

# REDUCTION OF THE BULLWHIP EFFECT IN THE CHAIN OF SUPPLY OF THE COMPANY LABIOFAM VILLA CLARA WITH A MODEL VENDOR MANAGEMENT INVENTORY (VMI)

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## ABSTRACT

With the purpose of diminishing the impact of the bullwhip effect in the link of the supply chain between the warehouse and the points of sales is carried out the present investigation in the Company LABIOFAM Villa Clara. The investigation is elaborated based on a bibliographical analysis in which aspects related with the contents study object are approached to fulfill the proposed objective. In the development of the investigation, leaves of an analysis to determine the product that more impact has in the storage costs, as well as its rotation. Then their current situation is determined and it is compared with the selected pattern that it follows a philosophy Vendor Management Inventory (VMI). Also, the impact of the bullwhip effect is determined in the current pattern and in the one proposed to confirm the impact and to facilitate the taking of decisions; although to supplement this analysis they are also kept in mind the possible new costs that associate brings the new model that intends. To arrive to the obtained results it was necessary to use technical of demand presage, determination of the size of the lot, interviews with personal of the center, direct observation and it consults to documents of the entity those that offer a scientific support to the investigation. After having applied the procedure it was demonstrated that the company can reduce the impact of the bullwhip effect, starting from the implementation of the proposed pattern that it follows the philosophy VMI.

Keywords: bullwhip effect, supply chain, Vendor Management Inventory.

## 1. Introduction

The current business world is becoming increasingly complex and unpredictable for companies globally. The increase in the competition of certain productions, the economic, financial, energy, food and environmental crisis and the accelerated development of science and technology, together with the globalization of the market, mean that all organizations, especially Cuban ones, face a race to find solutions that assure them a position in the market, help them to optimize their processes and make them more competitive.

Cuban companies do not escape the impact of this global scenario, which is why they have adopted new competitiveness strategies to consolidate their project. These strategies are geared to meet the expectations of customers in a growing manner, so that they are offered better products and services every day that offer greater opportunities and lower costs. Therefore, the mission of the top management is directed to direct its actions under the concept of incessant changes, at accelerated rates, with great complexity, imposing in this way the need for flexible solutions to the difficulties, on a scientific basis. (López Quintero, 2014)

For the national industry it is essential to apply new ways of managing the company, such as the focus on systems, process management and the integration of flows between suppliers and customers through the direct supply chain. All with the aim of increasing efficiency and effectiveness in organizations, making the most of the installed capacities, reducing production costs and reducing inventory.

The country's policy in recent years has focused on the development of biopharmaceutical and hygiene products. In this sense, the gradual substitution of imports for products of national production of recognized quality has been proposed. The LABIOFAM Villa Clara Company is one of the most important companies in the country that makes this new policy possible.

On the other hand, senior management is interested in the implementation of inventory management systems that allow a better alignment of the company's supply chain with suppliers and customers. The elements contained in this paragraph constitute the problematic situation of this work.

The alignment of supply chains with suppliers and customers and their effect on the reduction of inventories, is known in logistics as bullwhip or effect. In the warehouses of the company are high levels of goods, which involve high storage costs, although this does not occur in all products, raw materials, and inventories in process. This situation is reflected in the low turnover and, consequently, in the productive efficiency of the organization.

Starting from the above, it is defined as a research problem: the use of the appropriate inventory management system will allow the reduction of the whip effect in the supply chain studied and the rotation of the company's inventories.

For the solution of the research problem is defined as a general objective:

Implement an inventory system that allows the reduction of the effect of the whip and the increase of rotations in the warehouses of the selected company as an object of practical study.

To fulfill the objective, the research will be structured in:

## **1. Introduction**

## **2. Research background.**

## **3. Methodology to determinate the inventory level.**

## **4. Results**

Containing the selection of the inventories to be studied, the application to them of the inventories system without the VMI and with the VMI; as well as measuring the impact of its adoption on the whip effect of the supply chain analyzed.

## **2. Research background.**

It is not a secret that each time the suppliers are required to be more efficient when delivering the goods both in time and in safety; which has led to an increase in models and tools that allow their control and monitoring. Nowadays, with the new technologies, logistics has not been left behind and customers can know where in the world the requested goods are located 24 hours a day and other information thanks to satellites and the internet.

There are many authors and entities that in one way or another have dealt with the concept of logistics, either as Business Logistics or Supply Chain Management, some of the definitions, which demonstrate the evolution of the term through time together with the advance of technologies giving way to new concepts and methods and philosophies.

The extreme competitiveness that exists in the current economy, together with the effects of globalization, force the industry to find new ways to interact and satisfy customers. In a supply chain (CdS), manufacturers, commercial intermediaries, carriers, suppliers and official agencies collaborate to deliver the goods quickly and efficiently so that money flows through the economy.

The bullwhip effect is a phenomenon that hinders administrative management both inside and outside the supply chain and consists of a growing distortion of the demand transmitted by the different agents involved in the management of the flow of products as we move away From the market. In other words, the Bullwhip effect reflects the increase in uncertainty as the orders are transferred upstream in the CdS, in this sense, this effect is considered as the phenomenon of "amplification" of demand, known among the different

elements that make up a particular CdS. (Mejía Villamizar, et al., 2014)

Authors such as Holström, Disney, Chen and Kaipia, who have proposed techniques in order to eliminate the whiplash effect and the fulfillment of the real demand through the leveling of inventories such as the smoothing of demand, and the most effective Until now Vendor Managed Inventory.

Vendor Managed Inventory (VMI), It is a system that allows to make the supply chain more agile, by managing inventory levels by the manufacturer or retailer. The typical model of material requirements is given by traditional processes in which the buyer or retailer establishes a demand and the company plans the sourcing processes, reorder points, production planning, inventory levels, etc. On the other hand, with the application of the VMI model, it is possible to reduce delivery times, greater reliability in shipments and reduce transport, production and order costs, which leads to improved production and shipment scheduling, resulting in a greater profitability of the supply chain. The application of a VMI policy will depend on the incentives that each party has to cooperate; for this reason, if one of them has market power, it would not have any motivation to accept a joint policy different from its own and optimal for it (Montenegro Carrascal, 2011).

Action reward learning

The "action reward learning" model, proposed by (Kwak, 2009), is based on determining the replenishment quantities (inventory replenishment), through an analysis of a compensation factor, which determines the minimum cost associated with making a decision of replenishment, based on the amount of adjustment of the replenishment order that minimizes the costs of maintaining inventory or losing income due to not satisfying the total demand, having as a point of comparison the effect of using the compensation factor for the data of the previous period.

### 3. Methodology to determinate the inventory level and the bullwhip effect.

In this step we calculate the Bullwhip effect in the supply chain. To achieve this goal we will follow the following procedure:

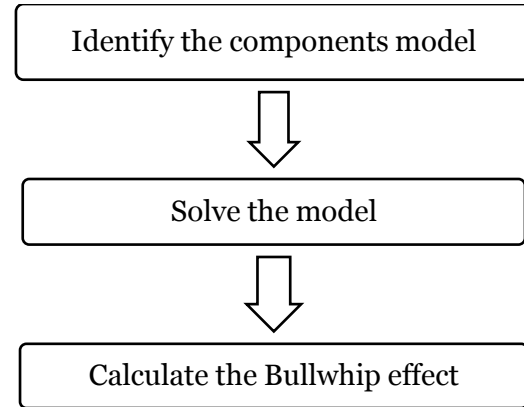


Figure 1: Methodology to determinate the inventory level and the bullwhip effect. Source: Self-made.

#### 3.1 Identify the components model

In the realization of this investigation the logistic and economic situation of the company is analyzed, for it is made the analysis of the economic and physical plans of the company, accounting summaries and the cost cards.

The objective of this analysis is to determine the components and find the necessary data to be able to apply the selected model and have economic and financial data to compare.

#### 3.2 Solve the model Action reward learning

The algorithm of the model can be summarized in the way indicated in table 1.1, where the notation of the variables and factors of the model are consigned.

symbol	Description
(t)	Replenishment period (t= 0, 1, 2...)
Dt	Actual demands of customers made during [t, t+1)
Dt'	Anticipated step anticipated in the client's demand in period t
6t'	Estimated standard deviation for consumer demand in period t
It	Inventory level at the beginning of period t
Qt	Amount of replacement at the beginning of period t
pi	Value of the CF compensation factor
Θ	CF value set (Θ= (ρ1, ρ2,..., ρ n))

h	Cost of maintaining inventory by SKU (Stock-Keeping Unit)
S	Cost due to shortage of inventory by SKU
Ct(pi)	Costs incurred in inventory in period t, when CF (pi) is chosen in period t-1
Ct(pi)'	Average inventory cost calculated in period t, when CF (pi) is chosen in period t-1.

Table 1.1. Notation for the model action-reward learning

Source : (Arango, 2011)

The inventory level of retailer it at the beginning of the replacement period t is calculated by equation 1.

$$I_t = I_{t-1} + Q_t - D_t \quad t = 1, 2, 3 \dots (1)$$

The cost of maintaining the inventory of each SKU is h and it occurs when it is positive. The cost per shortage of each SKU is s and occurs when it is negative. The replacement quantity  $Q_t$ , at the beginning of period t, consists of an average projection of the demand and an addition (or subtraction) produced by the compensation factor (CF), then:

$$Q_t = D_t + (1 + \rho_i) \sigma_t - I_t \quad (2)$$

Where  $\rho_i$  is the chosen value of CF in the replacement period t; it can be negative or positive.  $\sigma_t$  is the estimated standard deviation of customer demand, calculated as  $\sigma_t \approx 1.25 \times MAD_t$ .  $MAD_t$  represents the average absolute deviation of the error forecasts; it is calculated as:

$$MAD_t = (1 - \gamma) MAD_{t-1} + \gamma |D_t - I_{t-1}|.$$

The inventory cost that occurs at the beginning of period t by  $\rho_i$  is calculated as:

$$C_t(\rho_i) = \varepsilon \times |I_t|, \text{ donde } \varepsilon = \begin{cases} h & \text{si } I_t \geq 0 \\ s & \text{si } I_t < 0 \end{cases} \quad (3)$$

The cost  $C_t(\rho_i)$  is averaged with the previous values and is denoted as  $C_t(\rho_i)$ . The average cost of inventory for a value of CF  $\rho_i$  is found using the exponential method of the weighted average defined in the equation 4.

$$C_t(\rho_i)' = C_{t-1}(\rho_i)' + \beta_{ti} [C_t(\rho_i) + C_{t-1}(\rho_i)'] \quad (4)$$

Where  $C_0(\rho_i) = 0$  for  $\rho_i \in \Theta$

$\beta_{ti}$  is an adaptive smoothing parameter. When client demand changes abruptly,  $\beta_{ti}$  must take a high value, so that the recent demand data have more weight in the

equation of the total average cost (equation 5). When the demand behaves in a stable manner,  $\beta_{ti}$  must take small values. The parameter is calculated with the equation 5.

$$\beta_{ti} = |MD_t / MAD_t| \quad (5)$$

According to Kwak et al. (2009), the range of the value of CF can be considered as a necessary parameter for "action-reward learning". The same authors suggest using CF values between 2 and -4, which covers almost any demand, since it ensures that the model takes the average demand of the consumer, more than three times the standard deviation above and below said half.

The best CF value ( $\rho^*$ ) must be selected with the value of  $\rho^*$  that minimizes costs. The way to perform the selection of said parameter is explained in the original work of Kwak. (2009). (Arango, 2011)

### 3.3 Calculate the Bullwhip effect

The mathematical measure of the whip effect in terms of the oscillation of the demand that a CdS experiences, relates to the squares of the coefficients of variation of the transmitted and received demand, starting from the assumption that in the medium and long term the average values of the demands. (See equation 6) in figure 2.

$$BW = \frac{\frac{Var(q)}{d_q^2}}{\frac{Var(d)}{d_d^2}} = \frac{Var(q)}{Var(d)} \quad (6)$$

Figure 2: Whip effect equation.

Source: (Mejía Villamizar, et al., 2014)

Where:

- Var (q) and Var (d): Correspond to the variances of both demands, the one transmitted by the demand that the customers of the company expect to satisfy and the one received from the actual demand that they satisfy, respectively, in said step of the chain of supply.
- $d_q$  and  $d_d$ : Are the average demands transmitted q, and received d.
- BW: It is the indicator used to measure the whip effect produced by a step of the chain, which, when it is greater than 1, means that the transmitted demand is greater than what is actually being

sold, evidencing the whip effect. Also if the BW is equal to 1 it means there are no problems; but that is less than 1 does not only mean that the expected demand is lower than the one received, but that the company can fall in costs due to lack.

The formula allows to take the effect of the whip to a mathematical value in order to be able to use it for comparison, analysis and later decision making.

#### 4. Results

In this session will show the results according de details of the methodology in the previous session. This model was applied in the company LABIOFAM Villa Clara, in the production's process of honey with propolis 240ml.

Table 1.2 shows a summary of the main indicators and variables used in the model. The fifth quarter analyzed brings for the first time the missing characteristic of some 9789 units which represent a great cost to the company of \$ 75962.64 and are also a cost of opportunities with which you can lose customers.

t	Dt	Dt' pronost	It	Qt	Ct(pi)
0	6034,0	15000,0	0,00	15000,0	0,00
1	7800,0	15000,0	8966,0	17147,0	2062,2
2	5800,0	15000,0	18313,0	8312,0	4491,2
3	4056,0	15000,0	22569,0	1508,0	5190,9
4	10536,0	15000,0	13541,0	10123,0	2328,4
5	33453,0	20000,0	3211,00	12835,0	738,5

Table1.2: Summary of the results of the action reward learning model

Source: Self-made.

This model manages to reduce the inventory costs in the company and the rotation of the product increases to 6.241 times of 3.1677; but it must be borne in mind that the possibility of missing appears, its cost being much greater than that of storing the products.

The costs of maintaining inventory can be observed summarized in table 1.3 with the current model and with the action reward learning model following a philosophy of VMI.

	Model without VMI		Model wit VMI	
t	Inventory level	Costs	Inventory level	Costs with VMI
1	6295	1447,85	8966,00	2062,18
2	8266	1901,18	18313,00	4491,21
3	44930	10333,9	22569,00	5190,87
4	36481	8390,63	13541,00	2328,41
5	9631	2215,13	3211,00	738,53
Total		24288,69		14811,20

Table 1.3: Summary of inventory costs with the different models.

Source: Self-made.

In Figure 3: inventory costs are analyzed through a area chart.

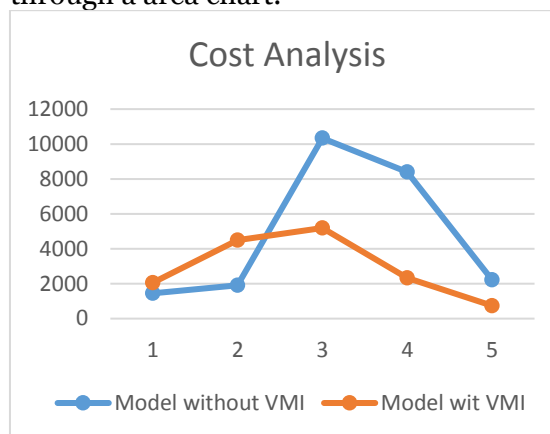


Figure 3: Cost Analysis

Source: Self-made.

As can be seen by analyzing the costs until December 2017, the model that applies the VMI philosophy is more economical, since it would save only \$ 9477, 49 in storage, without counting the cost of producing more units.

However, when comparing the inventory level with an area chart in figure 4 it can be observed.

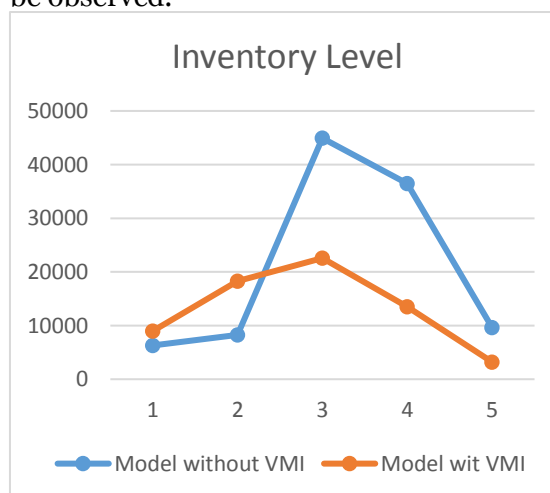


Figure 4: Inventory Level

Source: Self-made.

For the current model of 3.1677 times and that of the proposed model is 6.241 times; it can be seen that this indicator doubles from the current model to the one proposed.

Calculation of the Bullwhip effect

By applying formula # 1 of chapter 1 we can give a numerical value to the whip effect which is used to know how distorted the demand is within the steps in the current and proposed model.

For the current model:

The variance transmitted  $\text{Var}(q) = 5\,000\,000$  will be for the forecast of demand that the company is currently pursuing, which has an average of 16,000 units.

The variance received  $\text{Var}(d) = 145\,552\,109$  is the real demand that the company has satisfied in the periods analyzed, and that has an average of 12 329 units.

$$\text{BW} = (\text{Var}(q) / dq2) / (\text{Var}(d) / dq2)$$

$$\text{BW} = 0.01953 / 0.95755$$

$$\text{BW} = 0.0204$$

For the proposed model:

The variance transmitted  $\text{Var}(q) = 85\,848\,562$  which is the variance of the amount that should have been requested to apply the model in that time period with an average of 12 585 units.

The variance received  $\text{Var}(d) = 145\,552\,109$  which is the actual demand that the company has satisfied in the periods analyzed, which has an average of 12 329 units.

$$\text{BW} = (\text{Var}(q) / dq2) / (\text{Var}(d) / dq2)$$

$$\text{BW} = 0.5420 / 0.95755$$

$$\text{BW} = 0.566$$

As shown in the proposed model, the reduction in the impact of the whip effect is significant because it is closer to 1. Although the indicator is still below 1; which means that the actual demand varies much more than expected. The impact is reduced by the model, since the quantities requested are closer to this reality, making its implementation favorable for the company. In addition, the whip effect is affected only with the implantation of the model about 27 times; so that to apply these measures, those proposed in chapter one, this should continue to decrease for the benefit of the company.

## Conclusions

- The bibliographic search carried out for the preparation of the theoretical-referential framework of the research revealed the existence of a broad updated conceptual base on the subjects under study, as well as previous experiences in the application of a procedure that considers the use of the VMI philosophy to face the bullwhip effect in the supply chain.
- The procedure applied allows to reduce the inventory level in the warehouses and the costs of the selected product; it also increases its turnover, which increases the positive impact within the company.
- The action reward learning model reduces the effect of the whip on the selected step about 27 times what is currently happening in the company; so its application is a feasible solution.
- The results confirm the importance of applying this model in the company to reduce costs so that it can be economically sustainable.
- It is interesting the comparison with other inventory management systems regarding the reduction of the whip effect and analyzing the impact on product quality or other dimensions of competitiveness.

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