Computers & Industrial Engineering 82 (2015) 127–142

Contents lists available at ScienceDirect

Computers & Industrial Engineering

journal homepage: www.elsevier.com/locate/caie

The impact of information sharing on ordering policies to improve supply chain performances

Francesco Costantino [a], Giulio Di Gravio [a], Ahmed Shaban [a,b,*], Massimo Tronci [a]

[a] Department of Mechanical and Aerospace Engineering, University of Rome "La Sapienza", Via Eudossiana, 18, 00184 Rome, Italy
[b] Department of Industrial Engineering, Faculty of Engineering, Fayoum University, 63514 Fayoum, Egypt

ARTICLE INFO

Article history:
Received 30 May 2013
Received in revised form 19 January 2015
Accepted 21 January 2015
Available online 2 February 2015

Keywords:
Supply chain
Ordering policy
Information sharing
Bullwhip effect
Simulation

ABSTRACT

Bullwhip effect represents the amplification and distortion of demand variability as moving upstream in a supply chain, causing excessive inventories, insufficient capacities and high operational costs. A growing body of literature recognizes ordering policies and the lack of coordination as two main causes of the bullwhip effect, suggesting different techniques of intervention. This paper investigates the impact of information sharing on ordering policies through a comparison between a traditional (R, S) policy and a coordination mechanism based on ordering policy (a combination of (R, D) and (R, S) policies). This policy relies on a slow, easy to implement, information sharing to overcome drawbacks of the effect, in which replenishment orders are divided into two parts; the first is to inform the upstream echelons about the actual customer demand and the second is to inform about the adjustment of the inventory position, smoothing at the same time the orders of the different levels of the supply chain. A simulation model for a multi-echelon supply chain quantifies the supply chain dynamics under these different policies, identifying how information sharing succeeds to achieve an acceptable performance in terms of both bullwhip effect and inventory variance.

1. Introduction

A supply chain is a system of suppliers, manufacturers, distributors, retailers and customers where raw material, financial and information flows connect participants in both upstream and downstream directions. The lack of coordination and the search for local optimization by each partner, without considering the consequences on the other partners, reduces the performances of the whole supply chain. The main symptom of such inefficiency is the bullwhip effect, a misalignment between the demand and order signal (Fig. 1). Starting from any change in the demand, the order variability tends to transmit and increase at the upstream suppliers, generating and amplifying instability. This leads to stock-outs, large and expensive swings of capacity utilization, lower quality of products and a considerable increase of production and transport costs as deliveries continuously ramp up and down (Towill et al., 2007; Disney and Lamrecht, 2008). Many real cases described this phenomenon and its negative effects on various industries, as for Campbell Soup's (Fisher, Hammond, Obermeyer, & Raman, 1997), HP and Proctor & Gamble (Lee, Padmanabhan, & Whang, 1997a), a clothing supply chain (Disney & Towill, 2003), Glosuch (McCullen & Towill, 2000), fast moving consumer goods (Zotteri, 2012) and car manufacturing (Klug, 2013).

Among its behavioral and operational causes, inventory control is one of the main areas of intervention. If supply chains partners take inventory decisions basing only on the incoming orders and the local information, without knowing the actual customer demand or the inventory position of the other members, replenishment orders tends to amplify to cover uncertainty. Many researchers have attempted to improve the performances of the inventory control process by adopting actions to increase coordination. Sharing local and global information improves forecasting and inventory control processes in order to gain inventory stability, assuming that all the supply chain partners have a real-time access on information (Dejonckheere, Disney, Lambrecht, & Towill, 2004; Ciancimino, Cannella, Bruccoleri, & Framinan, 2012; Cho & Lee, 2013). The integration of traditional ordering policies with a collaborative approach proved its success in different configurations as for Information-Enriched Supply Chain, Vendor Managed

* Corresponding author at: Department of Mechanical and Aerospace Engineering, University of Rome "La Sapienza", Via Eudossiana, 18, 00184 Rome, Italy. Tel.: +39 0644585260; fax: +39 0644585746.

E-mail addresses: francesco.costantino@uniroma1.it (F. Costantino), giulio.digravio@uniroma1.it (G. Di Gravio), ahmed.shaban@uniroma1.it, ahmed.shaban@fayoum.edu.eg (A. Shaban), massimo.tronci@uniroma1.it (M. Tronci).

http://dx.doi.org/10.1016/j.cie.2015.01.024
0360-8352/

Inventory, Quick Response and Collaborative Planning, Forecasting and Replenishment (CPFR) (Lee et al., 1997a; Disney & Towill, 2003; Dejonckheere et al., 2004; Holweg, Disney, Holmström, & Småros, 2005; Ye & Wang, 2013).

However, the application of these organizational models requires specific and significant investments in information systems that not all the partners could generally afford (Sari, 2008; Lin, 2009). Literature is full of studies that theoretically explain and discuss the importance of collaboration to counteract the bullwhip effect in multi-echelon supply chains but only few applications propose solutions to implement at a reasonable effort. Furthermore, only few studies address cases where real-time information is not possible or where the trade-off between the implementation cost and the potential benefits is not reasonable (Costantino, Di Gravio, Shaban, & Tronci, 2013a, 2014a; Moyaux, Chaib-draa, & D'Amours, 2007). For that, more research is still required on modeling and analyzing alternative and gradual coordination-levels (Gunasekaran & Ngai, 2009; Ciancimino et al., 2012).

Starting from the evaluation of the Order-Up-To policy in a traditional multi-echelon supply chain as a benchmarking case, this paper presents and evaluates an easy-to-implement coordinative inventory control policy to improve supply chain performances in terms of bullwhip effect and inventory stability. This policy divides the order into two parts: the first represents the actual value of the customer demand and the second represents the (positive or negative) quantity to be added to the first part in order to stabilize inventory levels. While the first part moves the supply chain towards just in time (Kanban-like system), the design of the replenishment rule calculating the second part protects each member from the inventory decision of the other members. In this case, a slow information sharing allows any partner to know the real value of the customer demand with a certain delay (as no real-time system is required) by referring to the orders of its direct downstream echelon. A simulation model evaluates this policy, showing a dramatic improvement despite delayed information sharing.

The paper starts from a literature review on the bullwhip effect in Section 2, with a special focus on the impact of inventory control policies and information sharing. Section 3 introduces the research methodology, as for supply chain model, demand patterns and performance measures. Section 4 shows the performances of the Order-Up-To policy, comparing it to the coordinative policy. Section 5 discusses general implications of slow information sharing and Section 6 presents conclusions and future developments.

2. Literature review

In supply chains, each member issues an order to its supplier that in turn attempts to deliver products on time. In a non-collaborative environment, each partner issues his orders basing only on the information coming from the adjacent downstream echelon, trying to take into account a forecast of the demand (Chen, Drezner, Ryan, & Simchi-Levi, 2000; Zhang, 2004; Costantino, Di Gravio, Shaban, & Tronci, 2015b), the lead-time of delivery (Chatfield, Kim, Harrison, & Hayya, 2004; Croson & Donohue, 2006) and its actual inventory level (Disney & Lambrecht, 2008). These rational activities for managing supply chains can generate the bullwhip effect (Lee et al., 1997a, Lee, Padmanabhan, & Whang, 1997b). Lee et al. (1997a, 1997b) identified four operational causes of the bullwhip effect: demand signal processing, order batching, supply shortages and price fluctuations. They also explained the impact of lead-time and its interaction effect with forecast updating on the bullwhip effect. Furthermore, they provided some practical examples showing that, even if the demand is stable, a supply chain will face the bullwhip effect in any case of misalignment between demand and supply.

Global performances of supply chains depend on the information distortion generated by local optimization process of the partners as, without coordination, they make replenishment decisions without knowing real demand information or inventory levels at the other partners. Resellers could push purchase orders if the demand is not clear or if there is any suspect of delays of insufficient deliveries; at the same time, production systems increase the duration of the operations to create buffers for any loss in yield or failures interrupt schedules (Lee et al., 1997a, 1997b). Without visibility and control, excessive and uncontrolled orders spread in the supply chain to face uncertainty. The real state of information progressively hides while these distortions and misperceptions do not allow prompt responses to irregularities and unexpected events (Niranjan, Wagner, & Aggarwal, 2011). This lack of coordination and visibility among partners significantly affects business performances, causing inefficiencies and resulting in an increase of management costs due to (Costantino, Di Gravio, Shaban, & Tronci, 2014c):

- high levels of inventory to face unexpected variations of the demand with a relative increase of stocking costs;
- low service level to customers for unexpected stock-outs that, in the worst cases, can cause the cancelation of orders;
- reduction of quality for the necessity to increase production rates to satisfy peaks of demand;

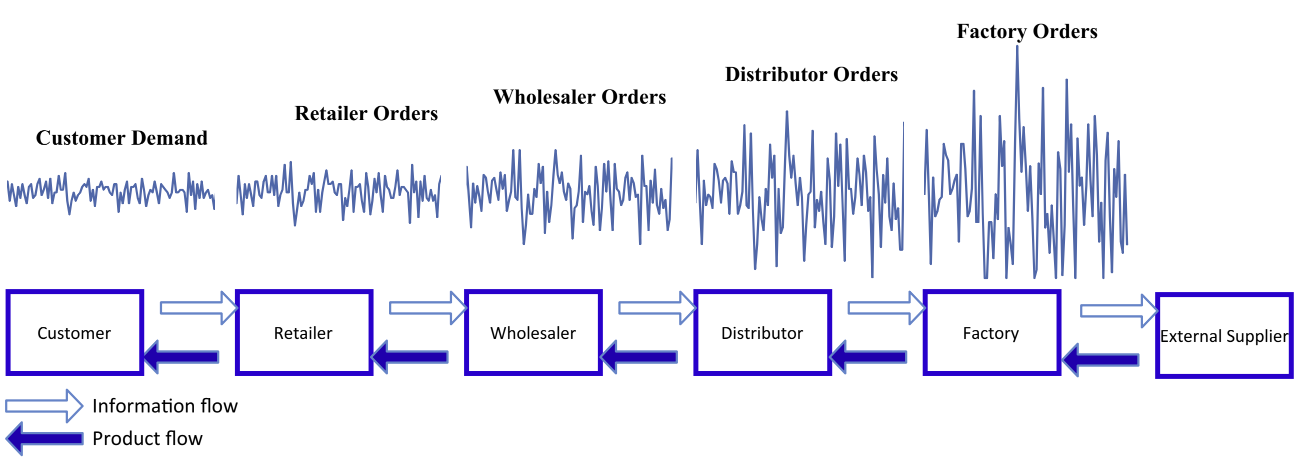

Fig. 1. Illustration of demand variability amplification.