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Impact of replenishment strategies on supply chain performance under e-shopping scenario

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ABSTRACT

With the development of Information and communication technologies (ICT), the supply chain performance and its management techniques have significantly transformed. The internet revolution has bought the surge in online shopping platforms attracting millions of small size manufactures to engage in the nascent business models. The research attempts to identify the factors influencing the supply chain performance for small size manufacturers under e-shopping scenario. The system dynamics simulation approach is attempted to assess the impact of replenishment strategies on supply chain performance indicators. The results reveal the existence of bullwhip effect in the e-shopping supply chains due to backlogged orders and management decisions. The comparison between two different inventory control strategies with replenishment patterns indicates that the target stock level method performs better over economic order quantity method under e-shopping scenario.

1. Introduction

Information and communication technologies (ICT) are enhancing supply chain performance with improved efficiency and responsiveness (Huang, Lin, Tai, Ho, & Jou, 2014). The Supply Chain (SC) performance is significantly boosted with the use of electronic portable devices. The revolutionary ICT has increased B2C and B2B transactions in E-Supply Chain Management (E-SCM) using Online Shopping Platform (OSP) (Disney, Naim, & Potter, 2004; Mangiaracina, Marchet, Perotti, & Tumino, 2015). Though the benefits of E-SCM have long been analyzed (Cousins, Lamming, Lawson, & Squire, 2008), there is still limited literature on the E-SCM for small businesses. Possessing the inherent advantage of information accessibility, E-SCM is mostly researched under the perspective of supply chain information sharing and collaboration (Giard & Sali, 2013; Kembro & Näslund, 2014). Organizations require both internal and external collaboration to construct a seamless and effective supply chain network. Limited available academic evidence reflects on the current trends of OSP-based business behaviors in relation to e-shopping supply chain performances. Disney et al. (2004) examined the bullwhip effect in four different E-SCM scenarios, where '*e-shopping*' scenario was introduced for the first time. They also found that under E-SCM, bullwhip effect in a single echelon supply chain still exists contradicting the conventional theory that the most effective way to reduce bullwhip effect is to reduce supply chain echelons and improve the overall visibility (Giard & Sali, 2013; Lee, Padmanabhan, & Whang, 1997). Vlachos, Georgiadis, and Iakovou (2007) follows a system dynamics approach for development of an efficient capacity planning policies for the remanufacturing facilities in a closed loop supply chain network. In order to understand the complex behavior of the influential factors in the OSP, a closer inspection of e-shopping scenario is necessary. Following a System Dynamics (SD) modelling approach, the research aims to compare the supply chain performances for two replenishment strategies for small businesses operating online. The developed single-echelon SD model is run under different e-shopping scenarios to understand the overall behavior of supply chain performance indicators. The bullwhip effect, service level and inventory costs serve as primary indicators for evaluating supply chain performances under different set conditions.

The paper follows a systematic approach to the research. Next section provides a literature review on four building blocks of this research namely- E-SCM, supply chain performance measurement, system dynamics and inventory control strategies. Section 3 outlines the research methodology, followed by the design of system dynamics model. In Section 4, the simulation results are analyzed. Section 5 concludes with a discussion on findings and future research directions.

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2. Literature review

There is evident research on E-SCM in the academic literature (e.g. Kembro & Näslund, 2014; Zhang, Pieter van Donk, & van der Vaart, 2011). The academic literature has covered this topic under different names such as e-business, e-commerce, and e-retail. with no accepted norm existing in the literature on the classification or difference (Gupta, Koulamas, & Kyparisis, 2009). The e-business impact on inventory levels (Rekik, Syntetos, & Jemai, 2015), pricing and delivery strategies (Huang et al., 2014) and sustainability (Mangiaracina et al., 2015) are being studied within the E-SCM context. An important factor that enables B2C type of e-business in current technology driven world is the prevalence of OSP. According to Huang et al. (2014), e-business facilitated with online transaction technologies will significantly improve supply chain performance by enhancing responsiveness and efficiency. The inventory cost and customer satisfaction both measure the extent to which efficiency and effectiveness can be achieved in the manufacturing process (Cousins et al., 2008). Customer satisfaction indicates the effectiveness of the response to customer demand in the supply chain (Gunasekaran, Patel, & McGaughey, 2004). The simplest indicator of customer satisfaction is the fill rate, which is calculated as the fraction of orders that are delivered (Nahmias & Olsen, 2015). Supply chain performance can be evaluated through three dimensions: bullwhip effect, inventory cost and service level (Cachon & Terwiesch, 2009). Intensive research on the bullwhip effect over years shows increased focus on reducing its impact (Wang & Disney, 2016). Collaboration and information visibility are critical to overcome bullwhip effect and inventory instability (Costantino, Gravio, Shaban, & Tronci, 2014). Bayraktara, Kohb, Gunasekaranc, Sarid, and Tatoglu (2008) examined the bullwhip effect under E-SCM environment to predict seasonal order swing as a measure to reduce the effect in supply chain network.

Two widely used inventory replenishment strategies are Economic Order Quantity (EOQ) and Target Stock Level (TSL). EOQ is one of the most fundamental order patterns providing optimal size of fixed orders that minimizes the total inventory cost (Beamon, 1998; Sterman, 2000). While TSL is a periodic replenishment strategy under which a fixed order review interval is approached (Giannoccaro, Pontrandolfo, & Scozzi, 2003). The research trend in replenishment strategies probe into the impact and operability under different scenarios of dynamic re-order quantity or reorder interval. Maximum storage requirement and finished goods inventory level can be achieved by the dynamic adjustment of the replenishment strategy for the seasonal products (Grewal, Enns, & Rogers, 2015). Within E-SCM context, Yang, Hong, and Lee (2014) revealed that collaborated order quantity benefits both manufacturers and distributors with credit period and quantity discount achieved. Eruguz, Jemai, Sahin, and Dallery (2014) conducted research using TSL policy into reorder interval and target stock level optimization within complex supply chain network. The comparative research by Tsou (2013) testified that under dynamic target inventory level TSL (JIT model) performs better with lower order cost, while EOQ policy has better performance with higher order cost or higher rate of stock shortage.

Within E-SCM research, there is an evident lack in the research synthesizing e-shopping supply chain with supply chain performance and associated behavioral analysis (Huang et al., 2014). To overcome this gap, series of SD simulations are conducted in the research. The paper illustrates online shopping platforms and their behaviors under different inventory replenishment conditions. The simulation study conducted in this paper is particularly applicable to the small businesses- the main entity in the online shopping market.

3. Model development

In order to identify the relationship between e-shopping supply chain performance and its influencing factors, SD modelling approach is followed. SD simulation is conducted using *VensimPLE©*, a continuous event simulation platform. SD modelling follows a three step approach (Sterman, 2000). The first step conceptualizes elements of e-shopping supply chain into the computer model. Manufacturer, customer demand, supplier behaviors and supply chain activities are embedded into SD model at this stage through a casual loop diagram and its corresponding stock and flow diagram as seen in Figs. 1 and 2 respectively. In Fig. 1, the colored box variables are the key variables targeted for the observation (e.g. service level, BWE, inventory cost). Other box variables such as supplier, manufacturer, backlogged orders are core variables not under direct observation. Remaining dependent/independent variables are also shown in the feedback loop to represent the complex relationship of different variables in the supply chain network. The next step is to run the simulation to identify potential influencing factors and to draw inferences from the analysis. All the variables shown in the causal loop diagram are consolidated in Table 1 with their associated cause and effect. Customer demand is generated as a primary data through the use of random function that randomizes the outcome under controlled normal distribution. The stochastic data is generated with the help of control variables available within the simulation platform. The SD model has considered following input values for different variables: Unit cost of product = £50, Ordering cost = £10, Holding cost per unit = £10, Holding rate = 20%, forecasting error = 10 units/week. The simulation is run for 260 weeks with a time step of 1 week. The hypothesized business type is a small business selling identifiable products online. Under above set assumptions, lead-time is only considered during the replenishment products are transported from supplier factory to the manufacturer's warehouse. Lead-time from manufacturer to customers is not considered in the simulation. Three dependent variables selected to be observed are bullwhip effect, inventory cost and customer service level.

3.1. Causal loop diagram

In the model, the manufacturer directly receives orders from end customers through OSPs. Orders in each period are calculated as the sum of two parts: customer demand and the backlogged orders that reflect the sum of unfulfilled orders for a given period. During each time-step, manufacturer will prioritize to fulfill the back-orders before new customer demand is fulfilled. For each period, the ratio of the fulfilled orders to simultaneous customer demand is calculated as the service level. Since the simulation model considers single echelon in the supply chain model, backlogged orders are considered as the major trigger to the bullwhip effect. After the delivery of orders by the manufacturer, replenishment orders are placed with their suppliers based on TSL or EOQ pattern. Under EOQ strategy, manufacturer will make a replenishment order with a fixed quantity, when stock level reaches the reorder point (ROP). Whereas in the TSL scenario, a variable-quantity replenishment order will be generated after a fixed review interval. For the modelling purpose, it is assumed that the manufacturer is small-sized and suppliers can always satisfy the replenishment requests. Hence the frequency of replenishment orders and inventory holding by the manufacturer altogether contributes to the overall inventory cost. Customer demand is randomly generated by the normal distribution function in the simulation platform. Developed stock and flow diagram in Fig. 2 illustrates the system behaviors, indicating the binary relationships among variables.