donselaar et al. (2008) present two options of inventory replenishment strategies in a retail environment that include all the previous variables into a single inventory policy. The Full Service (FS) strategy and the Efficient Full Service (EFS) strategy. In particular, in the Efficient full Service strategy, as shown by equation (1), if at the 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:

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

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

According to Barnes (2014), both retailers and distributors have historically attempted to solve their inventory challenges by using better forecasting tools to determine what to buy and when to buy it. However, the author considers that a better approach is to change the flow of inventory by reducing cycle times, more effective inventory positioning, and synchronizing supply chains based on the variability of demand.

Cycle time is determined by the sum of the review period and the delivery period. Therefore, decreasing both will diminish average cyclic inventory. Under this situation, it is most probable that the order quantity q will be reduced. Reducing the review period results in an increase of the number of replenishment times, or replenishment frequency. Increasing replenishment frequency impacts also the distribution cost by the need of additional trips to satisfy a store demand.

As described in the Seven-Eleven Japan (SEJ) Annual Report 2012 (Seven and I, 2012), the second strength of its Business Model consists of implementing a strategy for serving markets with highly concentrated population. This is achieved through a distribution system that leverage distinctive characteristics, mainly distance, of high store densities. A main factor for attaining economic feasible higher replenishment frequency levels is store density. The most clustered the stores the better. Under this condition, daily replenishment delivery becomes a feasible strategy. High-density, concentrated store openings are the foundation on which SEJ could offer high-value-added products and services every day.

According to Naruo, et al. (2007), SEJ attained greater sales levels combined with reductions on store inventory level. It used to be wrong common sense in retail that "much merchandise in store enables large sales". Instead, SEJ reduced the number of SKU´s and eliminated slow-moving items. The previous initiatives impacted in a reduced inventory level that enabled a financial cost reduction and a favorable store image change. Due to lower inventory levels, stores had the opportunity of including new items according to market variations and satisfy new needs from customers. Also, Naruo, et al. (2007) point out several benefits obtained in SEJ´s distribution system. In particular, the number of routes, and hence of trucks, was decreased by increasing the delivery frequency. Therefore, this made possible a drastic reduction of distribution costs. Further, inspection workload at the store side was reduced. On the other hand, store operators could now concentrate on sales and customers in the store. The SEJ success is based on the design of a combined distribution center (CDC) by product category and by the required temperature level. CDC´s are operated by a vendor's representative, or by an independent third party.

Similar to SEJ´s success experience, 7-Eleven America also excelled at driving individual daily orders from stores to its customers according to Mr. Dean Burkett, Director of Demand Planning and Replenishment for 7-Eleven America (O´Connor, 2016). Through proprietary handheld inventory and ordering systems, 7-Eleven store operators place their orders by 10 a.m. each day for deliveries out to the store that same day. The computer system promptly combines these orders and transmits them to the CDC´s, commissaries and bakeries that support these stores across North America. Most of the 10,700 7-Eleven stores operating in North America do not have backroom stocks at all. Their store shelves are stocked by making daily deliveries to each store using a complex but very effective supply chain. The company implemented first a daily delivery of fresh foods, bakery items and other perishable products throughout its nationwide network in 1994. At that time, 7-Eleven set up a sophisticated preparation and distribution system designed to minimize the number of daily deliveries to the stores from multiple suppliers. These centralized distribution centers (CDC´s) have turned out to be very beneficial.

According to the Fung Business Intelligence (2017), an important trend (#7) in the Asian Distribution and Retail area concerns the development of new retail business models. Small-sized retail formats such as convenience stores are enjoying stronger growth over recent years. They have the advantage of having closer access to their target market and the ability of offering faster response and customer convenience.

3. Definition of the inventory reduction strategy

As previously mentioned in the introduction, the leading company in the convenience store sector presents an important weakness. The average level of inventory in stores for "The One" is estimated in slightly higher than 40 days which is considered very high considering replenishment cycles of seven days. The company is located throughout the country with a distribution network supported by 19 distribution centers (DC), 10 transshipment points (TP) and 2 specialized transshipment points. Every DC supplies a group of stores denominated as plaza (see Figure 1).

Figure 1. Description of the distribution network

Figure 2 illustrates a store density map of all the plazas in Mexico. The plazas located in Metro Monterrey, Saltillo, CDMX and Guadalajara present the areas with the highest densities. These areas are worth of an analysis for increasing the delivery frequency. The delivery frequency to stores at the national level is of two visits per week 76% of the time. Only 5% of the stores are replenished 5 or 6 times weekly. Even though the current number of stores with 5 or 6 visits is small, we made a comparison of the average store inventory level versus those with two visits per week.

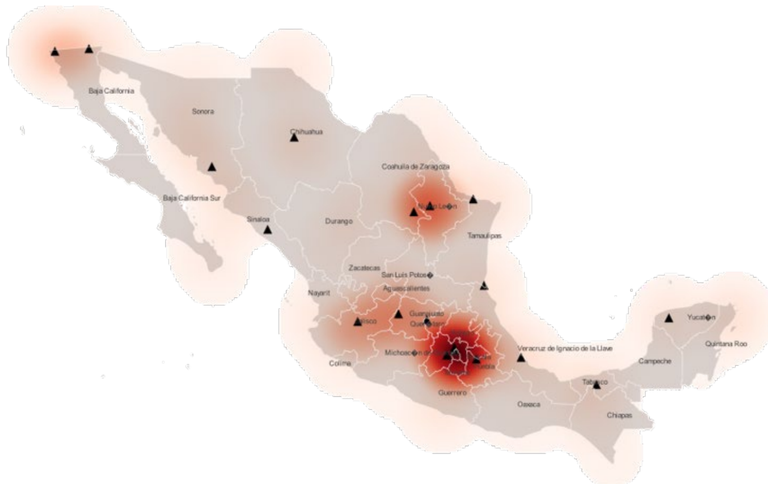

Figure 2. Description of store density map

Figure 3 illustrates that those stores with two visits have 16.5 days of inventory in excess (70% approximately) than those with 5 or 6 visits. Further, it should be pointed out that the previous stores are mostly located in plaza Azcapotzalco, CDMX and are part of a pilot test implemented by the company since the beginning of 2018. The plaza of Azcapotzalco is located at one with the highest store density of the country. The operational and financial performance of the pilot program in Azcapotzalco have been very satisfactory. Sales per store have increased 19% with stockout rates decreasing 24%. The value of inventory levels has been reduced 13%. Routes have grown 50% in clients and the service time per store have decreased about 50%. These results from the pilot test have encouraged the company to pursue the implementation of the strategy of increasing store delivery frequency.

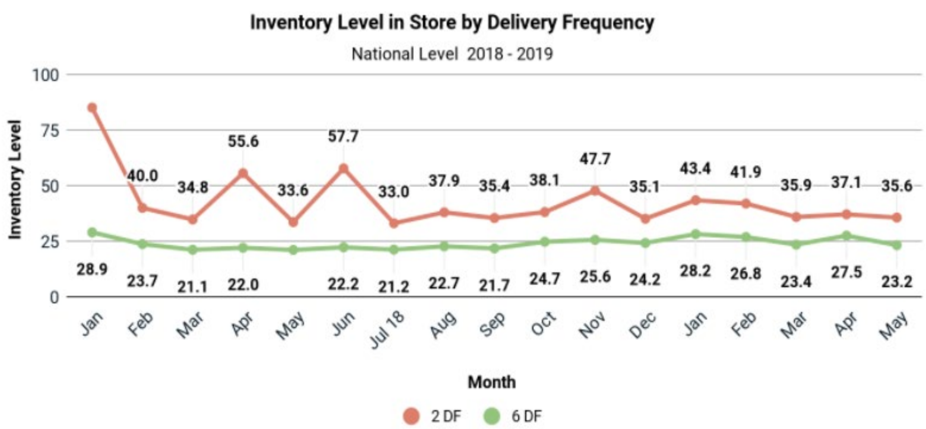

Figure 3. Description of days of inventory versus frequency delivery

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4. Reducing cycle time in Monterrey mega plaza

As illustrated in Figure 4, the cluster of stores located in the Monterrey mega plaza present store densities in the range of 0.26-2.54 stores per squared kilometer better than those shown in Japan (with 0.008-1.210 stores per squared kilometer). This condition allows the possibility for enabling daily delivery to replenish store inventories. Therefore, this work focuses on describing the efforts of "The One" to evaluate the option of increasing the store delivery frequencies for the mega plaza of Monterrey. The total of stores served by the DC located in Monterrey is 1698 dispersed in 4 plazas; centro, sur, norte and oriente. The plaza with the highest store density is plaza centro. The average inventory level of the stores is estimated on 30.3 days.

Figure 4. Illustration of store densities of Japanese Prefectures and Metro Monterrey

4.1 Defining delivery frequency values

The problem of defining the values of the delivery and replenishment frequency per store using mathematical methods has been treated in the literature. The works (Speranza and Ukovich 1994, Speranza and Ukovich 1996a, Speranza and Ukovich 1996b and Kerslake 2005) are relevant examples of these efforts.

The paper developed by Kerslake (2005) applied a simulation scheme to obtain the optimal delivery frequency values for a Grocery Chain X (to be called GCX hereafter). This scheme is built as a generic model in MS Excel that could simulate the existing ordering process for a given store. Currently, GCX defines the number of deliveries per week from the DC to a store based on its average weekly sales volume. To create a simulation that could accurately model the reorder and replenishment systems of Grocery Chain X, one has to fully understand the forecasting system and the Supervised Reorder System (SRO). The model did not include the definition of the truck routes in its scope. GCX is a supermarket chain with approximately 200 retail stores located throughout New England. The stores vary greatly in physical size and sales volume and have a wide range of delivery schedules.

The current work developed in this paper complements the previous scheme given by Kerslake (2005) by adding detailed routing procedures to better determine optimal distribution routes, transportation costs and the delivery frequency values that maximize earnings for the plazas served by the DC of metro Monterrey. The objective function includes sales and the costs of operating the DC and store network, distribution and keeping inventories. The values of the delivery frequencies considered are in the range of 1 to 6 per week. Figure 5 presents the main steps designed for the scheme utilized to obtain the delivery frequencies (Villarreal et al. 2021).

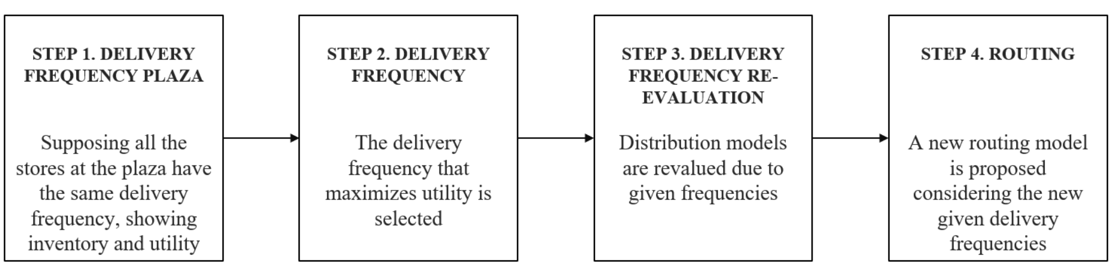

Figure 5. Description of scheme to determine delivery frequencies

The basic steps included are; the estimation of distribution and inventory keeping costs for each delivery frequency for each store of the plaza. Then, the frequency that maximizes profits for each store is chosen. Finally, the distribution costs are re-evaluated with the application of store routing procedures re-assessing optimal delivery frequencies per store.

5. Implementation of improvement initiatives

The initial stage of the implementation of the improvement strategy consisted on using the scheme for estimating the optimal delivery frequencies for 1588 stores located in metro Monterrey. Table 1 illustrates the resulting optimal delivery frequencies for the stores achieved with the scheme. The number of stores with 2 visits per week decreases 95%. These stores increase their frequency visits mainly to 5.

Table 1. Optimal delivery frequency values for stores located on Monterrey

Delivery frequency	1	2	3	5	6
Number of stores	0	74	234	1260	20

Originally, the next step of the implementation of the improvement strategy would correspond to a pilot program for a statistically significant sample of stores with delivery frequency of five. However, in order to proceed, it was also necessary that the DC operations could support the changes required to enable increased delivery frequencies. Due to this obstacle, the authors decided to proceed the work developing a simulation of the routing operations (Fatima et al. 2020) under the scenario with stores having delivery frequency of five times per week and located in plaza centro. The simulation included the use of an Oracle routing software. Figure 6 presents the routes designed with the previous system.

Figure 6. Illustration of new distribution routes for plaza centro

Table 2 presents the impact of increasing delivery frequency of stores to 5 times per week. According to the simulation the expected impact on inventory level is a decrease of 21.3%. Customer service in terms of stockout level and the percentage of lost sales could be decreased 43.5%. The expected impact on the distribution scheme is also illustrated in table 2. The original average number of total routes is reduced 52%, the average number of stores per route increases 52% and the distance between stores per route is also reduced 51%.

Table 2. Description of current and simulated values for monthly distribution indicators

Indicator	Original	Under Simulation	% Change
Inventory days	43.08	34.07	21.3
Stockout level percentage	1.78	1.03	- 43.5
Lost sales level percentage	1.68	0.98	- 43.5
Total number of routes	40	19	- 52
Stores per route	9	19	52
Distance among stores (kilometers)	1.5	0.7	- 51

6. Conclusions and recommendations

The work described in the document focuses on the efforts undertaken by the leading Mexican Convenience Store company to reduce inventory costs at the store level. The strategy delineated by the management of operations consisted on the increase of the delivery frequency of replenishing the stores. Originally 76% of the stores at the national level were supplied from their distribution center twice per week.

Reviewing some of the favorable conditions that allowed Seven Eleven Japan and America to supply stores daily, “The One” considered that store density was fundamental. High store density supports the feasibility of higher frequency values. Hence, the first step taken in the project was to obtain store density maps. Metro Monterrey, Saltillo, CDMX and Guadalajara present the areas with the highest densities showing higher possibilities for increasing delivery frequency. Then, the operations management team decided to evaluate the feasibility of higher delivery frequencies in the area of metro Monterrey. The following steps taken included the application of the methodology described previously in section 4.1. The results of this application suggest that the number of stores with 2 visits per week decreases 95%. These stores increase their frequency visits mainly to 5 times per week reaching 79%. Finally, because a pilot project was very difficult to undertake a simulation model was developed to evaluate the feasibility of the resulting optimal scenario. After reviewing the previous results illustrated in the last section, the management of operations of the company had shown great interest to continue towards the implementation of the project.

The authors of this project recommend the continuation of the application of the strategy designed and evaluated for decreasing store inventory levels. Another recommendation of the authors focuses on extending lower delivery frequencies for the suppliers of the DC´s of “The One”.

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Biographies

Mireya Elizondo is an Industrial Engineer just graduated from Universidad de Monterrey (UDEM). 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 and DMAIC principles for Improving the Productivity of assembly lines for a Mexican automotive company. Currently, she has started to work at a U.S. service-based logistics company.

Mariana Villarreal is an Industrial Engineer graduated from Universidad de Monterrey (UDEM). She has participated on several projects such as the Improvement of the routing operations of a leading convenience store firm. Another one in the automotive industry, in which she applied the DMAIC methodology to increase an assembly line's productivity. Nowadays, she works as a client strategy and operations consultant at a business consulting firm with presence in North and South America.

Vanessa Ocanas is an Industrial Engineer just graduated from Universidad de Monterrey (UDEM). Her specialty is logistics and supply chain management. She has participated in supply chain projects analyzing and maximizing the productivity of the transport units of a leading steel company producing flat steel in America. She applied Lean Thinking principles for standardization and time reduction in an assembly line of an American company that provides controlled units for industrial automation and information technology. Vanessa is currently a member of IISE and the STLE Societies.

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 23 years courses on industrial engineering and logistics in the Universidad de Monterrey, ITESM and Universidad Autonoma de Nuevo León. He has made several publications in journals such as Mathematical Programming, JOTA, JMMA, European Journal of Industrial Engineering, International Journal of Industrial Engineering and the Transportation Journal. He is currently a member of the IIE, INFORMS, POMS, and the Council of Logistics Management.