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Incentive information sharing in various market structures

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ABSTRACT

Information sharing between firms has been cited as a major means to improve firm performance. This paper develops a conceptual framework that relates information sharing to firm profitability in a duopoly market. The framework allows each firm to have its own private information about uncertain market demand. We utilize a game-theoretical model to examine this framework. Our results reveal that information sharing has no uniform effect on firm performance. Firms behaving in the Bertrand mode benefit from information sharing only under certain conditions. However, firms behaving in the Stackelberg mode always benefit from information sharing. Further, we examine how the value of information sharing is affected by the nature of firm, the product brand, and the degree of product differentiation. Our results show that when two firms have high level of customer satisfaction, offer products with reputable brands, or sell products that are strongly substituted in the market, information sharing becomes significantly important and imperative to both firms. Particularly if two firms behave in a Stackelberg mode, the value of information sharing further increases. Furthermore, we also address the issue of information distortion and propose EDI (Electronic Data Interchange) information system with a nonnegative matrix-factorization technique as an effective and valuable mechanism to eliminate any possible information distortion, so that both firms can share their forecast information truthfully.

1. Introduction

Nowadays producing accurate forecasts becomes more and more challenging because of uncertain and turbulent economy [22,23]. As an efficient tool in helping improve information precision, information sharing between competing firms is becoming increasingly prevalent [34]. From the firm's point of view, information sharing improves the precision of information available to itself and its rivals, which in turn leads to higher expected profits. Many firms have embarked on initiatives aimed at facilitating the sharing of information among themselves in order to improve information accuracy and pricing decisions [9,21,24,35]. For example, Sainsbury and Marks & Spencers in the U.K. and Super Valu store and Von's supermarket in the U.S. have created interorganizational systems for information exchange and sharing [24]. American Airlines and United Airlines in the airline industry exchange their cost information in order to improve profitability [1]. The sharing of consumer or market information among firms has been recognized as a strategic tool in improving performances [36]. Information sharing assists firms in making improved decisions, thus eliminating the costly trial and error process. Information sharing pools different signals together and thus yields more precise information about market demand. Given that information sharing effectively improves information accuracy and firm performance, it seems intuitive that information sharing may have a uniform effect on firm performance and always benefits the parties involved in such arrangements. This result, however, is not obvious and we need a careful study.

In this paper, we study the value of information sharing in a duopoly market and address why information sharing among competitors helps improve firm performance under some business environment, but not always. In order to reflect commonly discussed business situations in practice, we consider two horizontal pricing competition modes (i.e., Bertrand and Stackelberg modes). In the business market, some firms behave in Bertrand mode, and other firms behave in Stackelberg mode in the fragmented industries [6,12,27]. We first develop a conceptual framework associated with information sharing. Then we theoretically investigate the effect of information sharing on firm performances and derive the optimal strategies. Specifically, we utilize a game-theoretical model to study the following questions:

(i) Will firms always perform better through sharing information under any mode of conduct? If not, which mode of conduct is more efficient for information sharing?
(ii) When does information sharing become imperative as a function of product differentiation?

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(iii) Is there an incentive for firms to distort the information they would like to share?
(iv) If there is an incentive, what effective mechanism can be utilized to eliminate any possible information distortion and guarantee that information can be shared truthfully?

A number of studies on information sharing have been analyzed in the literature of marketing, supply chain management, and management information systems. For example, Cachon and Fisher [5] found that information sharing can create reduced lead time and batch size to firms, and Lee et al. [17] showed that firms can benefit from inventory reduction and cost savings because of information sharing. Raghunathan and Yeh [25] showed that information sharing about inventory data is beneficial to both the manufacturer and its retailers in the continuous replenishment program (CRP) context. Aviv [2] revealed that supply chain members' replenishment process can significantly benefit from the sharing of forecast information. Li et al. [20] studied the inter-organizational information sharing and showed that complete information sharing with multiple types of information can help firms achieve higher performance in a volatile market. Guo and Iyer [15] found that the manufacturer has a motivation to acquire more information about consumer preferences and demand under a voluntary sharing mechanism. All of the aforementioned papers focused on the inventory-related and replenishment-related benefits of information sharing in a vertical structure. Our research diverges significantly from these papers in that we focus on the effect of information sharing on pricing decisions in a horizontal structure.

Li [18] and Zhang [44] addressed the effect of information sharing on pricing decisions in a supply chain consisting of one manufacturer and multiple retailers. Their results showed that a manufacturer would like to buy its retailer information if information sharing is found to be beneficial to him. Li and Lin [19] conducted an empirical study to show that supplier uncertainty, shared vision between supply chain partners, and commitment of supply chain partners significantly influence the levels of information sharing and information quality. Guo et al. [14] utilized analytical models to show that valuable and useful information about systematic demand risk can be utilized to achieve accurate forecast sharing and better channel coordination in the supply chain of one manufacturer and multiple retailers. Choi et al. [7] used analytical models to show that the manufacturer and the retailer can utilize a proper returns policy to achieve a win–win result while sharing information. Yan and Wang [43] showed that all franchising members can benefit from information sharing while profit split is implemented. However, the aforementioned studies focused solely on the vertical channel structure and assumed that all parties would share their information truthfully. They did not address the issue of information distortion. Our study focuses on the horizontal channel structure (a duopoly market) and addresses the moderating role played by product differentiation, product brand, and firm's customer satisfaction in the information industry. Furthermore, our study indicates that each firm in a duopoly market does have a motivation to distort its information while sharing information.

Vives [34] and Gal-Or [9] are some most notably pioneering works which examined the value of sharing information between competing firms. However, there are several major differences between our study and theirs. First, Vives [34] and Gal-Or [9] only examined a special case where symmetric information is assumed. They did not address the sharing of asymmetric information. We assume that different firms have different forecast information and evaluate the value of asymmetric information sharing. Second, Vives [34] and Gal-Or [9] did not address the issue of information distortion, while we do. We also propose effective mechanism to eliminate any possible information distortion, so that both firms can share their forecast information truthfully. Third, Vives [34] and Gal-Or [9] did not address price leader and follower behavior (Stackelberg) in the duopoly market, while we do. In the business market, while some firms behave in the Bertrand mode, other firms behave in the Stackelberg mode [6,12,27].

Our study also complements the study of Raju and Roy [26]. Raju and Roy [26] investigated the impact of information accuracy on the performances of competing firms in the non-information sharing Bertrand and Stackelberg modes. However, they did not address the issue of information sharing for both the Bertrand and Stackelberg modes. In contrast, we extend our model to study information sharing equilibrium for both the Bertrand and Stackelberg modes and compare all scenarios to derive the value of information sharing. Furthermore, Raju and Roy [26] focused on the effect of product substitutability on information accuracy. On the other hand, our research focuses on different set of issues. We focus on how the value of information sharing is affected by the nature of firm, the product brand, and the degree of product differentiation. In addition, Raju and Roy [26] did not address the issue of information distortion when firms engage in information sharing (because distorted information may make the shared information useless or even stop the firms from participating in information sharing), while we do and propose a valuable and effective mechanism (e.g., Electronic Data Interchange (EDI) system with a nonnegative matrix-factorization technique to communicate their demand data directly) to eliminate information distortion.

Our research contributes to the extant information sharing literature, especially for the horizontal information sharing literature, by studying the strategic roles of the asymmetric information sharing, the various modes of conducts, the nature of firms and products, and the degree of product differentiation in an uncertain duopoly market. Specifically, we develop a conceptual framework to investigate the relationship between the information-sharing modes and the duopoly firm performances and provide valuable and counter-intuitive results to business managers. In the business markets, firms can compete on price, quantity, quality, and others. As in Vives [34], Raju and Roy [25], and Gal-Or et al. [11], our research focuses solely on price competition and the findings and approaches also are only applicable to industries competing purely on prices. In our research, we assume that each firm has its own private data about the uncertain demand. We first present a profit maximization model to obtain optimal strategies under four information scenarios: (1) the non-information sharing Bertrand mode, (2) the information sharing Bertrand mode, (3) the non-information sharing Stackelberg mode, and (4) the information sharing Stackelberg mode. We then compare these scenarios to derive some counter-intuitive and clear-cut results: 1) when firms behave in the Bertrand mode, information sharing is not always beneficial to each firm; 2) when firms behave in the non-information sharing, the Stackelberg mode provides no competitive advantage while comparing with the Bertrand mode; and 3) the information sharing Stackelberg mode can help firms achieve higher profit than other modes. Furthermore, we address the important issue of information distortion while sharing information, and propose an effective and valuable mechanism (i.e., Electronic Data Interchange (EDI) system with a nonnegative matrix-factorization technique to communicate their demand data directly) to eliminate any possible information distortion.

2. Model framework

We consider a duopoly market consisting of two firms selling substitute products (i.e., firm 1 sells product 1 and firm 2 sells product 2, respectively). To obtain the demand functions, we adopt the elegant framework established by Vives [34] and employ the same utility function for a representative consumer as follows: $U(q_1, q_2) - \sum_{i=1}^{2} p_i q_i$, where $q_i (q_i \geq 0,\ i = 1,\ 2)$ are the demands of the products and $p_i (p_i > 0,\ i = 1,\ 2)$ are their prices. According to Vives [34], U is assumed to be quadratic, strictly concave and symmetric in q_1 and q_2,