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The Forrester effect reduction: one size fits all?
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Introduction
In this paper, we try to show that the solutions applicable for the coordination of certain supply chains, aiming at inventory and stock-out reduction, turnover increase and control of the so called Forrester Effect, are not necessarily applicable to other chains. This study derives from a wider research, which objective was to analyse the entire situation of a group of consumer good distributors of Johnson & Johnson consumer products in Brazil. In the original study, the strategic, economical, financial and dynamic aspects were analysed, as well as the impact of the findings of this research on the imminent implementation of VMI process in the analysed supply chain.

Scope
The study was carried out based on a three level marketing system of the Wholesale Channel (BOWERSOX and CLOSS, 2001), with the Distributor operating with the exclusive distribution system (LAMBIN, 2000). In order to completely characterize this channel it is also necessary to add that it is inserted in a monopolistic competition market (PINDYKE AND RUBINFELD, 2001). Some Supply Chain coordination proposals found in the literature were simulated, analysed and compared.
The Forrester Effect
Before FORRESTER’s studies in the ’50s, (FORRESTER, 1973) there was little awareness of the effect of delays, amplification and organizational structure on the dynamic behaviour of the production-distribution type system. His work showed that the interactions between the components of a production-distribution type system could be more important than the components themselves.

In his honour, the name Forrester Effect is sometimes given to the dynamic behaviour inherent to the supply chains, which is characterized by the increasing amplification of the demand variance perceived by the nodes when one goes upstream in the supply chain, when any type of disturbance is introduced, for example, in the normal rate of consumer sales.

When he performed sensitivity analyses\(^1\) in the equation system proposed to model the supply chain in his study, FORRESTER (1973) concluded that the system is not sensitive to changes in most of the equation parameters. However, the system is very sensitive to a few equation parameters, which are called leverage points of the system, such as delivery delays\(^2\) and production adjustment delays. Other leverage points found are the information flows that control labour and inventory changes.

One of FORRESTER’s (1973) conclusions is that the elimination of nodes (tiers) from the supply chain significantly helps to reduce the characteristic fluctuations of demand in that type of system.

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1 An analysis of sensitiveness is normally performed through the changes by a factor of 2 or more in the parameters, according to FORRESTER (1973).

2 According to FORRESTER (1973, p. 269), and as we saw in the original research, for specific cases, faster answers tend to make the system unstable.
40 years have passed since his work and the elimination of nodes from the chain was not a solution widely adopted, since it sees to the chain’s dynamic optimisation but does not meet some strategic and economical requirements of reality. Without going into too much detail on this matter, we can say that the *disintermediation* does not allow each link to focus on its core business nor does it minimize the *Transaction Costs*, when the objective of the manufacturer is to attain a large number of independent points of sale, something usual in a continental-sized Country such as Brazil.

The pressures to implementing agile manufacturing practices (CORRÊA, 2003) and the reduction of the Transaction Costs allowed by the easier and cheaper access to communication and information technology resources, made it possible for Companies to begin to organize their interfaces, originating the perspective that KARLSON (2003) called “a shift from *enterprises* to *extraprises*”. It is within that perspective that the coordination efforts between companies emerge and EDI, ECR, VMI and other initiatives are but some examples.

**Vendor-Managed Inventory (VMI) and its practical results.**

“In order to appease the problems of the Supply Chain’s typical fluctuations, many companies integrate the chain, from customers to raw-material manufactures. Those policies are known as Electronic Data Interchange or EDI, Efficient Consumer Response or ECR and Vendor-Managed Inventory or VMI”. (STERMAN, 2000)

According to STERMAN (2000), all those policies are part of the general trend towards lean-manufacturing and just-in-time movements and each one of them intends to solve a different problem of Supply Chains.
EDI reduces time delays and order costs, allowing customers to purchase smaller lots and more frequently, appeasing the order flow received by the supplier. The ECR (STERMAN, 2000) involves additional changes in the processing of orders, distribution and shipment policies in order to reduce delivery time.

Those policies can include outsourcing storage, continuous replenishment, use of mixed loads to rationalize freight and other techniques. Point of sale information can also be electronically shared with suppliers, trying to eliminate information distortions and delays. However, VMI goes further (STERMAN, 2000): its philosophy is that the Vendor manages the entire downstream Supply Chain and determines how much to ship to each level, eliminating the need of customers to place orders.

VMI is a planning and management system that is not directly linked to inventory ownership. This means that the nodes of the chain must operate within a collaborative and trustful frame of mind. With VMI, instead of the customer monitoring his/her sales and inventory to trigger off replacement orders, the vendor takes on the responsibility for this activity.

This is based on the fact that a large part of the inventory management activity depends on demand forecasts. The forecast uncertainty for each point of sale is normally large. However, as the forecasts become more aggregated at higher levels of the chain they are more stable (because of the risk pooling effect).

The system increases the frequency of the orders and reduces the volume of every item in the orders. However, as one of the system’s objectives is to reduce the inventory throughout the chain (increase the service level is normally another), the savings obtained in inventory

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3 Our dynamic study in the original research suggested that the appeasing results from the purchase of smaller quantities and from removing delays. Removing delays is necessary as a consequence of the purchase of smaller lots.
carrying cannot be corroded by the increase of logistics costs. Consequently, the system is especially applicable to items with a great variety and relative low unit price. Thus, few units of each part number will constitute an order, which will have various different part numbers, decreasing some fixed and semi-fixed logistics costs such as freight.

That system is offered by systems solution providers with the declared purpose of:

- Improving the Vendor’s knowledge about the demand in a lower (downstream) point in the supply chain.

- Allowing the inventory throughout the chain to be reduced, by means of the Vendor’s management.

- Allowing the Vendor to reduce the impact of the Forrester effect on production, thus manufacturing becoming more economical.

- Allowing, through the group of the above mentioned measures, to reduce the product cost, so the Vendors can a) pass on part of the cost reduction to the consumer, increasing the value generated by the chain, and b) increase the contribution margin of the Distributor, giving him/her more incentives to take the product to a larger amount of points of sale.

In practice, however, the results of VMI are debatable and contradictory, as the following statements show:

“By understanding and managing the costs, and controlling the risks through careful negotiations, one can make both consignment and VMI work not only for the customer, but for the supplier as well” (WILLIAMS, 2000)

“Officially, the acronym VMI refers to vendor-managed inventory. Today, however, some 15 years after its introduction, the initials could also stand for very mixed impact.”
Although some businesses are going ahead and implementing the practice of VMI, others are retreating from the concept.” (COOKE, 1998)

“These industry initiatives - ECR, VMI, CRP, and QR - failed to fully address the needs of companies producing and distributing goods because the initiatives were not developed specifically for particular industries. These approaches do not coordinate the demand supply-chain processes, which is the exact point where manufacturers and distributors must coordinate requirements and replenishment. Additionally, they do not provide for disparate trading partners that adopt other approaches or use conventional practices.” (SIMBARI, 1996)

“Almost a year to the day since its inception, one of wholesaling's most progressive and promising efficient consumer response (ECR) initiatives has been shut down. Spartan Stores announced that effective Oct. 31 it was closing the door on what some called its continuous replenishment program (CRP), a program Spartan executives always described as their vendor-managed inventory (VMI) effort.” (MATHEWS, RYAN; 1995).

“Various published accounts have described VMI benefits that range from cheaper new product introductions to reduced returns at product end-of-life, but the literature often fails to explain just why these benefits have resulted from VMI. As with many new management theories, it is sometimes difficult to distinguish the achievable results from the hype, just as it is difficult to determine how these results might be replicated elsewhere.” (WALTER et al, 1999)

In order to try to understand this apparently occasional success of applications of one of the typical tools (VMI) of the Supply Chain Management, we tried to dig a little in the problem’s concept bases.
The primary objective of the Supply Chain Management can be understood as to offer a proper value to the customer and the maximum return on assets, by an effective management of the flow of materials, information and financial resources (REIS, 2003).

The Return on assets for any node in the chain is given by the product between the Net Margin and the Turnover (STICKNEY; WEIL, 2000).

In the specific case of monopolistic competition markets, it is common to see the gross Margin exogenously determined, by market conditions, thus each node of the chain can operate with a reasonably high degree of freedom basically on its own fixed costs and its inventory turnover.

As the ratio between the flow of \textit{sales} and the \textit{inventory} determines Turnover, there is a great pressure to reduce the inventory.

The causal diagram of STERMAN (2000) shows us that, in a long term, the \textbf{direct effort} to reduce the inventory can make the problem worse. Therefore, reducing inventory should not be seen as the main action point, but as consequence of the action on other points of larger leverage of the chain.
Thus, for the following question is natural: “Where must you act on the chain to increase turnover?” According to KIRKWOOD (1998), practical experience has shown that to modify the information links in a business process can have a deep impact on the process performance.

**Analysis: Why do some supply chains benefit from VMI and others do not seem to?**

In order to carry out this research, we used as a base KIRKWOOD’s (1998) simplified dynamic model for two nodes in the supply chain, adding one node to represent the complete chain downstream, between the vendor and the retailer, to include the distributor.

The dynamic numerical simulations of the Supply Chain were performed with help of the analysis software VenSim®4, chosen for offering graphics outputs, having a simple syntax for formulating equations and contour conditions to simulate the inventory and flows that represent

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4 Trademark of Ventana Systems, Inc.
the Supply Chain interactions, as well as being available for free, in the academic version, via
Internet. To carry out the simulation the method and various restrictions recommended by
KIRKWOOD (1998) were followed.

Applying a step-type stimulus in the system, through the retail demand, we simulated the
typical response of the Supply Chain system. This variable initially has constant value (balance) and suddenly assumes a new value, remaining at this new level. According to
KIRKWOOD (1998), a step type signal triggers a system in all its resonance frequencies, i.e.,
in all its natural vibration modes, therefore, being very useful to fully characterize the system’s
behaviour over time (BOT).

In the inventory and flow diagrams, the variables in small letters represent auxiliary variables
and those in capital letters represent auxiliary constants. The variables starting with a capital
letter represent inventory and, finally, the variables with the first three letters in capitals
represent functions.

The system’s behaviour over time is studied after submitting the system to an increase of 20%
in the initial retail demand, which is 100 units/week, remaining constant at this new level. The
increase occurs in week 10.

The model reflects a system in dynamic balance. According to KIRKWOOD (1998), it is
important to test the dynamic response of a system beginning at the balance condition. If not, it
is impossible to isolate what part of the response is due to the intentional stimulus caused and
what part is due to transient effects.

The following were the restrictions of modelling in our original study:

- The products are sold and not consigned, thus there are large restrictions to return
  products which are not sold. In practice, only damaged or exchanged products based on
  the Brazilian Consumer Protection Law go against the flow (upstream). The normal
flows are the logistical, downstream, and that of production orders, upstream. For the purpose of this simulation, the return of products was not allowed

- In addition to the Distributor’s Sales, Distributor’s Orders, Distributor’s Inventory, Order Log at the Plant and Production at the Plant, aspects which were studied by KIRKWOOD (1998) in his model, we also added the Turnover calculation at each node, aspect directly related to the yield of the chain, as mentioned above.

- Normally, in an actual arrangement, the chain’s nodes become more numerous as they approach the consumption end\(^5\). The large number of points of sale was represented by only one node with aggregated demand in our simplified model. Thus, the random (or not systematic) demand fluctuations at the consumption end are reduced by a number of points of sale greater than a few dozen. However, the system remains entirely sensitive to market macroscopic (or systematic) fluctuations such as, for example, that caused by an advertisement campaign. In other words, the co-variances become much more important than the consumption variances in each point of sale, since they are much

\(^5\) Normally, a Manufacturer has a small number of Distributors and those serve a large number of retailers. At every level analysed, therefore, the number of elements increases. Frequently, the group of the Manufacturer, his Distributors and retailers is called Network.
more numerous. That makes that simplified modelling possible, with aggregated demand and approximately constant at the beginning of our observation period.
Figure 2- Model 16 (The numbers from 1 to 15 were used in experimental models of chains with two links and three nodes, which did not present an adequate mathematical closure of the equation system): Inventory and flow diagram for two and three nodes (Retail, Distributor and Vendor).
An important observation in the proposed diagram of two links and three nodes (Model 16) is that the information flow does not need to be conservative, contrary to the material flow.

The system is entirely characterized by 27 equations that represent the inventory, flows and contour conditions that simulate the interactions of the extended chain. With help from VenSim®, the equations were integrated over time, using the Euler (KOPECHEOVA EMARON, 1975) numerical method. This method requires that the passage of time chosen for the numerical integration be less than 1/3 of the greatest time constant present in the process, which was duly followed.

The model dynamic response, in the first two nodes, was compared with the response of KIRKWOOD’s (1998) original model, in order to certify it before performing any other alteration.

Then, we tested KIRKWOOD’s (1998), FORRESTER’s (1973) and STERMAN’s (2000) proposals to stabilise supply chains, in our specific model:

According to KIRKWOOD (1998), to force delays in placing orders and to consider order placed earlier is a good way to minimize the problem.

According to FORRESTER (1973), the increase of delays tends to stabilise the system. His proposals of leverage points are the delivery delays, production delays and direct insertion of the number of orders received in the decision processes on labour (variable that we did not explicitly consider in our chain model). Still according to, action should be on the information points that control the inventory and labour changes. He also suggests increasing the appeasing of average sales and inventories. KIRKWOOD’s (1998) proposal is aligned with FORRESTER’s (1973) and was handle as being only one in our simulation.
According to STERMAN (2000), the analysis of sensitivity of the Supply Chain shows that the greatest leverage point in the system is the reduction of delays in the chain responses to demand fluctuations. The way to act is as follows: as orders are met at a faster pace and the chain’s response reduces the incidence of initial stock-outs, the phantom-orders\(^6\) fall and the customers demand less defensive inventory, stabilizing the orders in the entire chain.

Therefore, KIRKWOOD’s (1998) proposal is enclosed by the suggestions proposed by FORRESTER (1973) and both follow a line opposite to de STERMAN’s (2000) proposal, if the recommendations are interpreted as being general.

Study of alterations resulting from KIRKWOOD/FORRESTER’s proposal (to force delays in placing orders and to consider order placed earlier (in the pipeline)).

The diagram below shows the modifications performed in the information flow of our Supply Chain, in red, to encompass KIRKWOOD and FORRESTER’s recommendations.

In addition to the modifications in the information flow, all the time constants were duplicated to increase the delays. 37 equations were necessary to entirely characterize this new model.

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\(^6\) Ghost-orders: term used to explain the repetition of orders not accomplished, typical defence reaction of a customer who is loosing sales for breakage of supply.
Figure 3 - Model 16, modified at the leverage points suggested by Kirkwood/Forrester.
According to KIRKWOOD’s (1998) method adopted in this analysis, to evaluate the dynamic response of a system to a disturbance, we have to make sure that it was in a permanent regime. If it is in transitory regime and we apply a disturbance, we will not know how to differentiate what part of the behaviour is due to the previously existing transitory regime and what part is due to the newly induced disturbance.

The method made us previously run each proposal of alteration in the chain without the step of demand to determine since when (simulation horizon week) the system would enter a permanent regime, i.e., which is the length of relaxation for each system modified.

Only after determining the length of relaxation for each case, did we apply the step signal fluctuation for the new configuration.

In the case of the modifications suggested by KIRKWOOD (1998), it was determined that the length of relaxation of one of the variables studied was around 50 weeks (plant’s production). For security, a length of relaxation of 100 weeks was adopted.

The leverage points for interference in the system’s performance proposed by STERMAN (2000), are:

- Reducing delivery delays.
- Reducing production delays.

FORRESTER (1973) found that the production-distribution systems are relatively insensitive to changes in the parameters and that sensitivity studies must be carried out changing the parameters by a factor of at least 2. Due to this, to check the system’s dynamic response to de STERMAN’s (2000) hypothesis, all the delay parameters in relation to the reference model (Model 16) were divided by two, except the Time Interval for Average Sales, which remained 1 week.
The general inventory and flow diagram was not altered, only the equations.

In the case of the modifications suggested by STERMAN (2000), the length of relaxation found was 25 weeks. To allow the direct comparison of all the results in the same graphs, we adopted for all the simulations the sales step occurring in the hundredth week and a total time horizon of 200 weeks for the simulation. The results of both simulations are shown jointly in the graphs below and compared to Model 16:

![Graph for vendas do varejo](image)

**Vendas do varejo = Sales at retail**

**Figure 4 – The sales pulse (20% increase) was inserted in the a hundredth week, sufficient time for the three models to be in permanent regime before applying disturbance.**

The variation of demand is the exogene variable to the system and determined by the function STEP that increases its value in 20 units in week 100. Therefore, the behaviour of the three models is the same regarding retail sales.
Estoque do varejo = Inventory at retail

Figure 5 – In this figure that represents the retail inventory variation over time, we can see that the oscillation of the model with Sterman’s modifications stops around the twentieth week and that the oscillation of the model with Kirkwood/Forrester modifications stops around the fiftieth week. In addition, we can clearly see that before the pulse, initiated in the hundredth week, all the systems are in permanent (balance) regime. Sterman’s model is the one that returns sooner to the balance status (more stable). However, the retail inventory balance level is the highest. The Model 16 (reference) shows continuous fall of smooth oscillation and stabilises at the lowest inventory level.
Pedidos do varejo = orders from retail

Figure 6 – Retail orders: Model 16 (reference) shows the best behaviour. The model modified with Sterman’s and Kirkwood’s recommendations shows overshooting\(^7\) behaviours.

\(^7\) Overshooting: It is a system that shows amplitude oscillation higher than its final balance level.

This behaviour normally appears when an exponential growth is not adequately compensated by a decrease function as it gets near to the target-value.
Carteira de pedidos no distribuidor = order log at distributor

Figure 7 – Sterman’s model allows an earlier stabilization of the order Portfolio at the Distributor.

Processamento = processing

Figure 8 – Order Processing: the original model (16) shows the smallest oscillations regarding order processing.
Vendas do distribuidor = sales of distributor
Figure 9 – Distributor’s Sales: the original model also has the best stability of sales of the Distributor.

Pedidos do distribuidor = orders from distributor
Figure 10 – Distributor’s Orders: the reference model also shows the smallest oscillation amplitude in the orders.
Estoque do distribuidor = inventory at distributor

Figure 11 – Distributor’s Inventory: the reference model (16) is the one that oscillates the least and allows to maintain the Distributor’s inventory at the lowest level (greater turnover).

Carteira de pedidos na fábrica = order log at factory
Figure 12 – Sterman’s model provides faster paced manufacture and, therefore, the Order Portfolio at the plant is the smallest of the three models. However, the one of smoothest oscillation is the reference model (16). Note that the value of orders does not reach the negative values for longer than 100 weeks, meeting our restrictions to the modelling.

Giro do varejo = turnover at retail

Figure 13 – The largest retail turnover is attained with the reference model. However, Sterman’s model is the one that stabilises the system fastest after a disturbance.
Giro do distribuidor = turnover at distributor

Figure 14 – Distributor’s Turnover: the same analysis as that of retail turnover is applied.

Conclusions

The proposals of the different authors seem not to be applicable in a general manner, but only to the specific models proposed and studied by them, different from the model proposed herein, which intends to simulate a specific distribution chain, characterized previously.

This implies that each chain has its material and information (as well as others) flow particularities, and that it also has different relevant leverage points.

The generalization of this conclusion would require deeper sensitivity studies, with larger variations of the delays researched.

However, it is obvious that the distribution chain is a particular combination of activities and, as such can offer a company, or a network, a unique competitive position (PORTER 1999).
The configuration of a Supply Chain implies the association of dozens of activities and, therefore, it is difficult to reproduce or imitate.

This conclusion can help to explain CHASE et al. (2001) statement: “Many companies are attaining significant competitive advantages by establishing and adjusting their chains.”

CHASE et al. (2001) also consider that the main measurements of efficiency of the Supply Chain are the inventory turnover and the number of weeks of supply in stock. However, they point out the fact that many chains do not look for reducing costs, but maximizing the value for the customer.

Therefore, we can also come to the conclusion that the adjustment of each chain depends on the strategy set between the partners and that is specific.

Thus, the application of practices known as Vendor Managed Inventory (VMI), without being particularized for a specific chain, has reasonable chances of presenting a worsening in some performance aspects and that the worsened aspects can coincide with those that are trying to be improved, resulting in the non-legitimate “Vendor-Managed Inventory” but in a “Very Mixed Impact” (COOKE, 1998).

Bibliography


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