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Price and leadtime competition, and coordination for make-to-order supply chains ☆

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ABSTRACT

This paper develops a game theoretic model of a one-manufacturer and one-retailer supply chain facing an outside integrated chain (manufacturer) to study the price and leadtime competition and investigate coordination of the supply chain, where the make-to-order production mode is employed and consumers are sensitive to retail price and leadtime. We find that decentralization of the supply chain increases its leadtime while decreases the rival's leadtime; and the decentralization increases the retail prices. The existence of the outside competitor raises the leadtime. A higher reservation price or brand differentiation increases the retail prices but decreases the leadtimes; a higher transportation cost or lower leadtime sensitivity increases the retail prices and the leadtimes. The coordination of the supply chain facing integrated rival harms the integrated rival. We design contracts to coordinate the supply chain under leadtime-decision-first scenario and wholesale-price-decision-first scenario, respectively. Further, we find that the sequence of decisions affects the validity of the all-unit quantity discount scheme in coordinating the supply chain.

1. Introduction

Consumers are becoming more and more heterogeneous. To meet their heterogeneous demands, many firms adopt make-to-order (MTO) mode, such as GE's CAMCO, and restaurant chains (e.g. McDonald's). In the MTO environment, besides retail price, delivery time (leadtime) is also an important business strategy. A longer leadtime decreases the market demand due to a higher disutility for consumers. Many MTO firms such as Cat Logistics offer delivery time guarantees (Liu, Parlar, & Zhu, 2007). In short, leadtime decision has become an important marketing strategy. We in this paper study the price and leadtime competition between two supply chains and focus on the interaction between the retail price and the leadtime.

Our work is motivated by MTO settings (e.g., wedding & evening dress, furniture, automobile). A MTO manufacturer makes the product partially based on the consumer's order specification (say, size, color, style). In the industry, some manufacturers collect the consumers' orders via retailers while the other manufacturers directly collect the consumers' orders. Each manufacturer makes the products within a leadtime. Each manufacturer has its own brand. Consumer tastes for different brands are heterogeneous. Each brand has some loyal consumers. Besides loyal consumers, some consumers are switchers who can choose a product from the brands to maximize their utilities. Consumers want the manufacturer to provide the products in a shorter leadtime, while reducing leadtime incurs an extra (capacity) cost for the manufacturer. Each brand has to make the price and leadtime decisions to maximize its profit. Some industrial cases can be found in the automobile industry (e.g. Honda, General Motors, Shanghai GM), restaurant industry (say, Mcdonald's, KFC), and furniture industry (SNIMAY, Shanzhong Classical Furniture). The existence of outside competitor influences the contract arrangement between the member firms of supply chain (Xiao & Yang, 2009). Traditional coordination models do not consider the effect of the existence of outside rival on coordination mechanisms. This paper will investigate how to coordinate the supply chain when the outside competitor exists.

This paper considers a one-manufacturer and one-retailer supply chain competing with an outside integrated competitor to investigate the price and leadtime competition and coordination mechanisms, where the MTO production mode is employed. The wholesale price contract within the supply chain can be signed after or before making the leadtime decision. Thus, we divide the discussions into two scenarios: the *leadtime-decision-first* scenario and the *wholesale-price-decision-first* scenario. By comparing the two scenarios, we can examine the effects of the sequence of decisions on the price and leadtime competition and coordination mechanisms. Under the *leadtime-decision-first* scenario, the manufacturers quote the leadtimes before offering the unit wholesale

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price; while the manufacturer announces the unit wholesale price before quoting the leadtimes under the *wholesale-price-decision-first* scenario. Under the leadtime-decision-first scenario, we design an all-unit quantity discount contract to coordinate the supply chain. We also examine how the factors such as brand differentiation, leadtime sensitivity, and leadtime cost factor affect the price and leadtime competition to generate some interesting managerial insights. Under the wholesale-price-decision-first scenario, we investigate how the supply chain can be coordinated by a two-part-tariff-subsidy (TPTS) contract and examine whether an all-unit quantity discount scheme with a subsidy discount can coordinate the supply chain. In this paper, we obtain some interesting results. For example, (i) a higher reservation price decreases the leadtime while increases the retail price; (ii) the decentralization of the supply chain raises its leadtime while decreases the competitor's leadtime; and (iii) the sequence of decisions affects the validity of the all-unit quantity discount contract in coordinating the supply chain.

The rest of this paper is organized as follows. Section 2 reviews related literature and Section 3 presents a basic model (the leadtime-decision-first scenario) and considers the decisions of the supply chain without an outside competitor. Section 4 analyzes the equilibrium outcomes and coordination mechanisms in the competitive environment. Section 5 studies the equilibrium outcome and supply chain coordination under the wholesale-price-decision-first scenario. Section 6 concludes with a summary and directions for future research.

2. Literature review

This paper is closely related to MTO production system, pricing and leadtime decisions, supply chain coordination management, and brand differentiation.

There are several works in the literature about internal operations of MTO firms (Easton & Moodie, 1999; Carr & Duenyas, 2000; Rajagopalan, 2002). Some works have been made in the decisions of a single firm or production system (Carr & Duenyas, 2000; Rajagopalan, 2002). Carr and Duenyas (2000) study the order admission control and sequencing problems in a production system that operates with two production modes, one is make-to-stock, and another is MTO. A few publications extend the single firm model to the multiple firms model with horizontal competition (Easton & Moodie, 1999; Allon & Federgruen, 2007). Easton and Moodie (1999) study how to optimize the pricing and leadtime decisions with contingent orders simultaneously. Some studies extend the single firm model to the supply chain model (Sahin & Robinson, 2005; Xiao, Yang, & Shen, 2011). In this paper, we integrate the last two classes of models to consider a MTO supply chain facing an outside-integrated competitor. We find that the decentralization of supply chain affects the price and leadtime competition to a large degree; and the existence of outside-integrated competitor affects the validity of contract in coordinating the supply chain.

In a MTO environment, delivery leadtime is often an important factor for winning orders besides retail price, i.e., market demand is sensitive to both price and leadtime (Palaka, Erlebacher, & Kropp, 1998; So, 2000; Ray & Jewkes, 2004; Liu et al., 2007; Xiao, Choi, & Cheng, 2013). Guaranteeing a uniform delivery leadtime standard is a common practice in many industries (So & Song, 1998). Some studies consider the price and leadtime decisions of a firm in a monopoly setting (Palaka et al., 1998; Ray & Jewkes, 2004; Pekgün, Griffin, & Keskinocak, 2008; Chaharsooghi, Honarvar, Modarres, & Kamalabadi, 2011). Pekgün et al. (2008) study how the production and marketing departments of a monopoly firm determine the leadtime and price decisions, respectively. Unlike Pekgün et al. (2008), we consider the price and leadtime competition between two chains. Some studies consider the price and leadtime decisions of a firm in a competition setting (Lederer & Li, 1997; So, 2000; Allon & Federgruen, 2007). Lederer and Li (1997) study the competition between firms that produce goods or services in a MTO fashion for customers sensitive to delivery-time. So (2000) studies the impact of using guaranteed leadtime on competition. Allon and Federgruen (2007) develop an oligopoly model to study the price and waiting time competition. Some studies consider the price and leadtime decisions of a firm from a supply chain's perspective, e.g., Liu et al. (2007). Xiao et al. (2013) study the effects of the retailer's reservation utility and the endogenization of lead-time on the channel structure strategy of a firm in a competition setting. Unlike the above literature, we examine the effects of the existence of outside rival on the pricing and leadtime decisions of a supply chain. In the MTO environment, the cost of a firm can be often divided into two parts, demand-dependent cost and demand-independent cost (Benjaafar, Elahi, & Donohue, 2007; Xiao et al., 2013). In this paper, we adopt this type of cost structure. Unlike Xiao et al. (2013), we focus on how to coordinate the supply chain facing an integrated competitor and examine the effects of the sequence of decisions on the validity of contract in coordinating the supply chain.

From the supply chain coordination literature, we know that a supply chain is fully coordinated when all decisions are aligned to accomplish the system objective (Ingene & Parry, 1995; Sahin & Robinson, 2002; Chen & Zhuang, 2011). Pekgün et al. (2008) develop a transfer price contract with bonus payments to coordinate the two departments of a firm. Hou, Zeng, and Zhao (2009) study how to coordinate a supply chain with price dependent on leadtime via a revenue-sharing contract. Xiao et al. (2011) investigate how to coordinate a MTO supply chain via a revenue-sharing contract. One can refer to Cachon (2004) for more coordination contracts. In the following, we only review the closely related literature. Our paper is closely related to a two-part tariff contract (Oi, 1971; Moorthy, 1987; Ingene & Parry, 1995). Ingene and Parry (1995) consider the two-part tariff mechanism in a supply chain consisting of one manufacturer and multiple retailers. In the traditional two-part tariff mechanism, the marginal price is equal to the marginal cost in the full competition environment (Laffont, Rey, & Tirole, 1998; Armstrong & Vickers, 2001; Rochet & Stole, 2002). Unlike theirs, we find that the supply chain cannot be coordinated by a two-part tariff mechanism under the wholesale-price-decision-first scenario. We introduce a two-part-tariff-subsidy (TPTS) contract where the retailer shares the leadtime-dependent cost with its supplier when the leadtime is sufficiently low. Our model is also related to all-unit quantity discount contract (Weng, 1995; Qi, Bard, & Yu, 2004; Li, Xu, & Ye, 2011; Xiao & Qi, 2012). Weng (1995) studies how to coordinate the order quantity and pricing behavior. Qi et al. (2004) study how to coordinate a supply chain after demand disruptions. Xiao and Qi (2012) investigate how to coordinate a supply chain consisting of one supplier and one manufacturer, where the demand rate depends on selling price, leadtime, and delivery reliability. However, we find that the all-unit quantity discount contract cannot coordinate the supply chain facing an integrated rival under the wholesale-price-decision-first scenario.

This paper is also related to brand differentiation. From the consumer's perspective, products are often differentiated by both quality and brand name (Katz, 1984; Gilbert & Matutes, 1993). Agrawal (1996) develops a model of two competing manufacturers distributing their products to consumers through a common retailer, and illustrates the effect of brand loyalty on advertising and trade promotions. Baltas (2004) develops a simultaneous choice model illustrating consumer's selection of multiple brands. Villas-Boas (2004) considers a two-period model in which consumers