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Anaylsis of supply chain management disruptive situations

Vaibhav Diwan and Devendra Singh Verma
DAVV Indore.

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ABSTRACT

Supply chain resilience is an increasing area of interest for researchers and companies as its impact on efficiency and effectiveness of supply chains is mirrored on the ability of enterprises to compete in a fiercely competitive marketplace. Today's supply chains are more exposed to vulnerability due to the increasing probability of demand and supply uncertainty in complex supply chains. Some authors have reported how the risk of supply chain disruption has grown and how great the consequences of that disruption might be. However, literature have mainly focused on characteristics of supply chain to define the level of the risk or of the resilience to external (terrorist attacks, floods, earthquakes, etc.) and internal (failure of actors inside the supply chain) disruption causes. The paper presents a tactical approach to counteract the supply chain disruption issue, leading to operative rules that mitigate the effects of this negative occurrence. The approach relies on establishing novel ordering policies based on an information sharing approach. Orders placed are divided into two streams, transmitting the real demand information to the whole supply chain echelons and the required inventory adjustments in order to keep a stable inventory. A simulation model of a four echelons supply chain is developed to investigate the effect of a disruptive situation. Four ordering policies of information sharing approach are investigated and evaluated in terms of supply chain adaptability. The simulation results showed how the suggested approach can recover supply chain normal performance by reducing effects on inventories and increasing service levels of the supply chain.

Introduction

Supply chain management is a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses, and stores; so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system wide costs while satisfying service level requirements (Simchi-Levi et al., 1998). Today's supply chains are facing numerous changes that are contributing to increasing their complexity, such as the globalization of businesses and the adoption of some business philosophies as lean, efficient consumer response, and quick response programs. Barroso et al. (2010) indicated that these strategies and practices are designed for a stable world and have innumerable impacts on the supply chain, on one hand a reduction in the 1) level of inventory items along the supply chain, 2) number of suppliers, 3) lead time, 4) quantity delivered, and 5) buffers (in time and quantity); and on the other an increase of service level. Although the adoption of these practices will improve the operations of supply chain under normal conditions, they will tend to increase supply chain vulnerability to risks (Christopher and Towill, 2000; Norrman and Jansson, 2004; Tang, 2006). Supply chains may be exposed to two types of risks; foreseeable risks and unforeseeable risks (Oke and Gopalakrishnan, 2009).

Although the foreseeable risks are more frequent than unforeseeable risks, the Unforeseeable risks which can be defined as disruptions have more significant effect on supply chain performance. Some authors refer to disruption as disturbance, disturbance source, risk, uncertainty, or crisis (Barroso et al., 2010). Supply chains have recently faced a lot of disruptions such as terrorism attacks, natural disasters, and other disasters that affected very dramatically on the performance of supply chains that were not ready for such kind of disruptions. However, some other supply chains and organizations Have succeeded to be resilient to mitigate the negative effects of disruption by adopting appropriate strategies. Organizations and their supply chains must develop the ability to react to an unforeseeable disturbance (disruption) so that they can return quickly to their original state or move to a new stable one after suffering the disturbance (Carvalho et al., 2012; Peck, 2005). This paper presents a tactical approach to counteract a supply chain disruption issue which relies on establishing novel ordering policies based on an information sharing approach.

Literature Review

Supply chain risk management, in general, has gained a lot of attention by academics and practitioners in the last years. Thun and Hoenig (2011) described risk management as the identification and analysis of risks as well as their control. Supply chain disruption can be considered as one of the supply chain risks and the research in this area can be divided into empirical analysis and quantitative analysis (Zegordi and Davarzani, 2011). Thun and Hoenig (2011) conducted an empirical analysis based on a survey with 67 manufacturing plants in the German automotive industry. They identified supply chain risks and analyzed their likelihood to occur and their potential impact on the supply chain. Similar empirical studies were conducted by Vilko et al. (2011), Oke and Gopalakrishnan (2009), Craighead et al. (2007), Blackhurst et al.

Tele:
E-mail addresses: di_vaibhav@yahoo.co.in

(2005), Kleindorfer and Saad (2005), and Norrman and Jansson (2004) with focus on different countries or type of industry, to give some insights on this topic from a practitioner's perspective.

Beside the empirical research literature, other researchers have conducted quantitative analysis in order to investigate and quantify the impact of specific disruptions on supply chains performance and to propose the appropriate solutions for such disruptions. Schmitt and Synder (2012) argued that with the global expansion of supply chains there is a need for quantitative models addressing supply chain risk management. Tomlin (2006) suggested two different groups of strategies, mitigation and contingency, prior to a disruption and discussed the values of these two choices for managing a supply chain disruption. They studied a single-product setting in which a firm can source from two suppliers, one that is unreliable and another that is reliable but more expensive. Tang (2006) proposed robust strategies for mitigating disruption effects, and Pochard (2003) discussed an empirical solution based on dual-sourcing to mitigate the likelihood of disruptive events.

As a quantitative analysis tool, various simulation techniques have been applied in order to test and investigate the dynamic behavior of supply chains under disruption and mitigation strategies. Beside supply chain design, some researchers have modified the classical ordering policies in order to cope with a supply chain risk and to secure supply chain against potential risks.

Wilson (2007) investigated the effect of a transportation disruption on supply chain performance using system dynamics simulation, comparing a traditional supply chain and a vendor managed inventory system (VMI) when a transportation disruption occurs between 2 echelons in a 5-echelon supply chain. Tuncel and Alpan (2010) showed how a timed Petri nets framework can be used to model and analyze a supply chain network which is subject to various risks.

The majority of previous work based on quantitative analysis considers only simple structures of supply chains; two or three echelons at most. Therefore it is important to quantify disruption risk for extended supply chain as it will be indicated in this paper. Furthermore, supply chain dynamic behavior during and after disruption events has to be investigated.

Simulation Modeling

In this research, a single product multi-echelon supply chain is considered which is composed of several independent organizations. The adopted supply chain consists of four partners; retailer, wholesaler, distributor, and factory (see, Figure 1). Also, it is assumed that the lead time for ordering is 1 period of time and the product delivery lead time is 2 periods of time. Moreover, it is assumed that the inventories capacities of the supply chain partners are not limited

A disruption is defined as an event that interrupts the material flows in the supply chain, resulting in an abrupt stoppage of the movement of goods (Wilson, 2007). Similarly, Barroso et al. (2008) defined a disruption as a foreseeable or unforeseeable event, which affects directly the usual operation and stability of an organization or a supply chain. A disruption affecting a partner anywhere in the supply chain can have a significant impact on a corporation's ability to continue normal operations, get finished goods to the market and provide critical services to customers (Vilko et al., 2011). In this paper, the entire supply chain starts out of balance (disrupted) where there is no incoming shipments, or outgoing orders among the different supply chain partners. This can happen in reality for example when a company in the supply chain is facing a problem of quality such as what happened in various motor companies when they recalled their products. The disruption considered in this paper can be represented as follows in Figure 2. As the supply chain had been working normally until disruption happened. The disruption lasts for T2 periods and after that the supply chain has just started again to receive the customer demand. Although this type of supply chain disruption is not frequent but its consequences may have a significant impact on the supply chain performance and may last for long time. Moreover, this type of disruptions may sustain other supply chain problems such as bullwhip effect. This paper proposes an information sharing approach as a mitigation strategy in order to handle the problem of a specific supply chain disruption.

Proposed Approach

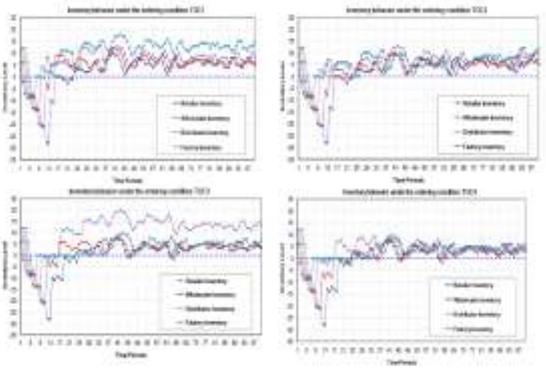
Vilko et al. (2011) indicated that supply chain risk management should be done as collaboration between the actors of the supply chain. Similarly, Machado et al. (2009) argued that increasing information sharing among supply chain partners will improve supply chain resilience, since the negative impact of lack of visibility in the supply chain is reduced. The proposed approach of information sharing is a tactical approach and can be considered as a coordination mechanism to deal with the ordering process of each partner whenever there is a disruption.

The proposed approach relies on dividing placed orders into two streams, the first stream transmits the real demand information $x(t)$ whereas the second one includes the required inventory adjustments $yi(t)$. This strategy is different from the traditional ordering policies, where in the traditional policies a supplier i just orders a single quantity $Oi(t)$ without indicating more information about the synthesis of the order. However, adopting the proposed approach of information sharing will allow the echelon i to know the real market demand and the inventory adjustment of $i-1$ which helps him to react and place balanced orders and hence reducing information distortion. In other words, the term $x(t)$ will be used to propagate the real market demand variability in the entire supply chain, and the term $yi(t)$ will be used by the partners to control their inventories. This approach also allows each partner to place and receive balanced orders without underestimating or overestimating the supply line so that a lot of dynamic problems such as bullwhip effect can be avoided. As indicated earlier that the amount of tokens $yi(t)$ will be used to stabilize the inventory of an echelon i . Thus, it will be sent to the upstream echelons only when there is a need for inventory stabilization. The problem is as in classical ordering policies; when to order this amount, and how much $yi(t)$ to order. The main condition to order tokens is the change in the observed customer demand level. In other words, if the customer demand is stable, the company orders only $x(t)$ where there is no need to order tokens $yi(t)$ from the upstream echelons. However, when customer demand increases, the echelon i expects that the customer demand mean has changed and its inventory should be adapted and stabilized by ordering a surplus quantity $yi(t)$.

In this research, demand change is defined as the increase of customer demand. Therefore, tokens order can be considered as a function of demand change and it can be expressed mathematically as following in equation (1).

$$y_i(t)=\begin{cases}0, & \text{if } x(t)\le x(t-1)\\ \alpha_i\left(x(t)-x(t-1)\right), & \text{if } x(t)>x(t-1)\end{cases} \quad (1)$$

And results are



Conclusions

Today's supply chains are more exposed to vulnerability due to the increasing probability of demand and supply uncertainty in complex supply chains. Some authors have reported how the risk of supply chain disruption has grown and how great the consequences of that disruption might be. The paper presents a tactical approach to counteract the supply chain disruption issue, leading to operative rules that mitigate the effects of this negative occurrence. The proposed approach relies on dividing placed orders into two streams, the first stream transmits the real demand information to the whole supply chain echelons whereas the second one to transmit

Inventory adjustments in order to keep a stable inventory. To investigate the proposed approach, a single product multi-echelon supply chain is considered which is composed of several independent organizations. A specific supply chain disruption is considered and modeled using simulation. Four ordering policies based on the proposed approach of information sharing have been proposed and evaluated using the simulation model. A comparison has been done among the proposed ordering policies based on instability period, inventory level, and ordering behavior before and after stability. In general, the proposed approach of information sharing succeeded to recover the supply chain performance; inventory level and ordering behavior. However, the recovery period (instability period) and inventory level realized after stability are dependent on the applied ordering policy. The proposed approach can be integrated with other tactical and strategic approaches in order to

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