A comparison between Lean and Visibility approach in supply chain planning

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Abstract: Nowadays, competition increases more and more in the market and it is moved from firm vs firm to supply chain vs supply chain. Therefore, supply chains (SC) are always looking to improve their efficiency to excel in the market. In order to do that, SC managers pay much attention to the coordination among SC members. SC planning allows the coordination among the SC players. In the literature, many SC planning approaches have been developed and analyzed, but up to now, the debate on which is the best approach is an open issue. On the other hand, lean approach is becoming more and more popular among SC managers. Both practitioners and academics have recognized the importance of Lean approach for single firm efficiency. This paper aim at evaluating the impact of Lean approach implementation in supply chain planning tasks. It provides an in-depth analysis of Lean SC planning policy impact on SC performances and compare it with traditional EOQ and Visibility policies. The influence of SC planning policies and of external parameters is assessed in a DES simulation study. The simulation model tests a multi-product three-echelon supply chain. Lean "pull" principle is developed through Kanban system implementation and Lean "create the flow" principle is developed through setup time and batch size reductions. The simulation study analyses inventory level, transportation performance and service level performances. According to simulation outputs a total SC logistic costs have been evaluated for each scenario. The results provide new insights suggesting that Lean supply chain planning policy gives competitive advantages. The results have important consequences for implementation of Lean concepts in practice in SC planning tasks.

Keywords: Supply chain planning; Lean management, inventory management; Lean logistics; simulation.

1.Introduction

Both practitioners and academics have recognized the importance of Supply chain (SC) planning for market competition. SC planning aim is to increase efficiency and effectiveness improving the coordination among SC members. This is not a simple issue because actors of a SC have different goals and different priorities. SC planning has been integrated into a comprehensive concept, which receives a lot of attention in scientific literature in recent years (Jonsson & Holmström 2016). Several approaches and SC planning policies have been developed during the past decades. One of the most studied is Visibility. Visibility consists in sharing information useful to production and transportation planning optimization. Visibility has been studied in several ways. In the literature, it is possible to find visibility implementation with different type of shared information: Kwak and Gavirneni (Kwak & Gavirneni 2011) showed the positive effect on SC efficiency of sharing inventory level and final demand between retailer and supplier under different order policies. A similar work of Bottani and Montanari (Bottani & Montanari 2010) studied the impact of information sharing of inventory levels in several SC configurations and found that every SC with information sharing incurs in lower total costs than the same SC configuration without info-sharing. Other authors analyzed the impact of information sharing about demand forecast and trend instead of past demand and they found that, assuming equal accuracy in firms' prediction systems, SC increases its efficiency implementing visibility (Angulo et al. 2004; Zhu et al. 2011). Different approach was used by Datta and Christopher (Datta & Christopher 2011) where authors compared SC performance in agent based model under several intensity of visibility: SC members transmit data instantaneously, daily, weekly, monthly and found that increasing intensity of information transmission means total SC cost reduction. However, which is the planning policy to make SC efficient and competitive is an open issue even now. On the other hand, Lean management is a diffused approach to improve operations efficiency and coordination in manufacturing firms. Lean management has become famous for its struggle against the waste. What is lean is difficult to define, authors state that is closer to philosophy of work than to a practice or a procedure(Bhasin & Burcher 2006). Many studies have demonstrated how lean leads to production costs reduction(Jasti & Kodali 2015). Nowadays Lean is becoming more and more popular among SC managers too. Past studies have analyzed which are the practices implemented with suppliers or customers by "Lean companies" (Liker & Choi 2004). However, the impact of Lean implementation in SC context is not clear. This paper aims at understanding the impact of Lean principles implementation in SC planning issue and analyzing in-depth the impact on inventories and transports. Section 2 presents the experimental design of the simulation study conducted. Section 3 describes the results obtained from the simulation work. Section 4 gives an overview and analysis of the results.

2. Experimental design

A simulation study has been set up to improve our understanding of lean supply chain. In this simulation work, to evaluate lean supply chain performance, a comparison with other SC planning policies is performed: Lean supply chain is compared with the traditional EOQ supply chain and with Visibility supply chain. The model used in the simulation study has been developed through a Discrete Event Simulation software (Rockwell Arena) and it is kept as basic as possible to avoid any noise that might cloud the sight on causes and effects.

2.1 The Supply chain model

The simulation model represents a three echelons supply chain composed by four suppliers, a manufacturer and a retailer. An input warehouse, a production phase and an output warehouse compose suppliers and manufacturer stages. Retailer stage is a distributor, it does not process items and it is composed only by a warehouse. An infinite stock in the supplier's input buffer is assumed. The production systems stages are composed by a queue for the items to work and a single machine where the items are processed. For the aim of this study it has been supposed that production systems aren't affect by failures. All these assumptions are common in inventory control literature (Kwak & Gavirneni 2011; Gavirneni 2002; Datta & Christopher 2011). In this simulation work, there are 24 different products from 4 different product families in the supply chain. One product family consists of 6 different products. Each supplier is responsible to produce one product family for the supply chain. However, the suppliers are not fully dedicated to this supply chain; they produce other products for other supply chains as well. The manufacturer works all the 24 products and its operations are fully dedicated to this supply chain. Multi-product SC and three-stage supply chain can provide valuable insights into managing complex systems efficiently that are not possible to study in single product and two-echelon supply chain studies. An infinite number of trucks are available for the transport of products, each single truck has a limited transport capacity and the lead-time to transport an item to the next stage of the supply chain is deterministic and equal to two days. Trucks leave the stage at the end of the day and shipped items are available to the next stage two days later at the beginning of the day. Moreover, LTL trips are possible; however, the minimum truck capacity saturation for an LTL trip is 50%. If the saturation does not satisfy this threshold, the shipment is postponed the day after: when it is possible there is a consolidation with next day shipments, otherwise the truck leaves less than half-saturated anyway. Everyday final customer demands finished product to the retailer and she has to satisfy the demand in Make-To-Stock logic. The retailer has to provide before the shipment time (basically before the end of the day) the demanded pieces. If she does not satisfy the demand there is the stock-out and so the back-log of the order. How supply chain members place orders depends on the specific supply chain policy. All supply chain members use the same planning policy. The planning policies studied in this paper are described below.

2.2 SC planning policies (exp. variables)

This research work aims to analyse the SC performance while SC has implemented lean approach. Two different SC planning policies are compared with Lean SC planning: Economic Order Quantity (EOQ) and Visibility (VIS). EOQ policy is the basic level of the planning policy task, it is recognized as the first attempt of inventory control optimization. The Visibility approach concerns information sharing practice and it is one of the most known approach to improve the planning function in a system.

2.2.1 EOQ

The EOQ approach is that all the SC members follow the (r,Q) policy. Every warehouse is exposed to a continue check: when the inventory-position goes down a certain level (reorder point), an order is placed upstream to the previous warehouse. If it is an internal order, the production of a batch starts, if it is an inter-stages order, the shipping. The order size and the reorder point could be different for each warehouse and they are fixed during the single replication. The inventory position is calculated as: Inventory position = inventory level + ordered items but none arrived – backlog orders (Cachon & Fisher 2000)

2.2.2 Visibility

Logic of the visibility approach exploits the information sharing among SC members. If visibility is operating every stages know the inventory position of the downstream stage and can take advantage of that (Kwak & Gavirneni 2011; Zhu et al. 2009; Gavirneni et al. 1999; Gavirneni 2002; Chen 1998). By means of this information, manufacturer is able to postpone the production (optimizing production timing) and so reduces the average WIP in the system using data about the direct customer's stock level. In this research work the visibility policy bases on the policy developed by Datta and Christopher (Datta & Christopher 2011).

2.2.3 Lean

Referring to the lean principles explained by Womack and Jones (CIT), we have decided to test "pull strategy" and "create the flow". "Pull" principle is implemented along the supply chain through a kanban system application in all the stages: the production starts only if there is a consumption of material at the downstream stage. "Create the flow" aims at a flow as levelled as possible, without any kind of interruption. The batch-size and setup time reduction represents this principle in the simulation model.

2.3 Experimental parameters

Supplier and manufacturer stages have finite production capacity.
Moreover, supplier is not dedicated only to this supply chain so every day it dedicates a variable amount of time to produce pieces for the manufacturer (65% on average).

Process times and demand rates have been defined in order that Manufacturer and Supplier are 80% saturated. This capacity saturation value is a good compromise between what there is in literature (e.g.(Kwak & Gavirneni 2011)) and in the real world. Like in the most part of SC simulation works the daily demand follows a Normal distribution. The service level of the SC is measured by the mean of the service levels of the single warehouses. It is verified that each single service level is inner of a range centred on the mean. The single warehouse service level is the ratio between the number of days of stockout and the overall number of days in the simulated period. The warehouse is in stockout whether it has not handled all the orders at the end of the day. This research work tested the supply chain performance of different service levels. The simulation was run for a period of 2050 days or 410 weeks with the first 50 days as the initialization period, the statistics from which were not used in the results

3. Results

This section describes and discusses the results of the simulation study. The holistic point of view is always used in the comments

3.1 Inventory level performance

An overview of inventory level for all the SC planning policies compared with EOQ is presented in fig 1.

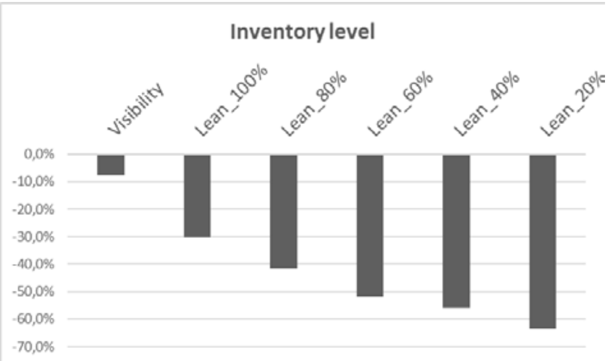

Figure 1: Inventory saving for Visibility and Lean policies

Visibility leads to an average 7,7% inventory saving. Lean_100%, Lean_80%, Lean_60%, Lean_40% and Lean_20% respectively lead to 30,1%,41,5%, 51,6%, 56% and 63,5% inventory savings. Lean leads always to greater inventory level savings than visibility. According to the values of this simulation work, the Lean inventory savings are at least three times Visibility inventory savings. Thus, we can conclude that Lean implementation impact on SC is very relevant and could lead to consistent logistic cost improvements. Moreover, the greater batch-size reduction the greater the benefits of Lean. However, the benefit of additional batch size reduction is not linear: a setup time and batch size reduction is more effective than a consecutive one. In fact, comparing the impact of two 40% reductions (the initial from Lean_100% to Lean_60% and the consecutive from Lean_60% to Lean_20%) the additional inventory saving is 21,5% for the initial one and 12,5% for the consecutive one. This highlights that, between the efforts that setup-time reduction requires and the benefits that it can lead to, a trade-off exists and has to be evaluated.

3.2 Transportation performance

An overview of transportation performances and savings for the different SC Planning policies is presented in figure 2. EOQ average number of trips is 9192, Visibility average number of trips is 9254, Lean_100% average number of trips is 9304. EOQ uses on average less trips than other SC planning policies. Lean has always greater number of trips than EOQ and Visibility. As could be seen from the figure, implementing setup time and batch-size reduction the number of trips for Lean SC increases. In the figure 2 the curve shows percentage difference between EOQ number of trips and other SC planning policies number of trips. Under Visibility number of trips increases by 0,6%, under Lean_100% it increases by 1,2%,, under Lean_80% it increases by 2,6% under Lean_60% it increases by 5,9%, under Lean_40% it increases by 8,8%, under Lean_20% it increases by 9,8%. The impact of setup time and batch size reduction is not negligible as for inventory level. However, for transportation performance the effect of setup time and batch size reduction is negative: the higher the reduction is the worse the transportation performance is. Same as for inventory level, the impact of setup time and batch size reduction is not linear. The curve of batch reduction effect is specular of what has been observed for inventory level: initial batch size reductions have negative effect smaller than consecutive batch-size reductions.

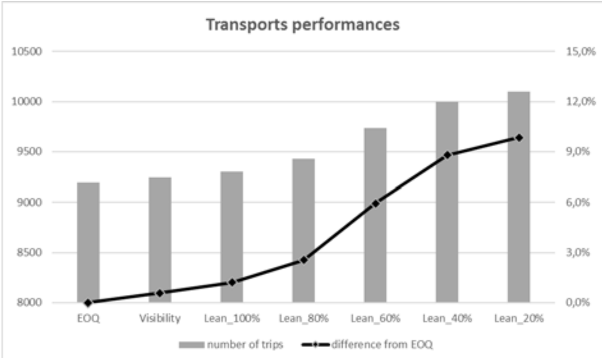

Figure 2: n° of trips for SC planning policies

4. Analysis

Simulation results show that implementing Lean SC planning there are inventory level decrease and number of trips increase. It is not immediate to give a final value of this performance and to achieve it, an analysis on SC logistic cost is necessary. Inventory carrying costs and transportation costs compose the SC logistic cost. The SC inventory carrying cost is computed as:

$$SC\ inventory\ carrying\ costs = (Average\ number\ of\ unit\ in\ stock) * (UICC) * (product\ value) \quad (1)$$

The unit Inventory Carrying Cost (UICC) is the unitary cost rate per year that considers different costs that incur with the product storage: capital cost, obsolescence cost and warehousing cost (Cachon & Fisher 2000). The computation of SC transportation cost is quite more complicated because transportation rates are very complex and very different among logistic providers. The next two paragraphs discuss impact of SC planning policies on SC logistic costs proposing two different transportation costs structures.

4.1 Transportation cost with fixed unit shipment cost

Assuming that SC has outsourced transportation activity and that it pays a fixed rate per shipped piece, the transportation cost is completely variable.

$$SC\ transportation\ costs = (number\ of\ shipped\ unit) * (unit\ shipment\ cost) \quad (2)$$

Since the number of shipped pieces is the same for all SC planning policies, if the transportation cost is completely variable, there is no difference in transportation costs between SC planning policies. In this context, benefits of a SC planning policy are measured only by inventory carrying costs saving. According to this context, Lean SC planning policy is the best performing planning policy leading up to 63% inventory carrying costs reduction.

4.2 Transportation cost with fixed trip cost

Assuming that SC pays a fixed cost per trip:

$$SC\ transportation\ costs = (number\ of\ trips) * (single\ trip\ cost) \quad (3)$$

The SC transportation cost depends on how many trips the SC uses to move pieces through stages. The efficiency is pursued maximizing the average truck capacity saturation. In this context, Lean leads to inventory carrying cost benefit but to transportation cost worsening too. Visibility has small inventory improvements and transportation that remains more or less the same. It is not immediate to compare different SC planning policies. Which is the best SC planning policy depends on weights of inventory carrying cost and transportation cost. To better understand the further analysis the unit Shipment fixed cost (USC) is introduced. USC is the shipment cost per unit assuming a FTL trip. That estimates the impact of transportation in case the piece moves by a completely saturated truck (Full Truck Load).

$$USC = \frac{single\ trip\ cost}{truck\ capacity} \quad (4)$$

Both coefficients (UICC and USC) are strictly connected to the context so they are different from SC to SC.

A new parameter μ is introduced to describe with a single value the relative weight of the UICC and USC in the cost analysis. μ is the ratio between USC impact on product value and UICC:

$$\mu = \frac{USC/(product\ value)}{UICC} \quad (5)$$

μ represents the proportion between the transportation cost impact and the inventory carrying cost impact on the product value. The figure 3 shows the comparison between Lean SC and Visibility SC. The curves represent the SC logistic cost savings of different Lean policies toward Visibility policy.

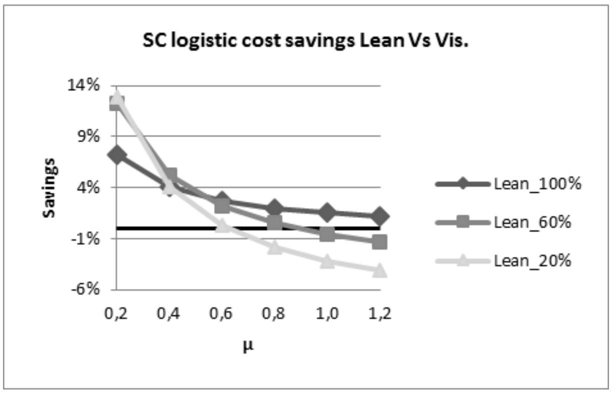

Figure 3: % saving on Visibility for different Lean policies

For the Lean SC without the batch size reduction (Lean_100%) the average saving compared with Visibility SC is 8% with μ equals to 0,2. Lean_100% is better than Visibility SC for all μ simulated. For the Lean_60% (40% batch-size reduction) the average saving compared with Visibility SC is 12% with μ equals to 0,2. LEAN_60% is better than Visibility SC while μ is lower than 0,9. For the LEAN_20% (80% batch-size reduction) the average saving compared with Visibility SC is 13% with μ equals to 0,2. LEAN_60% is better than Visibility SC while μ is lower than 0,6.The higher μ value is the higher the transportation relative impact is on the SC logistic cost. The higher the transportation relative impact is the smaller the Lean SC benefits are due to the worsening transportation performances. Furthermore, it is possible to state that there is a trade-off for batch-size reduction implementation. The batch-size reduction is very profitable in environment where μ is low because inventory carrying cost sustains the worsening in transportation costs. When μ assumes high values, negative effect on transportation is not counterbalanced enough by the inventory carrying cost savings so excessive batch size reduction leads to SC logistic costs worsening. Furthermore, it is possible to state that there is a trade-off for batch-size reduction implementation. The batch-size reduction is very profitable in environment where μ is low because inventory carrying cost sustains the worsening in transportation costs. When μ assumes high values, negative effect on transportation is not counterbalanced enough by the inventory carrying cost savings so excessive batch size reduction leads to SC logistic costs worsening.

Cetinkaya and Lee modelled a grocery supply chain (Çetinkaya & Lee 2000) and from their simulation parameters the μ values varies from 0,15 to 0,35. According to the highest μ value, Lean_100% SC logistic cost is 5% lower than Visibility SC logistic cost. Implementing 40% setup time and batch size reduction (Lean_60%), it is possible to increase SC logistic cost saving up to 8%.Gumus and al. studied the impact of Consignment stock and VMI practice on a generic supply chain (CIT). Using the same parameters, μ value is 0,2 and Lean leads to a maximum SC logistic cost saving equals to 13% with the 80% setup time and batch-size reduction.

5. Conclusion

This study has addressed one of the most important practical issue in SC planning: the impact of different SC planning policy to SC performances. It has focused on a three-echelon and multi-product supply and it has analysed in depth SC logistic cost considering both inventory carrying costs and transportation costs. Different SC planning policies have been tested to provide practitioners with guidance on which SC planning policy to apply in a specific context. The results of the experiments underline the potential of Lean SC planning policy to improve SC performance and to reduce SC logistic cost; this should provide confidence for future implementations. Moreover, this study provided insights regarding batch-size reduction impact on SC logistic cost and provided a guideline on how the company context affects the performances of Lean and visibility. Finally, the main limitations of this study are: (1) only 80% capacity saturation and (2) no different transportation rule have been tested. Future research should assess SC planning performances while parameters like capacity saturation or demand variability change and should analyse different SC planning policies for transportation to improve performances.

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