A Lean Approach for Reducing Inventory for a Mexican Convenience Store Network

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Abstract

The Lean Manufacturing approach for waste elimination can be applied in all sorts of operations. In this work this approach is adapted and applied for the reduction of inventory in the network of convenience stores of the leading Mexican company in this sector. The work describes the efforts devoted to achieve such objective in the store network served by the Distribution Center (DC) of San Martin located in Mexico City (CDMX). The initiatives considered are the increase of store inventory replenishment frequency and the reduction of the delivery time from the DC to the stores. The use of lean tools and mathematical models for defining replenishment frequencies and delivery routes is described. The description of expected results and those of a pilot program are given.

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

1. Introduction
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. The Mexican CS sector rank 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 company will be called "The Firm" 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 ensure customer satisfaction. This aspect represents an important weakness for "The Firm". The national average level of inventory in stores for "The Firm" is estimated in slightly higher than 30 days which is considered very high considering replenishment cycles of seven days.

According to Barnes (2014), retailers and distributors alike have attempted to solve their inventory issues by using forecasting tools to determine what to buy and when to buy it with higher precision. A better approach considered in Barnes (2014), 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. This work has the purpose of describing the efforts of "The Firm" to decrease the level of inventory in the stores by increasing their inventory replenishment frequency and reducing their order delivery time to stores in the area of San Martin CDMX.

The document of this work 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 application 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 lean retail thinking

The origin of waste elimination is associated with the concept of lean manufacturing. This can be traced back to the 1930´s when Henry Ford revolutionized car manufacturing with the introduction of mass production. The most important contribution to the development of lean manufacturing techniques since then came from the Japanese automotive firm Toyota. Its success is based on its renowned Toyota Production System. This system is based on a philosophy of continuous improvement where the elimination of waste is fundamental. The process of elimination is facilitated by the definition of seven forms of waste, activities that add cost but no value: production of goods not yet ordered; waiting; rectification of mistakes; excess processing; excess movement; excess transport; and excess stock.

This concept of lean and its corresponding process of waste elimination has been extended to other processes. The seven types of waste of lean manufacturing were adapted for the supply chain environment by Jones et al. (1997). A methodology for extending the lean approach to enable waste elimination throughout the supply chain is proposed by Hines and Taylor (2000). Also, Rother and Shock (1999) recommend the use of the value stream map (VSM) and the supply chain mapping toolkit described by Hines and Taylor (2000) as fundamental aids for identifying waste. Furthermore, the concept of lean was also extended to the area of transportation by Simmons et al. (2014), Villarreal (2012) and Sternberg et al. (2013).

The retail markets are characterized by a strong competition, short product life cycles, long product development lead times, and highly volatile demand. Attempt to apply lean concept in retail is recent. It dates from the 1990s. In this regard, several retailers such as Wall Mart, Tesco and IKEA are well known (Lukic 2012). Also, Naruo and Toma (2007) demonstrate that lean principles and concepts can be successfully applied in a company from the retail industry, such as Seven-Eleven Japan (SEJ).

According to Lukic (2012) the core of lean retail is primarily a commitment to eliminating waste. The author considers that the principal types of waste in retail are excess inventory, product defects, unnecessary motion, redundant employees and a waste of time. He suggests the utilization of tools such as: the simplification of work, the application of demand pulling mechanisms and removal of bottlenecks among others. SEJ´s operations strategy (7-Eleven 2006) consists of the following aspects: Seven-Eleven Japan’s Franchise System, development of original daily products, the support of a dedicated combined distribution system, strengthen a strategy of area dominance in markets promoting high store density and the withdrawal of slow-moving or dead products and vigorously introduce new ones.

One of the main factors favoring higher store replenishment frequency levels corresponds to store density. The most clustered the stores the better. Under this condition, transportation cost is lowered making daily delivery a feasible strategy. High-density concentrated store openings provided SEJ the foundation of high-value-added products and services. Through this market concentration strategy, SEJ has been able to establish a distribution system and implement product strategies that leverage the distinctive features of high store densities.

According to Naruo and Toma (2007), SEJ experienced an increase of sales combined with a reduction of the inventory level. It used to be wrong common sense in retail that "much merchandise in store enables large sales". Instead, SEJ decreased the number of SKU´s and eliminated dead or slow-moving items. These initiatives resulted in a reduced inventory level. The results were a financial cost reduction and a store image change. Due to a lower inventory level, stores had the chance to introduce new items, and that attracted customers. Also, Naruo and Toma (2007) point out that SEJ reduced the number of routes, and hence of trucks, by increasing the delivery frequency. This enabled a drastic reduction of the distribution costs. Furthermore, it reduced inspection workload in the store side. On the other hand, it enabled the store operators to concentrate on sales and customers in the store. SEJ had succeeded in increasing delivery frequency by product category. The SEJ success relies on the designing of a combined distribution center (CDC). SEJ designed the CDC concept by category and by temperature. The CDC is operated by a vendor's representative, or by an independent third party.

Similarly, according to Mr. Dean Burkett, Director of Demand Planning and Replenishment for 7-Eleven America (O´Connor 2016) Seven Eleven USA excelled at driving individual daily orders from stores to their shelves. Using 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 CDCs, commissaries and bakeries that support these stores across North America. Only a small percentage of the 10,700 7-Eleven stores operating in North America, have a very limited backroom for stocking inventory. 7-Eleven keeps their store shelves stocked by making daily deliveries to every store using a complex but very effective supply chain. The company first instituted 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 (CDCs) have turned out to be very beneficial.

3. Application of the inventory reduction strategy

As previously mentioned in the introduction, the leading company in the convenience store sector presents an important weakness. The national average level of inventory in stores for "The Firm" is estimated in slightly higher than 30 days, which is considered very high considering weekly replenishment cycles. The company is located throughout Mexico with a distribution network supported by 18 distribution centers (DC) and 12 transshipment points (TP). Every DC supplies a group of stores denominated as plaza. The company manages its inventories at stores with a weekly periodic review inventory system. Figure 1 illustrates a store density map of all the plazas in Mexico. The plazas located in Metro Monterrey, Saltillo, Guadalajara and CDMX present the areas with the highest store 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.

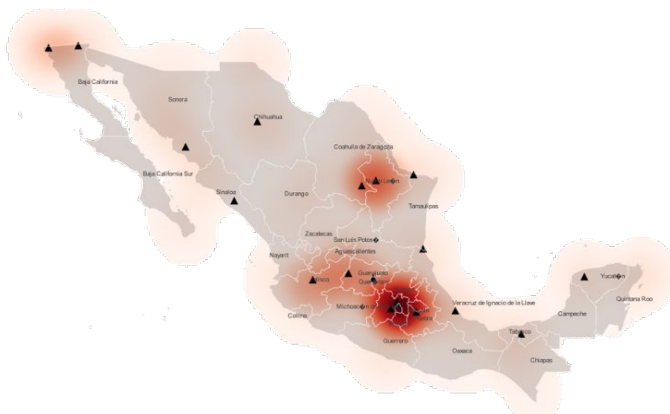

Figure 1 Description of store density map

This work will focus on the reduction of inventory for the store network located in San Martin CDMX. This market is satisfied by 1611 stores that are grouped in four plazas; Oriente, Satelite, Reforma, and Pachuca. The purpose of this work focuses on the design and implementation of initiatives for plaza Oriente. The number of stores located in this plaza is 456 served by 49 routes. The current distribution scheme is mainly with a frequency of 2 times per week (80% of the stores). The average inventory in stores for the plaza is estimated in 36.2 days. As previously mentioned, the inventory management system for each store is of periodic review with a weekly cycle time, four days of delivery time and three days for the review period. In fact, 80% of the stores have 4 days of average delivery time. Therefore, average cyclic inventory considers the required inventory to satisfy demand during the cycle time. Also, safety stock must be estimated to protect customer service for demand variability during cycle time. Both types of inventory, cyclic and safety, should decrease by reducing the cycle time through an increase of store replenishment frequency delivery and, of course, by the reduction of the delivery time from de CD of San Martin to the stores.

Figure 2 illustrates the location of the store network for plaza Oriente and the estimated densities measured as stores per squared kilometer. The range of densities of the plazas served by San Martin goes from 0.04 to 1.313 stores per squared kilometer. As a comparison, the estimated store density per prefecture for SEJ ranges from 0.008 to 1.21 stores per squared kilometer.

3.1 Defining delivery frequency values

As previously stated, decreasing inventory replenishment cycle time includes the problem of defining the values of the inventory replenishment frequency per store. This problem has been treated in the literature using mathematical methods. The works [Speranza and Ukovich 1994, Speranza and Ukovich 1996a, Speranza and Ukovich 1996b and Kerslake 2005] are relevant examples of these efforts.

Figure 2 Illustration of store densities of Japanese Prefectures and San Martin CDMX

In particular, the work developed by Kerslake (2005) is of our interest. These authors applied a simulation scheme to determine the optimal delivery frequency values for a Grocery Chain X (to be called GCX hereafter). The scheme is built as a generic model in MS Excel that could simulate the existing 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 first 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. Similar to the study by Kerslake (2005), the current work utilizes an approach that includes simulation and routing procedures to determine the delivery frequency values that maximize the earnings for the plazas served by the DC of San Martin Obispo. 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 3 presents the main steps designed for the scheme utilized to obtain the delivery frequencies.

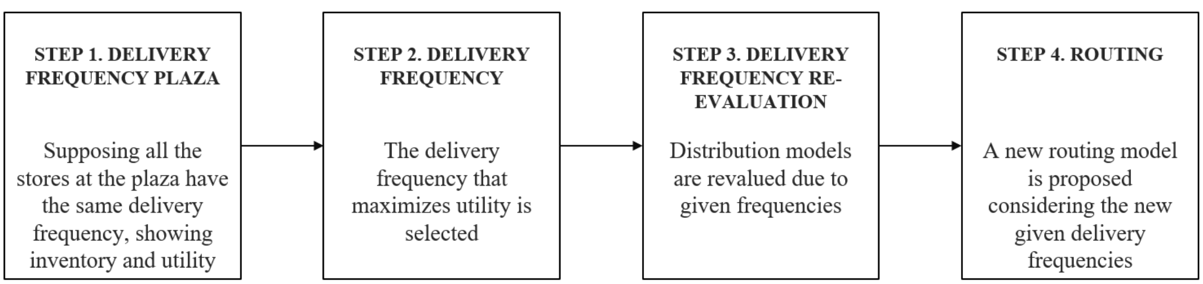

Figure 3 Description of scheme to determine delivery frequencies.

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.

3.2 Reduction of delivery time to stores

The previous scheme used to determine optimal delivery frequencies was applied considering the current state of the distribution process before the new delivery frequencies were established. In addition, the reduction of delivery times from the distribution center to stores was also analyzed under the same context. This objective is pursued by using tools from the area of lean transportation (Villarreal et al. 2009, Villarreal et al. 2012 and Sternberg 2013). The basic idea under this approach is to identify relevant types of waste and develop initiatives to eliminate them. The process of waste elimination considers the waste typology suggested by Sternberg (2013) that includes unnecessary movements, waiting, incorrect processing, overproduction, resource utilization, defects and uncovered assignments.

The scheme used in this work is the one recommended by Villarreal et al. (2017). Figure 4 illustrates the Transportation Value Stream Map (TVSM) (Villarreal 2012) for the routing operations to supply the stores of plaza Oriente. The average total delivery cycle time is 6 hours and 37 minutes with an average number of stores per route of 9. Non transit time spent on activities at the DC for loading and finishing the route totals 1.33 hrs per route on average.

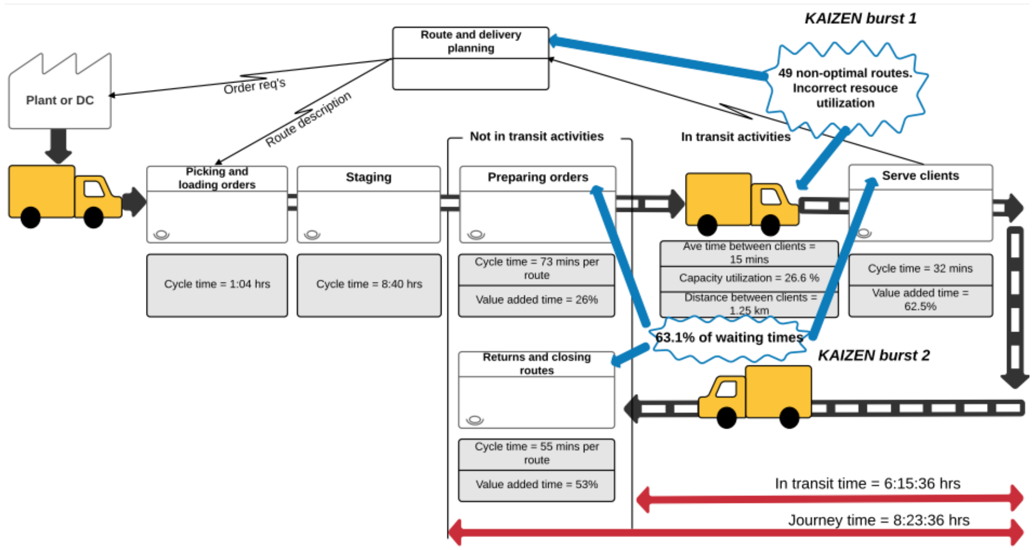

Figure 4 Transportation value stream map for OXXO´s routing operations in plaza Oriente

The most relevant wastes identified are incorrect processing during route planning and waiting in the DC staging area. The first waste is originated by the deficient route planning done by the staff of The Firm. Route design was not dynamic and with heavy use of experience by the planners. Waiting time occurred due to the lack of synchronization of the store order slotting and consolidation activities of the DC and the route sequence defined by the planners.

4. 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 the stores of the plaza Oriente. Table 1 illustrates the initial delivery frequency values and the resulting optimal delivery frequencies for the stores achieved with the scheme. The number of stores with 2 visits per week decreases 51%. These stores increase their frequency visits to 4 and 6.

Table 1 Delivery frequency values for initial and optimal result

	Number of stores	
Frequency	Initial	Optimal
1	2	1
2	1401	685
3	159	165
4	1	515
5	13	13
6	184	381

The next step of the implementation of the improvement strategy corresponds to a pilot program that included all the stores that changed their delivery frequency from 2 to 4 and a sample of 25 stores that changed frequency from 2 to 6. At the same time, it was decided to utilize an optimization package for the routes required to cover the stores of the pilot program. Table 2 illustrates a summary of the main supply indicators; inventory days, percentage of lost sale and stockout level. These results are for 56 days. The value of the level of average store inventory decreased 12% for those stores that increased frequency delivery from 2 to 4 days. Similarly, those stores that went from frequency delivery of 2 to 6 times per week reduced the average store inventory level about 21%. Even though average store inventory levels decreased, customer service improved. For stores with delivery frequency of 4 times per week the store stockout level decreased to 36.1% impacting on lower average levels of store lost sale values estimated on about 38%. For stores with frequency of 6 per week, the average percentage stockout level was reduced to 35.6% having an impact on the average store lost sale of 41.2%. An important result considered is that distribution costs for the pilot program did not change due mainly to lower number of daily routes. The program of implementation of the new frequencies is still on progress. Additionally, the projects to reduce waiting time due to the lack of synchronization of the store order slotting and consolidation activities of the DC are also at the implementation stage.

Table 2 Change on Monthly Supply Indicators

Indicator	Stores to frequency 4			25 stores to frequency 6		
	Week 43	Week 51	%Change	Week 43	Week 51	%Change
Inventory days	37.9	33.4	-12.0	25.48	20.13	-21.0
% Lost sale	2.45	1.52	-38.0	2.24	1.32	-41.2
% Stockout	1.59	1.01	-36.1	1.54	0.99	-35.6

The management of the supply chain for the firm were delighted with the previous results. The pilot program will continue for the rest of the first 3 months of year 2020. This project helped The Firm define their delivery frequencies for Plaza Oriente adapted to their inventory needs and objectives. However, since the plaza's circumstances and needs also change through time, the delivery frequencies must be defined every 3 months for optimal results using the proposed model.

5. Future applications

During the implementation phase and pilot test duration, future applications for this investigation were made as for confirming that this delivery frequency selection model can be replicated for its use throughout the country, and even for international use given the Firm´s presence over Latin America. At the same time, it is foreseen that this model will be ran continuously as part of the Firm's distribution planning over time.

The future of the retail store industry relies on the ability of fulfilling demand without over-inventory or stockouts, and for this to happen, companies must have an adaptable supply chain planning. This planning must ensure inventory levels and on-time deliveries through a versatile delivery frequency plan, as the one proposed on this project.

References

Barnes, J., The Myths and Truths of Inventory Optimization, *Supply Chain Management Review,* March/April, 2014.

Jones, D. T., P. Hines, and N. Rich, Lean Logistics. *International Journal of Physical Distribution & Logistics Management*, Vol. 27, Nos (3/4), pp 153–173, 1997.

Hines, P. and Taylor, D., *Going Lean*, Lean Enterprise Research Centre Cardiff Business School, Cardiff, UK, pp. 3-43, 2000.

Rother, M. and Shook, J., *Learning to See: Value Stream Mapping to Add Value and Eliminate Muda*, The Lean Enterprise Institute, Inc., Brookline, MA., 1999.

Simons, D., Mason, R., and Gardner, B., Overall Vehicle Effectiveness. *International Journal of Logistics: Research and Applications,* Vol. 7, No. 2, pp.119–134, 2004.

Villarreal, B., The Transportation Value Stream Map (TVSM), *European Journal of Industrial Engineering*, Vol. 6, No. 2, pp. 216-233, 2012.

Sternberg, H., Stefansson, G., Westernberg, E., Boije af Gennas, R., Allenstrom, E., Nauska, M.L., Applying a Lean Approach to Identify Waste in Motor Carrier Operations, *International Journal of Productivity and Performance Management,* Vol. 62 No. 1, pp. 47-65, 2013.

Lukic, R., The Effects of Application of Lean Concept in Retail, *Economia Seria Management*, Vol. 15, No. 1, pp. 88-98, 2012.

Naruo, S., Toma, S. G., in IFIP International Federation for Information Processing, Volume 246, Advances in Production Management Systems, eds. Olhager, J., Persson, F., (Boston: Springer), pp. 387-395, 2007.

O´Connor, T., 7-Eleven Operations, *Supply Chain World Magazine*, 2016.

Speranza, M. G. and Ukovich, W., Minimizing transportation and inventory costs for several products on a single link, *Operations Research* 42, 879-894, 1994.

Speranza, M. G. and Ukovich, W., An algorithm for optimal shipments with given frequencies, *Naval Research Logistics,* Vol. 43, 1996a.

Speranza, M. G., W. Ukovich, An algorithm for optimal shipments with given frequencies, *Naval Research Logistics,* 43 655–671, 1996b.

Kerslake, C.W., *A Method For Analyzing The Delivery Frequency From A Distribution Center to A Retail Grocery Store*, Master of Engineering in Logistics at the Massachusetts Institute of Technology, June 2005.

Villarreal, B., Garcia, D., Rosas, I., Eliminating transportation waste in food distribution: a case study, *Transportation Journal*, Vol. 48, No. 4, pp. 72-77, 2009.

Villarreal, B., Sañudo, M., Vega, A., Macias, S., Garza, E., A lean scheme for improving vehicle routing operations, *Proceedings of the 2012 International Conference on Industrial and Operations Management,* Istanbul, Turkey, July 3–6, 2012.

Villarreal, B., Garza-Reyes, J.A., Kumar, V. and Ming, K., Improving road transport operations through lean thinking: a case study, *International Journal of Logistics Research and Applications*, Vol. 20, No. 2, pp. 163, 2017.

7-Eleven. (n.d.). Convenience Store Operations. Retrieved from http://www.7andi.com/dbps_data/_template_/_user_/_SITE_/localhos t/_res/en/ir/library/co/pdf/p24_33.pdf.

Biographies

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.

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 as a Logistics Coordinator.

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.