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Two-way information sharing under supply chain competition

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ABSTRACT

We study manufacturer-retailer bilateral information sharing in two competing supply chains (*SCs*), in which both the manufacturer and the retailer have partial information on demand. Based on Bertrand competition model and Winkler's consensus model, we develop a finite Bayesian Stackelberg game to analyze the two-way information sharing problem under horizontal supply chain (*SC*) competition. In line with the literature, we find that sharing demand forecast voluntarily in a *SC* benefits the manufacturer but hurts the retailer. However, we find whether *SCs* benefit from information sharing depends on competition intensity and forecast error. As competition is intensive, the expected values of information sharing (EVISs) for the entire *SCs* are high. Moreover, information sharing in one supply chain can improve the rival supply chain's EVIS under some conditions. Numerical experiments are conducted to get some managerial insights.

1. Introduction

Information sharing is necessary for integrating a supply chain (*SC*). To achieve efficiency, members in a supply chain are expected to collaborate in managing material, information and financial flow. A recent Chinese bank survey[1] finds that 61% of the 821 firms believe that information sharing is essential for business success, while 63% confirm that *SC* players should synchronize forecast information and production plans. As a result, information sharing has been extensively studied and many literature appeared (Chen, 2003).

As firm vs. firm competition gives way to supply chain vs. supply chain competition, some researchers began to study information sharing under *SC* competition (Ha and Tong, 2008; Ha et al., 2011). They find that sharing information within one *SC's* players can improve the *SC* coordination and effectively respond to the threats of competing *SCs*. Managers, on the other hand, also realize the importance of information sharing under *SC* competition. For example, the survey of 617 manufacturers by Huo et al. (2013) finds that *SC* performance is positively correlated with information sharing facing international *SC* competition.

With the advance of IT technologies, firms can easily obtain some information about the market. Thus, each *SC* player has partial demand information to share. For example, in the smart phone *SC* consisting of Samsung and Apple (Samsung supplies LCD and AP to Apple), both of them derive their own demand information through their own sales channel. Similarly, JD.com and P&G (the former sells the latter's products online since July 2013) collect demand information through offline and/or online channels. Due to such observations, Mishra et al. (2009) studied demand forecast sharing in a *SC* whose players have partial information.

In this paper, we study two-way information sharing under *SC* competition, in which the downstream retailers and the upstream manufacturers have partial demand information and share the demand information within the players in a *SC*. The two *SCs* engage in a Bertrand competition, which assumes that the two retailers from different *SCs* compete in price (Singh and Vives, 1984). Taking the smart phone industry as an example, Samsung and Apple (to supply iPhone 5) face competition from Google and LG (to supply Nexus 4), whose *SC* also has informed upstream and downstream players. As two-way information sharing and *SC* competition become prevalent in real life, we aim to address the following problems:

a) How do manufacturers and retailers decide on price and information sharing under *SC* competition?
b) Can information sharing improve *SC* profitability? Is it possible to induce *SC* to coordinate and share information so as to benefit each *SC* player?

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[1] Junfa Ding. Blue Book of Supply Chain Management in China. Beijing: China Fortune Press. 2013 (ISBN:9787504746979) http://roll.sohu.com/20130608/n378403739.shtml.

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c) How does competition between *SCs* impact firms' profits?

We propose a Bayesian Stackelberg game model to identify the equilibrium prices for all players in both *SCs*. We find that:

(i) The expected value of information sharing (EVIS) for the manufacturer is positive,
(ii) The EVIS for the retailer is negative,
(iii) The EVIS for a *SC* may be negative or positive depending on forecast error and competition intensity,
(iv) Information sharing in a *SC* improves EVIS for the manufacturer in the rival *SC*, and can also increase EVIS for the rival *SC* under some conditions.

So sharing demand forecast under *SC* competition can benefit the manufacturers but hurt the retailers. However, if a *SC* can get a positive profit from information sharing under some conditions, the leader in the *SC* may be incentivized to induce information sharing. Interestingly, information sharing in one *SC* can benefit the manufacturer of the rival *SC*, and even the entire rival *SC*. Numerical experiments are conducted to show how forecasting accuracy and other parameters impact the EVIS.

The rest of the paper is organized as follows. In Section 2 we review the literature. Section 3 formalizes the problem and presents a basic model, and then Section 4 examines the EVIS in supply chains. In Section 5, numerical experiments are presented. Finally, we summarize and conclude the paper in Section 6.

2. Literature review

Information sharing is a classic topic in economics and *SC* management with abundant literature. Sahin and Robinson (Sahin and Robinson, 2002) and Chen (Chen, 2003) gave comprehensive reviews. We discuss below articles which are most relevant to our research.

2.1 Value of information sharing

From the perspective of EVIS, Gavirneni et al. (1999) find the benefits of the demand information sharing depend on retailer's replenishment policy and demand variance. Hariharan and Zipkin (1995) and Gallego and Özer (2001) find that the demand information sharing often prompts a postponement policy. Still, Gaur et al. (2005) report that information sharing reduces manufacturer's safety stock by 16%, but the benefit is highly dependent on system parameters. Recently, Jonsson and Mattsson (2013) numerically show that the value of information sharing depends on the type of information shared and whether the demand is stationary. Then again, Ketzenberg et al. (2013) believe that the value of information sharing can range from 0 to 30% profit increase. Information sharing has also been shown to eliminate bullwhip effects (Lee et al., 1997; Fiala, 2005; Ouyang, 2007; Wu and Cheng, 2008). Chen and Samroengraja (2004) indicate that the bullwhip effect can be partially eliminated by centralizing demand information. Different from the above literature, we treat the upstream and the downstream information sharing bilaterally, and assume that there is a competitive threat from a rival *SC*. We determine the EVIS by computing the profit difference between information sharing and no information sharing.

2.2 Information sharing under horizontal competition

Li (2002) points out that information sharing in a *SC* with one manufacturer and multiple retailers has two effects: the '*direct effect*' impacts the manufacturer and the individual retailer, while the '*indirect effect*' (or '*leakage effect*') impacts competing retailers. Shamir (2012) shows that sharing information among the retailers and the manufacturer can benefit the competing retailers. Li and Zhang (2008) consider confidentiality in information sharing and find that retailers have no incentive to distort information under intense competition. Zhang (2002) identifies the conditions under which information sharing can be achieved and finds that a manufacturer's optimal strategy does not depend on downstream competition. Our paper differs from the literature in that we consider two pairs of *SC* players in two competing *SCs*. The retailer shares demand information with his upstream manufacturer respectively and competes with the other retailer from the rival *SC*. The *SC* players do not have knowledge of the rival *SC*'s demand forecast.

2.3 Information sharing within a SC when facing competition across SC

Recent literature has taken into account information sharing under complex competition (Jain et al., 2011; Chen et al., 2012; Lee and Yang, 2013). Yue and Liu (2006) and Yao et al. (2005) find that sharing direct channel sales information with retailer will negatively impacts brick and mortar's performance, but a good return policy can create positive effects. Information sharing in strategic channel choice provides useful managerial insights for studying *SC* competition. Recently, Ha et al. (Ha and Tong, 2008; Ha et al., 2011) focus on one-way information sharing and production diseconomies in their studies. Our research differs from theirs in that we focus on a two-way information sharing structure and is not limited to production diseconomies.

2.4 Two-way information sharing

In two-way information sharing, both upstream and downstream players possess partially information on the demand. Mishra et al. (2009) analyze the two-way information sharing between partially informed manufacturer and retailer. They show that revenue sharing contract does not bring on information sharing, but the discount contract does. Zhang and Chen (2013) propose a revenue sharing contract to coordinate the *SC*, in which both the supplier and the retailer share their information completely. Boyaci and Gallego (2004) point out that researchers should stay in touch with modern competitive environments and consider two or more competing *SCs*. In this paper, we study information sharing under contending *SCs*, where manufacturers and retailers possess partial information on demand. Table 1 summarizes the literature most relevant to our work and clearly positions our research.

3. The basic model

3.1 Notation and assumptions

We consider two *SCs*, 1 and 2, each consisting of one manufacturer (she) and one retailer (he). The retailer receives products from the manufacturer in his own *SC* and engages in differentiated Bertrand competition. The demand function of retailer i ($i=1,2$) is

$$q_i = a - p_i + \beta p_j,\ \ i, j \in \{1, 2\}, j \neq i$$

where a is demand intercept, p_i and p_j are prices set by retailer i and j respectively; q_i is the demand quantities of retailer i; and $\beta \in (0, 1)$ is the competition intensity (larger β indicates more intense competition). The demand intercept, a, is normally distributed. For convenience, we assume that $a = \bar{a} + \theta$, where $\bar{a}$ is a