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Price and warranty period decisions for complementary products with horizontal firms' cooperation/noncooperation strategies

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ABSTRACT

The purpose of this paper is to explore the optimal strategies on price and warranty period of two complementary products in a supply chain with two manufacturers and one common retailer from a two-stage game theoretic perspective. Five decentralized models are established by considering the two manufacturers' cooperation/noncooperation strategies and the firms' different bargain powers. The corresponding closed-form expressions for equilibrium decisions are obtained. Through a systematic analysis and comparison, some interesting and valuable managerial insights are established. We find that, the retailer always has the advantage to get the higher profit when she is a leader; however, this is not always valid for two manufacturers, for example, two manufacturers' profits when they are leaders and they adopt the noncooperation strategy in the supply chain are lower than that when two manufacturers and the retailer have the identical market power. All channel members as well as consumers benefit from lower retail prices, longer warranty periods and larger profits when the two manufacturers' adopt cooperation action.

1. Introduction

In today's market, price is very important as it determines the company's profit and survival. Manufacturers and retailers have been using price reduction to lure customers and boost sales. Besides price, more and more firms have resorted to dependence on services and/or product quality to build brand loyalty to avoid traditional competition which focuses solely on price. For example, IBM and Dell enjoy a good reputation in terms of their customer services and supports. In many cases, consumers may predict the quality of a product based on its warranty, which is considered as the assurance that the producer provides after evaluating the strength of products (Boulding and Kirmani, 1993). Warranty has become a popular measure for encouraging market demand by reducing risks for consumers and has also associated with the firms' corporate social responsibility which is a key characteristic of corporate sustainability and business sustainability (Van Marrewijk, 2003; Ahi and Searcy, 2013). Firm has the social and environmental responsibility to give a reasonable warranty period for its product, which is an important reflection of enterprise to perform social responsibility. Enterprise was always supposed to use its products and services to meet the material and spiritual needs of consumers. If the producer promises to renew or repair products when failures occur, the commitment length of warranty and the reliability of the product, which is related to its life-cycle distribution, play a key role on determining the total cost of product (Wu et al., 2009). A satisfactory warranty policy will certainly enhance consumers' purchase willingness, and will benefit the sustainability and resource-efficiency. So, firms should have the responsibility to prolong the service life of products, to ensure products are used as intensively as possible, and to make them as cost- and material-efficiently as possible. However, a firm must make a trade-off between the investment and the benefit from providing warranty period because who has to pay a cost for the warranty period.

This research is related to the literature rooted in warranty period and product life-cycle. Warranty period decision and product life-cycle have received extensive attention lately due to the above mentioned factors. Chien (2008) has developed a general age-replacement model for free-replacement warranty, which includes minimal repair, as well as planned and unplanned replacement. Silalertruksa et al. (2012) evaluated the cost performance of palm oil biodiesel in Thailand compared to diesel fuel when their

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externalities are internalized into their respective production costs. In this research, the costs imposed on the environment and society that are not accounted for in the market price and the life cycle cost including all costs arising over the entire life cycle of palm oil based biodiesel production as also its external costs are investigated. Buczkowski et al. (2005) proposed a network flow model to solve the problem of outsourcing warranty repairs when items have priority levels. Östlin et al. (2009) focused on how to provide remanufactured products in an effective way during the product's life-cycle. Darghouth and Chelbi (2012) considered a particular maintenance service contract for a certain type of equipment whose failures can only be detected by inspection. Mashoko et al. (2013) developed a life cycle inventories for bagasse power production in South Africa. Chen et al. (2012) considered the issues associated with a manufacturer's pricing strategies in a two-echelon supply chain that comprises one manufacturer and two competing retailers, with warranty period-dependent demands. None of these papers studied the warranty period decisions of two complementary products in a two-echelon supply chain.

Our research is also related to the pricing problem. There are a number of studies concerning the pricing problem (e.g. Choi, 1991; Tsay and Agrawal, 2004; Wu et al., 2009; Zhao et al., 2012). Choi (1991), for instance, examined the optimal pricing decision of two substitutable products in a two-echelon supply chain consisting of two manufacturers and one retailer, and investigated three types of game structures. Fahimnia et al. (2013) evaluated the impacts of carbon pricing on both a standard forward supply chain and a closed-loop supply chain. Wang (2006) studied decentralized production-pricing decisions of complementary products and their implications to supply chain performance. Galarrag et al. (2011) collected an extensive sample from market transactions in December 2009 and studied the price premium for the most energy efficient refrigerators using the hedonic method. Mukhopadhyay et al. (2011) showed that information sharing would benefit the leading firm; however, it would be detrimental to the follower firm and the system as a whole if the follower firm shares information unconditionally by considering a duopoly market where two separate firms offer complementary goods in a leader-follower type of strategy. Pesic et al. (2013) presented a model of seasonal water pricing aimed primarily at diminishing excessive fresh water use in the city of Belgrade. Wei et al. (2013) considered the pricing decisions for two complementary products with firms' different market powers under decentralized decision case where the manufacturers adopt noncooperative action. To the best of our knowledge, no research has considered the pricing and warranty period decisions of complementary products by considering the manufacturers' cooperation and noncooperation strategies in a two-echelon supply chain.

Differing from those of prior studies, by considering a two-echelon supply chain where two manufacturers produce two complementary products respectively and sell them to one common retailer who then sells them to the end customers, this article studies the two manufacturers' optimal decisions on wholesale price and warranty period and the common retailer's optimal decisions on retail prices. Moreover, our article focuses on three different game scenarios, namely, the manufacturer-leader Stackelberg, retailer-leader Stackelberg and Nash games, and considers how the two manufacturers and the common retailer make their own optimal decisions about wholesale price, retail price and warranty period when facing different channel power structures under perfect information. The two manufacturers' decision strategies (i.e., cooperation or noncooperation) are also considered in the manufacturer-leader Stackelberg and retailer-leader Stackelberg cases. To the best of our knowledge, no research has studied the price and warranty period decisions of two complementary products in a two-echelon supply chain as considered in this article. Our paper tries to fill this research gap.

The main contributions of this paper are as follows. First, five decentralized decision models are established by considering the channel leadership between the two echelons and the two manufacturers' decision strategies (i.e., cooperation or noncooperation), which extends the current study related to the complementary products. Second, by using the game-theoretical approach, the analytical equilibrium wholesale prices, retail prices and warranty periods are obtained in the five decision models. Third, through numerical studies, we obtain some valuable managerial insights, for example, (1) In order to obtain the bigger warranty periods, the consumers would rather no channel member in a dominant position, they also do not want the manufacturer is a leader. Moreover, the best choice for the consumers to obtain the biggest warranty periods is the retailer ia a leader and the two manufacturers adopt the cooperation strategy; (2) All channel members and the whole supply chain can benefit from the two manufacturers' cooperation strategy in both MS and RS decision cases; (3) The retailer always has the advantage to get the higher profit when she is a leader in the supply chain; however, this is not always valid for two manufacturers, for example, two manufacturers' profits when they are leaders and they adopt the noncooperation strategy in the supply chain are lower than that when two manufacturers and the retailer have the identical market power.

The remainder of this article is organized as follows. In Section 2, we introduce the problem description and notations. Section 3 details our decision models and analytical results. Comparisons and Managerial Implications are given in section 4. Section 5 summarizes our results and presents several extensions to consider for future research.

2. Problem description

We consider a two-echelon supply chain with three independent, risk-neutral, and profit-maximizing chain members—one common retailer and two manufacturers (manufacturer 1 and manufacturer 2). The manufacturer 1 produces a product (product 1) with unit manufacturing cost c_1 and sells it to the common retailer with unit wholesale price w_1, moreover, the manufacturer 2 produces another product (product 2) with unit manufacturing cost c_2 and sells it to the common retailer with unit wholesale price w_2. The retailer then sells the product 1 and product 2 to the end consumer with unit retail prices p_1 and p_2, respectively. We assume that products 1 and 2 are functionally complementary products with each other (e.g., a computer and an operating system, bed and mattress, etc.), and all activities occur in a single period.

In order to have an analytically tractable model and to gain sharper insights into the problem, we assume that the deterministic linear consumer demand for each product is only sensitive to two factors: (1) retail price and (2) warranty period provided by the manufacturers. Notice that only the warranty that are provided by the two manufacturers are considered. Effectively, we do not take into account the effect of the services provided by the common retailer to the consumer demand for each product. We can think of this as the retailer providing the same level of service to both complementary products; the only difference to the consumer's perception (other than price) is the warranty periods provided by the manufacturers respectively. We also assume that the investment in warranty period has a decreasing return to scale. Namely, the next dollar invested by the manufacturer returns less warranty period than the last dollar invested, i.e., it is harder (and costs more) to provide the next unit of warranty period than the last one. This diminishing return of warranty period can be captured by the quadratic form of warranty-period cost. In our model we assume