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Supply chain forecasting when information is not shared

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ABSTRACT

The operations management literature is abundant in discussions on the benefits of information sharing in supply chains. However, there are many supply chains where information may not be shared due to constraints such as compatibility of information systems, information quality, trust and confidentiality. Furthermore, a steady stream of papers has explored a phenomenon known as Downstream Demand Inference (DDI) where the upstream member in a supply chain can infer the downstream demand without the need for a formal information sharing mechanism. Recent research has shown that, under more realistic circumstances, DDI is not possible with optimal forecasting methods or Single Exponential Smoothing but is possible when supply chains use a Simple Moving Average (SMA) method. In this paper, we evaluate a simple DDI strategy based on SMA for supply chains where information cannot be shared. This strategy allows the upstream member in the supply chain to infer the consumer demand mathematically rather than it being shared. We compare the DDI strategy with the No Information Sharing (NIS) strategy and an optimal Forecast Information Sharing (FIS) strategy in the supply chain. The comparison is made analytically and by experimentation on real sales data from a major European supermarket located in Germany. We show that using the DDI strategy improves on NIS by reducing the Mean Square Error (MSE) of the forecasts, and cutting inventory costs in the supply chain.

1. Introduction

The economic climate is becoming increasingly volatile. Having more information about the end consumer of products and services provides a critical means of reducing the uncertainty in future demand. Businesses are continually adopting new approaches to obtain and utilise this information in their planning.

These approaches require coordination of information sharing in the supply chains so that the relevant end-consumer data is passed to the upstream supply chain members (Ciancimino, Cannella, Bruccoleri, & Framinan, 2012; Asgari, Nikbaksh, Hill, & Farahani, 2016). Advancements in information technology (IT) provide an efficient platform for such information to be transmitted in a speedy manner (Moskowitz, Drnevich, Ersoy, Altinkemer, & Chaturvedi, 2011; Cannella, Framinan, & Barbosa-Povoa, 2013, Cannella, Framinan, Manfredi, Barbosa-Povoa, & Relvas, 2015). Supply chain visibility provides opportunities for managers not only to plan efficiently but also to react appropriately to the correct information. In recent years, there has been a greater tendency to use IT systems to make inventory, transportation and pricing decisions based on greater visibility of information. Sharing of information proves to be the backbone for various formal coordination initiatives such as Collaborative Planning, Forecasting and Replenishment (CPFR), Efficient Consumer Response (ECR) and Forecast Information Sharing (FIS).

Supply chains are becoming aware of the importance of such visibility. Many companies are sharing information on both sides of their supply chains to create a more collaborative environment. Examples in the retail industry include the introduction of information sharing platforms by two major retailers in the UK with their suppliers: Tesco's Knowledge Hub and the Save and Sustain of Asda. Angeline (2011) reported that collaboration between retailers and their suppliers contributed to a 260,000 tonne reduction in the amount of food and drink waste in the UK in 2010. In addition, GlobalNetXchange, a consortium of 30 companies including Unilever, Procter and Gamble and KimberlyClark have reported a 5–20% reduction in inventory costs and an increase in off-the-shelf availability of 2–12% following the launch of their CPFR programme

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(Terwiesch, Ren, & Cohen, 2005). Other empirical studies investigating benefits of sharing information have reported reductions in inventory levels up to 50% (Disney, & Towill, 2002), reductions in inventory costs up to 40% (Ireland, & Crum, 2006), and reductions in supply-chain costs by up to 40% (Boone, & Ganeshan, 2008).

Notwithstanding the above success stories, the implementation of processes for effective information sharing is not widespread. About 84% of 111 companies surveyed by PRG (E2Open, 2013) reported a formal supplier relationship management strategy in place. However, only one out of six of these companies were using those programmes. Similarly, interviews of 393 executives in a report by Butner (2010) revealed that more than half of the respondents have implemented practices aimed at improving information visibility. However, fewer than 20 percent were pursuing these practices extensively. The report also showed that only two-thirds of these organisations shared real time data with their supply chain partners. Similarly, Seifert (2003) reported two surveys on the assessment of the level of data sharing. The first, by CapGemini, of 16 retailers in Europe and North America, found that only 40% of the retailers shared shopper data with all of their suppliers. The second survey by Forrester Research of 89 retailers showed that 27% of retailers were sharing such data. In addition, the results from interviews carried out with 15 companies by Allred, Fawcett, Wallin, and Magnan (2011) showed that high-level collaborations are rare and efforts to improve information sharing are seldom embraced holistically. The report by Butner (2010), mentioned earlier, ranks 'supply chain visibility' as one of the greatest management challenges. Shue Yen and Chae (2006) have criticised the supply chain information sharing literature for presenting the idea of formal information sharing too simplistically, while not focussing on the bigger issues that hinder this inter-organisational collaboration. This provides the motivation for the research conducted in this paper where we evaluate a strategy to deal with supply chain demand management when information is not shared.

This new strategy is based on a recently discovered phenomenon known as Downstream Demand Inference (DDI). This applies to cases where the manufacturer is not aware of the demand process at the retailer. A stream of research has shown that the upstream member in the supply chain can infer the downstream demand without the need of a formal information sharing mechanism (e.g. Zhang, 2004; Gilbert, 2005). However, Ali and Boylan (2012) recently showed that, under a more practical setting, with less restrictive assumptions than those considered in previous research, DDI is not possible with optimal forecasting methods or Single Exponential Smoothing but is possible when supply chains use a Simple Moving Average (SMA) method. The Simple Moving Average, of length k, is defined as the average of the last k observations. It is not the optimal forecasting method for any Auto-Regressive Moving Average demand process (eg AR(1), MA(1)), but is a robust method that is often used in practice.

Hence, the strategy we evaluate for supply chains where information cannot be shared is based on the DDI approach using the SMA method. The performance of our strategy is measured by comparing the Mean Square Error (MSE) of the forecasts, and inventory cost of the DDI strategy with two other strategies: No Information Sharing (NIS) and Forecast Information Sharing (FIS). We define NIS as a strategy where the supply chain links do not share information formally and the forecasts are based simply on the orders received from the downstream supply chain member. On the other hand, an FIS strategy is where the supply chain links share consumer demand and hence the forecasts. A detailed description of the three strategies is presented in Section 3 of the paper.

Until now, there has been a lack of an analytical framework to allow comparison of DDI with the other two strategies (NIS and FIS) when using a Simple Moving Average forecasting method. The first contribution of this paper is to establish an expression for the Mean Square Error of the DDI approach, thus enabling a comparison across the three strategies when demand follows an autoregressive process of order one (AR(1)). The second contribution is to demonstrate that DDI is always dominated by FIS and that, beyond a certain 'break-point' of the autoregressive parameter of an AR(1) process, DDI dominates NIS in terms of Mean Square Error. The third contribution of the paper is to provide empirical evidence on the accuracy and stock control performance of the three strategies using data on almost two thousand products of a European supermarket. These results confirm the existence of a 'break-point' for DDI dominating NIS and demonstrate an overall benefit in forecasting accuracy by using DDI. However, it also shows that longer Simple Moving Averages are needed for this accuracy benefit to translate to improvements in stock control performance.

The remainder of the paper is organised as follows. Section 2 is dedicated to a review of the literature and is divided into two subsections: 'Information Sharing Inhibitors' and 'Downstream Demand Inference (DDI)'. In Section 3, we present the three demand management strategies and derive the Mean Square Error (MSE) associated with them for AR(1) demand processes. We numerically compare the performance of these strategies in Section 4, followed by an empirical investigation on the point of sale (POS) data of a European supermarket in Section 5. Finally, in Section 6, we present the conclusions and implications of the paper along with some natural avenues for further research.

2. Literature review

2.1. Information sharing inhibitors

One of the most common blockages for information sharing discussed in the literature is the lack of availability of formal information systems. Research published by SCM World (Courtin, 2013) points out that many companies are held back by the huge investment costs and system implementation issues associated with formal collaborations to share information. A survey of 30 UK companies conducted by Frohlich (2002) shows three types of barriers to technology integration in supply chains: supplier-related, customer (manufacturer)-related and internal barriers. Cost is a major reason for resistance both by the suppliers and the customers and this often involves negotiation between the two parties involved in terms of the IT investment and customisation (Klein, Rai, & Straub, 2007). Cost of the information systems is not only an issue in terms of the initial price but also in terms of implementation where time and monetary budgets are often exceeded by 50–100% (Fawcett, Osterhaus, Brau, & McCarter, 2007). Companies involved also face internal organisational barriers for implementations as all organisations have a tendency to resist change.

Even when companies are able to successfully implement an Enterprise Resource Planning (ERP) system, sharing information may still be an issue. Successfully implemented systems in two companies may not 'talk' to each other. According to a market survey by Manhattan Associates (Greening, 2009): "……. *85% of the respondent companies accepted that their information systems could be leveraged further to develop competitive advantage.*" Although compatibility issues are being addressed by IT developments, sharing information is not just a technology related issue. Even when a company develops the required IT capability to share information, trust and commitment issues may negate this development (Mendelson, 2000). Managers make the ultimate decision on what information will be shared and with whom. Information will not be shared with a company which the managers do not trust, making mutual trust another major inhibitor of sharing information. These obstacles are not just inter-organisational. Within an organisation, company structures and cultures may militate against external collaborations (Fawcett et al., 2007; Allred et al., 2011).