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OVAP: A strategy to implement partial information sharing among supply chain retailers

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ABSTRACT

This paper analyses the impact on supply chain performance of adopting different strategies to implement partial information sharing among heterogeneous retailers. Supply chains are modelled using a multi-agent systems approach. We find that the strategy adopted to construct the partial information sharing structure (*i.e.*, the retailers who share information) has a significant impact on supply chain performance. We propose a practical strategy, named Order VAriance Prioritization (OVAP), which gives priority to the retailers with higher order variance. OVAP outperforms the worst (*i.e.* naive) implementation method by 27.2% and 7.8% with respect to the levels of bullwhip and average inventory.

1. Introduction

1.1. Context and motivation

Information Sharing (IS) has been acknowledged as an effective practice for coordination among the nodes of decentralized Supply Chains (SCs), improving the global performance and reducing production and logistics inefficiencies caused by the bullwhip effect (Ali et al., 2012; Chatfield et al., 2004; Dejonckheere et al., 2004; Lee et al., 1997; Shan et al., 2014; Trapero et al., 2012; Wang and Disney, 2016). However, there are numerous barriers to the implementation of IS in SCs (Ali et al., 2017; Spekman and Davis, 2016) including the risk of information leakage (Huang et al., 2016; Kong et al., 2013), lack of trust (Shnaiderman and Ouardighi, 2014), resource investments in Information Technology (Gunasekaran et al., 2017; Kembro et al., 2014), wide variety of technology and tools (Ramanathan, 2014), different types of information (Rached et al., 2016; Yu et al., 2010), information distortion (Jeong and Leon, 2012; Niranjan et al., 2011), and unbalanced share of gains between SC members (Lee and Whang, 2000; Rached et al., 2015; Shih et al., 2015). These barriers, together with the decentralization and globalization of modern SCs make it difficult to achieve a full/perfect IS among SC members and thus, this assumption deviates from real-life in some cases (Huang and Wang, 2017). As a consequence, partial IS is a prevalent scenario in real-life SCs (Shnaiderman and Ouardighi, 2014; Xu et al., 2015; Zhou et al., 2009).

According to the literature, partial IS in SCs takes place when the information is asymmetrically shared among SC members (see *e.g.* Gümüş, 2014; Gunasekaran et al., 2015; Inderfurth et al., 2013; Li et al., 2016; Zhou et al., 2017a), delayed (see *e.g.* Hoberg and

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Thonemann, 2014; Hosoda and Disney, 2012), partially revealed (Zhang et al., 2016), shared only between some members of the SC (see *e.g.* Ganesh et al., 2014a, 2014b; Lau et al., 2004; Huang and Wang, 2017), or inaccurate, either intentionally (see *e.g.* Huang et al., 2017; Shnaiderman and Ouardighi, 2014) or unintentionally (see *e.g.* Cannella et al., 2015; Kwak and Gavirneni, 2015). A specific case of partial IS occurs when the information is symmetrically, timely and accurately shared, but takes place only between some members of the SC. In fact, it is common that some members of SC do not participate in IS, particularly at the retailer stage (empirical evidence showed that only 27% of retailers shared POS data with other members, see Shang et al., 2016). Nevertheless, despite being a common practice, there is a lack of academic studies on the topic (Holmstrom et al., 2016). To the best of authors' knowledge, there are only five studies addressing this theme: Costantino et al. (2014) and Ganesh et al. (2014a, 2014b) analyse how different degrees of collaboration between SC members impact the bullwhip effect, inventory holding and shortage costs, and/or customer service levels in a serial SC. Lau et al. (2004) analyse partial IS in three divergent SCs with increasing complexity. Finally, Huang and Iravani (2005) analyse a SC with one capacitated manufacturer and two different retailers where the former may receive demand and inventory information from any of the retailers.

All these works agree that retailers provide, by sharing customer demand information, the highest performance improvement for SCs with respect to other members (*e.g.* wholesalers and distributors). Nevertheless, an important limitation of the above studies is that they assume – with the exception of Lau et al. (2004) – a single retailer in the SC. However, real SCs often include more than one retailer (Wan and Evers, 2011) and, due to the complexities of modern SCs, retailers may operate under different market scenarios (*e.g.* different customer demand) and/or Operational Factors (OFs) (*e.g.* lead time, inventory order policies, forecasting methods, etc.). These implications concern both traditional SCs (*i.e.*, SCs without IS) and partial IS SCs that are willing to adopt or upgrade the IS strategy (*i.e.*, to incorporate new retailers). In cases where it is undesirable or infeasible to transform the current (traditional or partial IS) SC into a full IS SC, where all retailers share information with upstream echelons, it is of great interest to define a strategy to incorporate new retailers in IS by identifying the retailer(s) who can provide the highest global performance improvement by sharing market demand information with upstream members. In this manner, a roadmap for implementing IS can be devised in order to capture most IS benefits at a reduced cost. Despite its potential, to the best of the authors' knowledge, the analysis of different strategies for implementing partial information sharing among heterogeneous retailers has not been previously addressed.

Thus, it is important to understand how to select the most suitable retailers taking into account that (1) they are usually heterogeneous and (2) upstream members often lack visibility regarding retailers' internal processes and policies. A practical and user-friendly method for identifying appropriate retailers is to analyse retailers' order patterns and, more specifically, the variability of orders. There are two main reasons to follow such an approach: (1) orders are one of the few data transmitted upstream by retailers in a traditional SC, and (2), IS is known to be more beneficial in a SC where members have to face higher order variability (Chatfield and Pritchard, 2013). According to these considerations, we argue that IS might be more beneficial when it involves retailers who transmit upstream most of the variability of the orders in the SC, and by doing so, reduces their contribution to the demand amplification.

1.2. Objectives and contribution

Motivated by the considerations in the previous section, our research objectives are:

1. To determine the impact of the IS implementation strategy (*i.e.*, how to select the appropriate retailers for IS) on SC performance when retailers are heterogeneous. More specifically, we intend to prove that the specific strategy adopted for IS implementation has a significant effect for the SC in terms of the bullwhip effect and inventory levels.
2. To propose and test (through simulation) a practical IS implementation strategy to achieve effective IS for SCs with heterogeneous retailers and partial IS, quantifying its benefits in terms of bullwhip and average inventory reductions. More specifically, we will show that our proposed strategy exploits most of IS capability under partial IS.

Such strategy, named Order VAriance Prioritization (OVAP), considers retailers' order variability to identify potential retailers for IS. As such, this is a "pre-assessment" strategy, since it is based on current information of the SC, and it can be determined prior to the performance assessment, avoiding the need of running a SC model. Consequently, OVAP can be implemented in practice. More specifically, OVAP determines the retailers for IS as follows:

– Estimate retailers' order variance prior to IS implementation.
– Generate a sequence of retailers, which are ranked from the highest to the lowest order variance (*i.e.*, retailers with higher order variance are potentially better partners for IS).

In order to get more accurate dynamic insights, a model of an entire SC should be considered (Chatfield, 2013). As such, to fulfil the research objectives we model a SC with four echelons (*i.e.*, Factory, Distributor, Wholesaler and Retailer), each of them characterized by one member with the exception of the Retailer's echelon. In order to consider several partial IS structures and allow for a precise representation of the performance of OVAP, we consider four retailers (see Fig. 1). Each retailer may or may not share private market demand information with the Wholesaler (*i.e.*, partial IS), who may use this data in his/her inventory control policy. Additionally, retailers are heterogeneous, as they face different market and geographical conditions. Such heterogeneity is specifically simulated by systematically varying three different OFs (*i.e.*, average lead time, market demand variability, and forecasting period). Finally, since SC processes are often subject to uncertainty, we consider stochastic demand and lead times in order to obtain more