



Pricing policies of a competitive dual-channel green supply chain



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ABSTRACT

This study examines a dual-channel supply chain in which the manufacturer makes green products for the environmental conscious. We discuss the pricing and greening strategies for the chain members in both centralized and decentralized cases using the Stackelberg game model under a consistent pricing strategy. Furthermore, we compare the results of the single channel and dual-channel supply chains. We obtain that when the greening cost is greater than a threshold, the manufacturer does not open direct channel. However, when the degree of customer loyalty to the retail channel and the greening cost satisfy certain conditions, the dual-channel green supply chain does exist. Interestingly, we find that the retail price in the centralized green supply chain is higher than that in the decentralized supply chain, which contrasts with the result of 'double marginalization'. We also propose a contract to coordinate the decentralized dual-channel green supply chain. Finally, extensions of consistent pricing strategy are discussed and different results are achieved. Our main contributions are that we introduce e-commerce into green supply chain management and obtain pricing and greening strategies for chain members.

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1. Introduction

Due to the intensifying issue of the global environment, the concept of sustainable development, including low-carbon economy and green GDP, is widely accepted, thereby contributing to the increasing research on green supply chain management (GSCM) (Zhu and Cote, 2004; Karakayali et al., 2007; El Saadany and Jaber, 2010). GSCM compels chain members to reconsider many problems, such as inventory decisions, product innovation, returns management, reverse logistics design and coordination between channel players (Guide and Wassenhove, 2006a,b; Östlin et al., 2008; Hall and Vredenburg, 2012). The adoption of GSCM can improve the environmental performance and economic performance of organizations, which in turn encourages the organizations to continue greening (Zhu et al., 2007; Green et al., 2012).

In fact, the implementation of GSCM requires consideration of many factors, for example, the importance levels of greening activities, financial and non-financial effectiveness, and outcomes/performance (Zhu et al., 2007; Lin et al., 2014; Tseng et al., 2014). As one of the importance factors of greening activities, green products play an important role in the development of GSCM with regard to decision making processes. Navinchandra (1990) first proposed the

idea of green product design, that is, to increase products' compatibility with the environment without compromising their function or quality. Then, Porter and Van der Linde (1995) and Pujari (2006) pointed out that innovations with green products could not only improve the environment but also increase manufacturers' competitive advantage. Moreover, governments, non-governmental organizations and consumers exert enormous pressure on the core enterprises in supply chains and force them to develop and introduce sustainable products (Seuring and Müller, 2008; Seuring, 2013). Thus, innovation is the top priority for GSCM, particularly for green products (Lin and Tseng, 2014).

Therefore, an increasing number of companies focus on green products and put plans into practice. For example, in California, a clothing company called Patagonia has devoted attention to greening its products for several years (Ghosh and Shah, 2012). A giant manufacturer and global brand, Adidas, reduces its environmental impact through greening its products from the perspectives of manufacturing materials and packaging materials (www.adidas-group.com). Another giant manufacturer, Pepsi-Cola, uses reusable plastic shipping containers instead of corrugated materials to relieve the impact on the environment (Wilkerson, 2005). Many large manufacturers in China also produce green products to protect the environment and improve competitiveness. In the 2014 Appliance World Expo, Gree, Midea, Haier and others displayed their newly launched energy-saving products to audiences (www.appliance-expo.com). China National Organic Green Food

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Industrial Corporation produces green foods out of consideration for the environment and human health (cnogf.com). In addition to the manufacturing industry, the retail giant, Wal-Mart, also focuses on green products. In October 2005, Wal-Mart CEO Lee Scott set three ambitious goals for the company, one of which was to sell products that sustain Wal-Mart's resources and the environment (Plambeck, 2007). One of the largest home appliance retailers in the world, Best Buy, sells ENERGY STAR certified products to help businesses and individuals save money and protect our climate through superior energy efficiency (www.bestbuy.com).

As discussed above, many manufacturers and retailers are producing or selling green products to improve the current environment quality. This paper also considers pricing policies of the green products in a supply chain. In fact, with the rapid development of e-commerce and increasing consumer acceptance of green products, many manufacturers are opening online shops to sell green products (www.sys2011.com, www.ehaier.com). This is called a dual-channel supply chain, including an independent retail channel and an online channel. Obviously, the online sales of green products can help manufacturers win the benefits associated with greatly increasing demand for the products. However, the introduction of the direct channel also aggravates competition between the manufacturer and the traditional retailer. Considering the characteristics of the green products and the channel conflicts, we are interested in studying greening and pricing policies and profit allocations in a dual-channel green supply chain based on the Stackelberg game model.

This work extends GSCM to the dual-channel supply chain in which the manufacturer opens his own direct channel to sell green products. Based on observations and analysis, we try to answer these questions: Under what conditions does a manufacturer decide to open the direct channel when the greening cost of green products is taken into consideration? How do the degree of customer loyalty to the retail channel, the greening cost and the expansion effectiveness coefficients of the green degree per unit influence the green degrees, pricing policies and profits of the two members in the dual-channel supply chain? To answer these questions, this paper adopts the Stackelberg game model to analyze the dual-channel green supply chain and its channel competitions. Here, it is assumed that the manufacturer produces a single type of green product and can decide the green degree of the products to maximize his profit. Producing green products requires extra money for green innovation. The assumptions are similar to those in Ghosh and Shah (2012). The main difference between their study and our work is that we investigate green supply chains in the context of dual channels. First, referring to the consistent pricing policy of both channels, the manufacturer's and the retailer's profits are compared under the decentralized single channel green supply chain and the decentralized dual-channel green supply chain to investigate the effects of the introduction of the direct channel. We find that when the greening cost is greater than a threshold, the manufacturer should not open his direct channel. However, when the degree of customer loyalty to the retail channel and the greening cost satisfy certain conditions, the dual-channel green supply chain does exist. Furthermore, we discuss the pricing and greening strategies for the chain members in both centralized and decentralized cases. Then, we analyze the effect of the green degree, the greening cost and the greening sensitivity on the pricing decisions of the two members. Finally, we design a coordination mechanism for the decentralized dual-channel green supply chain to obtain win–win results. To expand the applicability of the dual-channel green supply chain, the pricing and greening strategies under an inconsistent pricing policy are discussed as a further extension.

The remainder of this paper is organized as follows. In Section 2, the literature review is described. Section 3 introduces the

notations, assumptions and the model. The theoretical results and comparisons of these results are presented in Section 4. We also provide further discussions about the results and propose a contract for coordinating the decentralized model in this section. We illustrate some managerial insights through numerical experiments in Section 5. A further extension is performed in the context of inconsistent pricing policy under the dual-channel green supply chain in Section 6. Section 7 gives conclusions and directions for future research.

2. Literature review

2.1. Research on green products

The existing literature has studied green products in GSCM from two aspects: One is that manufacturers produce green products from the perspective of products' recyclability. The other is that manufacturers produce green products without considering the characteristics of products. There are many results focusing on products' recyclability. For example, Chen and Sheu (2009) studied how to improve their products' recyclability by establishing a differential game model in terms of market competition, recycling dynamics and profit function. Sheu (2011) considered competitions between reverse-logistics (RL) suppliers and producers whose products contained recycled components in the green supply chain. The study applied the asymmetrical Nash bargaining game and discussed when chain members' profits and social welfare (including recycling-induced environmental benefits) could be maximized. Sheu and Chen (2012) analyzed a similar problem to that in Sheu (2011) using a three-stage game-theoretic model. Results indicated that under certain conditions, producing green products could bring about non-negative green profit for the manufacturers.

Other researchers are interested in studying the problems of green products, but they do not consider the characteristics of green products, such as recyclability. Xu et al. (2011) proposed a game model to analyze the game relationships between enterprises and consumers in the home appliance industry. Barari et al. (2012) presented an evolutionary game model in which the producer manufactured green products and the retailer was responsible for attracting consumers to buy the green products. Coordination between the producer and the retailer could balance the environmental and commercial benefits. Ghosh and Shah (2012) compared different structures of green supply chains consisting of a manufacturer and a retailer. The manufacturer decided the green degree of green products that were believed to increase the demand in the retail end to maximize his profit. Results showed that when the manufacturer and the retailer were integrated as a whole system, green innovation could be maximized. Cao and Zhang (2013) believed that green products' utility diversity could generate market demand; they coordinated the green channel between suppliers and manufactures using pricing strategy. Zhang and Liu (2013) considered the effect of green products on market demand in a three-level supply chain that included a supplier, a manufacturer and a retailer. The green degree of the green products was assumed constant. A three-level leader-follower game and Stackelberg game were applied in their models, in which coordination mechanisms were designed to relieve competition between chain members. Zhang et al. (2014) investigated the pricing strategies of a green supply chain in which the manufacturer made green products and non-green products together. Results indicated that production costs affected the choice of production modes and system performance.

However, all of the above studies are restricted to a single channel supply chain, and none of them focuses on green products in GSCM

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