Production, Manufacturing and Logistics

Sustaining long-term supply chain partnerships using price-only contracts

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A B S T R A C T

In this paper, we study how an informal, long-term relationship between a manufacturer and a retailer performs in turbulent market environments characterized by uncertain demand. We show that the long-term partnership based on repeated interaction is sustainable under price-only contracts when the supply chain partners are sufficiently patient. That is, the channel can be coordinated over a long time horizon when the factor whereby the members discount the future value of this trusting relationship is sufficiently high. Second, above the minimum discount factor, a range of wholesale prices exists that can sustain the long-term partnership, and there are different possible profit divisions between the two players. Third, when the market is turbulent, i.e., either the expected demand or the demand variance changes from period to period according to a probabilistic law, it is typically less possible to sustain the long-term partnership in a booming market or in a market with low demand variability. Finally, obtaining more information about future market fluctuation may not help the supply chain to sustain the long-term partnership, due to partners' strategic considerations. With the availability of the market signal, total supply chain profits increase, but the retailer may even be worse-off.

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1. Introduction

It is well-known that due to the double-marginalization effect, a supply chain governed by a wholesale-price contract cannot be coordinated in a single-shot interaction, i.e., joint maximum payoffs cannot be achieved (Lariviere & Porteus, 2001). More elaborate contracts must be designed to achieve coordination (see Tayur, Magazine, & Ganeshan, 1999 or a review in Cachon (2003)). However, in practice, firms often interact repeatedly with each other. Pyke and Johnson (2003) argue that critical, high-value-added components or components with complex interfaces are often better handled through long-term supply chain partnerships. The anticipation of future interaction may restrain firms' opportunistic behavior in a single interaction (Taylor & Plambeck, 2007). When anticipating repeating business, firms can adopt an informal agreement that can be sustained by the future value of a trusting, cooperative relationship. Second, price-only contracts are easy to implement and are still fairly common in industries. In practice, the actual implementation of those more elaborate contracts may differ from what is stipulated in the sophisticated contracts (Neuville, 1997). Moreover, these contracts have additional administrative and handling costs, or might create additional moral hazard problems (Krishnan, Kapuscinski, & Butz, 2004). We fill the gap in the literature by studying, in the case of repeating business, how external environmental turbulence influences their motivation to cooperate under price-only contracts.

In addition, today's markets are often characterized by fluctuating demand due to financial crises, emerging markets, natural disasters, unstable geopolitics, changing consumption patterns, and emerging technologies. These random events may shift market demand and/or increase demand volatility, which we refer to as turbulent markets in this paper. For example, the pharmaceutical market fluctuates greatly because of changing government regulations and/or the introduction of new drugs or diagnostics. The former usually shifts demand, while the latter injects more variability. Another example of a turbulent market is the pork industry. The mean demand for pork in the US has remained constant since 1985. However, its variability has increased due to changing consumption patterns towards greater variety and more value-added products. The demand for pork in China is mainly characterized by shifting demand due to strong economic growth coupled with a slowing population growth rate (Pan & Kinsey, 2002). Firms may thus face a booming or a busting market if random events shift the demand, or they may face a stable or a volatile market if random events impact variability. These situations may impact the downstream firm differently from the upstream firm and, hence, the temptation to break an "informal" partnership will be different. This poses to supply chain partners the following questions: How will their partnerships survive turbulent environments? and Which types of

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environments will present a higher temptation to deviate from coordination?

In this paper, we study how an informal relationship between a manufacturer (she) and a retailer (he), based on repeated interaction, performs in turbulent market environments. Players may be motivated to cooperate with each other if the gains from cooperation over the long run exceed the short run gains that they would obtain from not cooperating. During an economic boom, attractive short run gains may make deviation from cooperation more tempting. We may thus expect that market turbulence adversely impacts their motivation to coordinate the supply chain through repeated interaction. We develop a mathematical model that allows us to address the following questions: (1) Under which circumstances, will jointly maximal payoffs be achieved through repeated interaction? (2) How will the jointly maximal profits be divided and what will the cooperating wholesale price be? (3) What will be the impact of turbulent markets on their motivation to sustain the long-term partnership? (4) What types of turbulent markets will constrain the long-term partnership? and (5) Who benefits from the availability of the information about market turbulence?

We offer the following insights. First, we show that the long-term partnership based on repeated interaction is sustainable under wholesale-price contracts when the supply chain partners are sufficiently patient, i.e., the factor whereby the members discount the future value of this trusting relationship is sufficiently high. At the minimum discount factor, the manufacturer's expected profit in each period is not higher than the profit the manufacturer would obtain in a single-stage game. All the additional gains generated by the long-term partnership flow to the retailer. This is because due to repeated interactions, the disadvantage of the retailer as a second mover is mitigated, and his ability to punish a deviating manufacturer in the same period gains him some power in the supply chain. At higher discount factors, a range of wholesale prices exists that can sustain the long-term partnership, and there are different possible profit divisions between the two players. With increasing discount factor, it becomes more likely that the manufacturer could obtain more than her stage-game profit.

Second, in a turbulent environment, where the market turbulence is modeled as a parameter of the market demand distribution that changes from period to period according to a probabilistic law, we find that the ability to sustain the partnership is restricted compared with stationary environments. If a signal concerning turbulence is observable at the beginning of each period, then the ability to sustain the partnership can be restricted or enhanced, depending on the signal content (e.g., mean or variance). The availability of the market signal increases the manufacturer's expected profits, but may decrease the retailer's profits. Furthermore, we find that the supply chain partners have the highest temptation to deviate in a booming market or in a market with low variance.

In Section 2, related literature is briefly discussed. In Section 3 the single-period constituent game (the stage game) is briefly discussed. In Section 4.1, the stage game is repeatedly played in stationary markets where the demand is independently and identically distributed in each period. In Section 4.2, the game is repeatedly played in turbulent markets, where the demand distribution changes from one period to another. In Section 5, points for further research are developed and conclusions are drawn. Proofs and additional results are provided in Appendix.

2. Related literature

Japanese techniques such as Total Quality Management (TQM) or Just-In-Time (JIT) production have triggered considerable interest in supplier-manufacturer relationships. The traditional strategy literature has mainly focused on the exploitation of bargaining power (Porter, 1980). The quality management practitioners, however, have argued that the cost of close coordination with manufacturers is less than the added benefits of better quality, reduced inventories, etc., that it provides (Deming, 1986). Kahn, Kalwani, and Morrison (1986) identified the impact of adversarial manufacturer relations on purchasing costs. Ali, Smith, and Saker (1997), for example, strongly advocate the adoption of partnership relationships with manufacturers. A number of authors compare the advantages and disadvantages of partnership sourcing versus competitive sourcing. Richardson and Roumasset (1995) compare sole sourcing, competitive sourcing, and parallel sourcing (sole sourcing, but limited to a particular product category) and find the optimal sourcing arrangement in different environments. Taylor and Wiggins (1997) compare the cost performance of the American system, which involves competitive bidding, large batches, and quality inspection of an incoming order, to the Japanese system of repeat purchases from one manufacturer, small batches, and no inspection. They conclude that, when using flexible manufacturing technology and producing complex products, the Japanese system performs better. Parker and Hartley (1997) critique the partnership-sourcing approach by adopting a transaction-cost framework and point out the existence of a continuum of relationships between adversaries and partners.

Lariviere and Porteus (2001) analyze a wholesale-price contract in a decentralized manufacturer-newsvendor supply chain in a Stackelberg game setting, and find that supply chain coordination cannot be achieved (i.e., the retailer orders fewer items than in a centralized supply chain) due to the double marginalization effect. Perakis and Roels (2007) quantify the loss of efficiency of decentralized supply chains that use price-only contracts relative to the centralized supply chain.

In the economics, marketing, and operations management literature, more elaborate contracts that do allow for supply chain coordination are studied, including franchising contracts, buy-back, revenue-sharing, quantity flexibility and sales-rebate contracts (see Cachon, 2003; Tsay, Nahmias, & Agrawal, 1998 for comprehensive reviews). When contract parameters are carefully set, the reallocation of the inventory risk between the two supply chain partners can induce the retailer to order the supply chain optimal quantity. However, these more elaborate contracts are more complex to administer (Krishnan et al., 2004). In practice, it is fairly common for many supply chain transactions to be governed by simple contracts defined by a per-unit wholesale price (Lariviere & Porteus, 2001). Taking into account the retailer's ordering opportunities both before and after the supplier's production decision, Cachon (2004) and Dong and Zhu (2007) show that supply chain efficiency can be improved using wholesale-price contracts. As with elaborate contracts, efficiency is improved by reallocating inventory risks. Martinez de Albeniz and Simchi-Levi (2007) consider re-negotiation (i.e., there are multiple quoting-and-ordering interactions between the two players) before a market demand is realized, and show that the supply chain efficiency improves as the length of negotiation process extends. By dividing one ordering opportunity into multiple ones, the disadvantage of the retailer as a second mover is mitigated, and it gains some power to "force" the supplier to reduce its price in the following interaction.

From a different perspective, we study how the value of the ongoing relationship can create an incentive for the supply chain partners to cooperate under wholesale-price contracts. Repeated interaction plays an important role in the coordination mechanism, as evidenced in Martinez de Albeniz and Simchi-Levi (2007). We however study a different situation in which there is a market opportunity following each interaction. The impacts of repeated interaction, each followed by a market opportunity, on firms' decisions have been studied by researchers, but not for the purpose of aligning individuals' objectives with that of the supply chain. For example, Nagarajan and Sošić (2008) and Huang and Sošić (2010)