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Assessing the value of information sharing and its impact on the performance of the various partners in supply chains ☆

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ABSTRACT

With major developments in information and communication technologies, real-time information sharing becomes a significant challenge and has a considerable impact on the overall performance of supply chains. Here, we study the influence of information sharing for a monoproduct serial supply chain consisting of a supplier, warehouse, retailer and customers in the context of a decentralized decision. The objectives of this study are twofold: (1) to estimate the gains from sharing different types of information on each elementary cost and for each partner of the supply chain in detail and (2) to determine the cumulative impact of simultaneously sharing different types of information.

A mathematical model is developed to assess the value of information sharing in terms of logistic costs and for different combinations related to the sharing or non-sharing of three types of upstream and downstream information: the customer demand and the supplier-warehouse and warehouse-retailer lead times. A perturbation is also injected to consider the intended or unintended distortion in the communicated information.

Our study clearly showed that the gains are not cumulative when we simultaneously share different types of information. The results also highlighted the necessity to establish incentive cooperation mechanisms between the different links in the supply chain in many scenarios where the gains are not balanced. A distortion in the communicated information can also have a significant effect on the gains from sharing.

1. Introduction and literature review

Information is an issue that increasingly focuses all interests in a collaborative context. Information sharing has become a topic of debate in all areas. Specifically, all interests are moving toward utilizing the available information and obtaining the most benefit from its exploitation. In the same sense, the domain of supply chain management is rich and promising. This domain represents major challenges for many interveners. In this area, information sharing is an issue that emerged with the development of information and communication technologies. An important part of the research in supply chain management focuses on the study of the effect of information sharing on the performance of the supply chain. Moreover, in the context of reducing system costs, cooperation and collaboration on decisions inevitably become the key words to success. Thus, information sharing can increase the performance of the supply chain.

In this context, many studies in the literature have examined the value of information sharing in its different forms. Two papers reviewed the work in the field from 1996 to 2002 (Huang, Lau, & Mak, 2003; Chen, 2003). A more recent paper presented a literature review of information sharing and collaboration on a single dyadic supply chain structure (Jairo & Diego, 2014). In another literature review, Lotfi, Mukhtar, Sahran, and Zadeh (2013) studied the benefits of and barriers to information sharing in supply chains. The existing studies about information sharing differ on many points, such as the structure of the supply chain, the shared information and sense of sharing, and the assessment of the sharing gains as well as the approaches and application fields.

Regarding the structure of the chain, a large number of studies treated the case of a simple serial supply chain. For example, Agrawal, Sengupta, and Shanker (2008) considered a two-echelon serial supply chain composed of a warehouse and retailer. A different serial supply chain composed of one manufacturer and one retailer was considered in Lee, So, and Tang (2000), Li and Zhang

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(2015) and Ali, Boylan, and Syntetos (2012). Costantino, Gravio, Shaban, and Tronci (2014) considered a four-echelon serial supply chain consisting of a customer, retailer, wholesaler, distributor and factory. Many other papers, such as those of Cachon and Fisher (2000), Laux, Huang, and Mak (2004), Chen, Yang, and Yen (2007) and Choudhary and Shankar (2015), considered a divergent supply chain composed of one supplier, several warehouses and several retailers. Other authors studied a convergent structure composed of several suppliers, several warehouses and one retailer (Strader, Lin, & Shaw, 1999). Ding, Guo, and Liu (2011) combined a convergent and divergent structure consisting of several suppliers, one warehouse and several retailers.

According to the type of shared information and its sources, customer demand is among the most studied information in terms of sharing in the literature. This downstream information was studied in the majority of papers (Byrne & Heavey, 2006; Cho & Lee, 2013; Chu & Lee, 2006; Ding et al., 2011; He & Liang, 2011; Li & Zhang, 2015; Li, Gilbert, & Lai, 2014; Lee et al., 2000; Zhang & Chen, 2013). The lead time as a piece of upstream information has rarely been discussed in the literature (Chen & Yu, 2005; Jia, Guo, & Li, 2007), although lead time appears in many papers considering a system that is not subjected to explicit sharing (Agrawal et al., 2008; Cachon & Fisher, 2000; Li & Zhang, 2008; Moyaux, Chaib, & D'Amours, 2007; Zhao & Xie, 2002). Furthermore, some authors studied hybrid models in which information on the demand and inventory level is shared simultaneously (Chengalur-Smith, Duchessi, & Gil-Garcia, 2012; Li, Sikora, Shaw, & Tan, 2006; Yu, Ting, & Chen, 2010). Li et al. (2006) presented five models of information sharing. The first model considers the sharing of order information, the second considers the sharing of a probabilistic demand, the third model considers the sharing of stock level information, the fourth model considers the sharing of sold quantities information and the last model is a hybrid model in which both the demand and stock levels are shared (these two pieces of information originate downstream in the supply chain). Yu et al. (2010) added the simultaneous sharing of the production capacity to the demand and inventory level. Other information, such as the order quantity (Jeong and Leon, 2012; Xue, Shen, Tan, Zhang, & Fan, 2011), the production capacity (Chen et al., 2007; Yu et al., 2010) and the sales quantity (Li et al., 2006), have been rarely studied in the literature.

Concerning the valorization of information sharing in supply chains, many authors (Birendra, Srinivasan, & Xiaohang, 2007; Jeong & Leon, 2012) attempted to maximize a benefit function calculated under different sharing and non-sharing scenarios. Other authors used a cost function to assess the value of information sharing. This cost function is typically composed of a combination of holding, penalty and transportation costs (Byrne & Heavey, 2006; Cho & Lee, 2013; Gavirneni, Kapuscinski, & Tayur, 1999; Yu et al., 2010). Other authors used other performance indicators, such as the customer service level, the order cycle time (Li et al., 2006) or the improvement of the supplier demand forecast accuracy (Wang, 2012).

Regarding the approaches used to study the effect of information sharing, many studies used a simulation approach supported by a numerical study on random data, such as in the works of Chen et al. (2007) and Ding et al. (2011). Other studies associated multi-agent systems with simulation (Laux et al., 2004). Zhao and Xie (2002) conducted a statistical analysis to study the impact of forecasting errors and information sharing on the performance of the supply chain. In the same context, Ye and Wang (2013) developed a statistical study to identify the effect of information technology alignment and information sharing on the operational performance of the supply chain. Mehrabi, Baboli, and Campagne (2007) used genetic algorithms to find optimized solutions for two inventory management policies involving sharing or not sharing information. Other papers, such as those by Byrne and Heavey (2006), Moyaux et al. (2007) and Strader et al. (1999), used a simulation approach followed by the validation of a numerical study on actual data. Other studies, such as Helper, Davis, and Wei (2010), Li and Zhang (2008) and Guo, Ding, and Liu (2006), used analytical approaches to study the effect of information sharing. Liu and Kumar (2003) used the Unified Modeling Language (UML) to model existing collaborative initiatives in supply chains, such as the Third-Party Logistics (3PL), the Vendor Managed Inventory (VMI) or the Collaborative Planning, Forecasting, and Replenishment (CPFR). The main objective of this study was to develop a methodology for the design of reconfigurable supply chains based on three key elements: an architecture for information sharing, then an exchangeable schema for shared data and, finally, an information model flow. More generally, Hobbs (1996) presented a general framework based on transaction cost analysis in supply chains to encourage vertical cooperation between partners. He noted, for example, that a lack of information or information asymmetries can lead to opportunistic behavior by hiding information about defects or problems from the buyer.

In addition to information sharing, an increasing number of studies are considering coordination involving revenue-sharing contracts, which automatically implies information sharing. These revenue-sharing contracts can be implemented in different ways. Traditionally, these contracts imply that the retailer buys from the supplier at a wholesale unit price and pays in return a percentage of the generated revenues from its sales to the supplier (Cachon & Lariviere, 2005). More recently, reverse revenue sharing contracts have been developed in which the retailer gets a fraction of the supplier's revenues (Geng & Mallik, 2007). Xu, Dan, Zhang, and Liu (2014) developed a two-way revenue sharing contract in which both suppliers and retailers share a fraction of their revenues with their partners. Indeed, the manufacturer receives a fraction of the revenue generated by the retailer's channel as in the traditional revenue sharing contract, and the retailer receives a fraction of the revenue generated by the manufacturer's direct channel as a reverse revenue sharing contract. Chen, Federgruen, and Zheng (2001) suggested a revenue-sharing contract in a two-echelon distribution system composed of one supplier that delivers a single product to multiple retailers. The revenue-sharing contract is built on a nontraditional discount pricing scheme based on three components: the retailer's annual sales volumes, the order quantity and the order frequency. Xiao and Xu (2013) designed a generalized revenue-sharing policy that not only implies the traditional sharing of the retailer's revenues but also includes the transfer price paid by the retailer. In this way, both the supplier and retailer simultaneously share revenues and costs. In the same context, Pezeshki, Baboli, and Jokar (2013b) presented a study on coordination in a divergent supply chain composed of one supplier and several retailers. In their study, the authors proposed a revenue-sharing contract with penalty as a coordination mechanism applied initially on a dyadic supply chain and then on a more complex divergent chain integrating several retailers. This mechanism is integrated to harmonize the pricing decisions and capacities. In the same context of cooperation, Zhang and Chen (2013) discussed the case of coordination with demand information sharing between the supplier and retailer to guarantee the sharing of both information and revenue. Their study showed that the supply chain partners should sign a coordinative contract to ensure the complete sharing of their mutual information. According to Yang (2012), sharing demand information plays an important role in the coordination between the links of the supply chain, which will help each member to make the best management decisions. More recently, many other researchers studied a new concept related to information sharing involving a level of trust between different links in supply chains. Pezeshki, Baboli,