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Pricing and supply priority in a dual-channel supply chain

Tiaojun Xiao[a,b,*], Jim (Junmin) Shi[c]

[a] Institute of Game Behavior and Operations Management, Nanjing University of Finance and Economics, Nanjing 210046, China
[b] School of Management Science and Engineering, Nanjing University, Nanjing 210093, China
[c] Tuchman School of Management, New Jersey Institute of Technology, University Heights, Newark, NJ 07102, USA

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ABSTRACT

This paper studies a manufacturer marketing a product through a dual-channel supply chain, comprised of an online channel and a brick-and-mortar retail channel. In particular, we consider the pricing and channel priority strategies of dual-channel supply chain in the presence of supply shortage caused by random yields. To this end, we develop game theoretic models to investigate the price decisions and the channel priority strategy, as well as examine the impacts of channel coordination and the time sequence of decisions, i.e., *ex-ante* and *ex-post* production yield, on the channel priority strategy. While encountered with a potential supply shortage, the manufacturer has two channel-allocation priority strategies: *direct channel priority* and *retail channel priority*. Our study shows that: (i) coordination of the dual-channel supply chain can alleviate the retailer's complaint of insufficient supply; (ii) counter-intuitively, the retail channel priority is adopted only when the total surplus in the retail channel is low in the decentralized setting; and (iii) the effect of the unit cost of sales of the direct channel on the motivation to use retail channel priority depends on the effect of channel priority on the demand. In addition, we find that the main results of pricing and channel priority strategies remain robust to the time sequence of channel priority decision (yield *ex-ante* or *ex-post*).

1. Introduction

E-commerce, such as an online channel (referred to as a direct channel), provides a plausible platform to attract potential consumers and thus opens another door to increase manufacturer's revenue. Therefore, more and more manufacturers such as Apple, Hewlett-Packard, Nike, and Sony are marketing their products not only through a brick-and-mortar retailer (referred to as a retail channel), but also through a direct channel, i.e., leveraging dual channels composed of a direct online channel and an indirect retail channel (Cai, 2010; Pinkerton, 2006; Teimoury, Mirzahosseinian, & Kaboli, 2008). When a manufacturer produces its products, its yield may be random due to such controllable or uncontrollable reasons as defective units, machine breakdowns, damage or shrinkage occurred during transshipment, and random components allocation from suppliers (Tang & Yin, 2007; Yano & Lee, 1995). In the presence of yield uncertainty, the manufacturer may be inevitably exposed to the risk of supply shortage. Unfortunately, many companies do not have an established, formal and cross-functional process to manage the allocation of insufficient inventory to mitigate the impact on customers and shareholders, cf. Uskert, Davis, and Lord (2011). How to manage this uncertainty is an imperative and timely issue for the manufacturer to maintain its competitive advantage and secure its profit.

With a potential supply shortage, a manufacturer with dual channels is typically faced with assigning priority issue given two channel strategies: satisfy the direct channel first, or satisfy the retail channel first. Throughout the paper, we adopt the term *direct channel priority* (denoted as DCP) to signify that the manufacturer's chosen priority is to satisfy the direct channel demand first, while the term *retail channel priority* (denoted as RCP) refers to the opposite. Both cases have been widely observed in practice. For example, the brick-and-mortar retailers of Apple, Sony, and Panasonic often complain that the manufacturers reserve their hot-selling products for the direct channel, while the retailers must wait for product allocations under supply shortage (Pinkerton, 2006). Right after Apple introduced the iPhone 5s in late 2013, because of limited supply, consumers could only buy online because there was no guarantee any retail store would have the device available in stock (Lee, 2013). For an example of RCP, when the Air Jordan 2011 shoe was first introduced, it was only available at third-party retail stores for several months before Nike officially put the quality-performance footwear on its own website (Business Wire, 2011). As another example of RCP application, the demand for the highly popular Sony PS4 (debuted in November 2013) had far exceeded

* Corresponding author. Tel.: +86 25 83686733.
E-mail addresses: xiaotj@nju.edu.cn, xiaotiaojun@263.net (T. Xiao), Junmin.Shi@njit.edu (J. (Junmin) Shi).

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its supply. In late March 2014, consumers could only buy the game console at some Best Buy stores, while Sony's online store showed no units available (Johnson, 2014).

Given the observations that both DCP and RCP are commonly applied in a variety of marketplaces, one natural question for the manufacturer is which strategy is preferable over the other. Intuitively, under the RCP policy, retail channel snatches consumers away from the direct channel, which consequently decreases the manufacturer's profit from the direct channel. However, the leverage of the DCP policy leads the retail channel to lose consumers. In each case, the channel priority intensifies the conflict between the manufacturer and the retailer. Moreover, channel priority influences the manufacturer's profit from the retail channel because it affects the retail price as well as the unit wholesale price. Thus, the manufacturer needs to make a trade-off between the two channel priority strategies.

The decentralization of channel structure is commonly understood as a reason to decrease supply chain efficiency due to its inherent double marginalization effect (Spengler, 1950). To mitigate the negative effect of decentralization, some effective contracts have been designed and implemented to coordinate the pricing behavior of retailers (Chen, Zhang, & Sun, 2012; Jeuland & Shugan, 1983). The coordination of the retail channel alleviates the conflict between the dual-channel manufacturer and the retailer, and affects both the demand and the manufacturer's profit in both channels (especially under supply shortage), which in turn influences the manufacturer's channel priority strategy. However, the extant literature does not investigate how to coordinate supply chain to deal with potential supply shortage. It is one of our goals to explore how decentralization (coordination) of the retail channel affects the manufacturer's channel priority strategy.

To address these aforementioned questions, we develop game theoretic models of a one-manufacturer and one-retailer supply chain in the presence of random yields, through which we investigate the optimal price decisions and channel priority strategy, and explore the effects of decentralization of the supply chain on the channel priority strategy. In terms of the decision timeline of the channel priority strategy, we consider two types of models: the yield *ex-ante* model in which the channel priority decision is decided before the yield uncertainty is resolved; and the yield *ex-post* model in which it is determined after the yield is realized. In each model, we systematically study the system under two different settings: the centralized (coordinated) setting and the decentralized setting. For each setting, we investigate the channel priority strategy by comparing the performances of RCP and DCP in terms of their expected profits. We find that channel coordination can alleviate the retailers' complaints about supply shortage, and also that the manufacturer has an incentive to select RCP rather than DCP in the centralized setting. However, in contrast to the centralized setting, the decentralized manufacturer uses RCP only when the total surplus for the retail channel is not too high. In addition, under DCP, the manufacturer may offer a direct channel price higher than the consumer's reservation price such that only the retail channel is active; however, such phenomenon does not happen under RCP.

2. Literature review

This paper is related to the literature of dual-channel supply chain and supply/yield uncertainty. In the literature on dual channels, some typical studies concerning the manufacturer's channel structure strategy include but are not limited to Chiang, Chhajed, and Hess (2003), Liu and Zhang (2006), Yoo and Lee (2011), and Xiao, Choi, and Cheng (2014), all of which consider deterministic models; except for Chen, Kaya, and Özer (2008) that adopts stochastic models. The other major focus is to study the optimal decisions pertaining to the dual-channel supply chain. For example, Cattani, Gilland, Heese, and Swaminathan (2006) explain the popularity of equal pricing strategy; Teimoury et al. (2008) develop a dual-channel inventory model where stock is carried by both the manufacturer and the retailer, and consumer demand are lost when both the retail store and manufacturer warehouse are simultaneously out of stock. Dumrongsiri, Fan, Jain, and Moinzadeh (2008) develop a newsvendor model to study the dual-channel strategy of a manufacturer. Additionally, Huang and Swaminathan (2009) investigate the effects of the channel structure on the optimal pricing strategies. In contrast, our study focuses on the management of the dual-channel supply chain under supply uncertainty. Supply chain coordination can improve the profitability of the decentralized channel by reducing the double marginalization effect. Various contracts are designed to coordinate the supply chain since Jeuland and Shugan (1983). Tsay and Agrawal (2004), study how to coordinate the sales effort of a dual channel supply chain via generalized wholesale pricing contract. Cao (2014) studies how to coordinate a dual channel supply chain under demand disruptions. Cai (2010) investigates the effects of channel structures and channel coordination on the players of a dual-channel supply chain. In this paper, we consider both the centralized supply chain and the decentralized supply chain. Unlike the literature on supply chain coordination, we examine the effect of coordination of the dual-channel supply chain on the channel priority strategy.

The random yield literature includes two streams of models. The first stream assumes that supply/yield is random but market demand is deterministic, in order to explore issues such as inventory decisions (Güllu, Önol, & Erkip, 1997), pricing strategies (Tang & Yin, 2007), the value of supply chain centralization (Fang & Shou, 2015), component procurement strategies (Pan & So, 2016). The other assumes yield uncertainty and demand uncertainty simultaneously, e.g., Fu et al. (2015), Gallego and Moon (1993), Güler (2015), Güler and Bilgic (2009), Mukhopadhyay and Ma (2009), Xia, Ramachandran, and Gurnani (2011), Xiao, Chen, and Lee (2010), Yin and Ma (2015) among many others. Interested readers are referred to Yano and Lee (1995) for a detailed review. Yield uncertainty is likely to result in supply shortage. As pointed out earlier, under supply shortage, the channel priority strategy of the manufacturer with dual channels becomes an important issue. To the best of our knowledge, this is the first study to address such issue.

This paper is also related to the literature on allocation of limited capacity. For example, Cachon and Lariviere (1999) study how to allocate limited capacity when the retailers' optimal stocking levels are private information. Cachon (2004) studies the allocation of inventory risk under demand uncertainty. Plambeck and Taylor (2007) explore how to renegotiate the supply contracts under information update. Hall and Liu (2010) develop cooperative game models to study the capacity allocation of a manufacturer with multiple products. The above literature discusses the case where the capacity is deterministic and supply shortage is caused by downstream uncertain demand/order. In contrast, we focus on the case where supply shortage is caused by its upstream supplier side (e.g., random capacity) rather than the downstream demand side. Since the yield is random, it is difficult for one to allocate its supply via following a specific rule. Moreover, the traditional capacity allocation models study how the supplier or manufacturer allocates its capacity between the retailers after observing the total order quantity. However, we study the channel allocation priority strategy of the manufacturer under supply uncertainty, i.e., while facing potential supply shortage, the manufacturer needs to decide whether to first meet the retailer or its direct channel before supply uncertainty is resolved. In addition, we also consider the case where the channel priority decision is decided after the yield is realized.