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Optimal pricing decisions under the coexistence of "trade old for new" and "trade old for remanufactured" programs

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ABSTRACT

Under the coexistence of "trade old for new" (TON) and "trade old for remanufactured" (TOR) programs, we study a firm's optimal pricing decisions and identify the thresholds that determine whether the firm should offer TON and TOR simultaneously. The result shows that adopting two kinds of trade-ins simultaneously does not necessarily benefit the firm and that the firm should use different trade-in schemes under different conditions. Moreover, we extend the model to the case with budget constraints on the TOR subsidy. The result shows that the firm's profit decreases when the actual TOR quantity exceeds the upper limit.

1. Introduction

In practice, we find a variety of firms that offer "trade old for new" (TON) programs to consumers who currently own an old product, which means that such a consumer can purchase a new product with a discount by trading-in his old product. For instance, AT&T offered $100 credit for purchasing a new Samsung Galaxy S4 when consumers returned their old Galaxy S3 (Droidlife Website, 2013). In China, the TON program known to the public was first driven by the government subsidy plan for automobile and home appliances that began in 2009 and ended in 2011 and thus became a common industry practice. In the automotive sector, FAW-Volkswagen Automobile Co. Ltd. provides consumers who currently own an old car with replacement service on its official website and in its automobile 4S shop (FAW-Volkswagen, 2013). TON has been a widely used promotion tool for selling and plays a vital role in the collection of used products as well.

As the TON program prevails in practice, many scholars prove that any return flow of old products led by trade-in programs has the potential to generate incomes through remanufacturing operations (Ray et al., 2005; Rao, 2009; Zhu et al., 2016). Remanufacturing is a process in which old products are disassembled, and their parts are repaired and reused in the production of new or remanufactured products (Ferrer and Swaminathan, 2006). The successful examples from industry, such as Kodak (Geyer et al., 2007), BMW, IBM, DEC and Xerox (Ayres et al., 1997), show that remanufacturing is profitable and environmentally friendly. However, many sales managers are reluctant to introduce remanufactured products because consumers may not accept remanufactured products. In fact, the willingness-to-pay for remanufactured products of most consumers is lower than that for new products (Guide and Li, 2010). Therefore, how to increase the sales of remanufactured products has become a large problem for the remanufacturing industry.

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To promote remanufacturing activity and improve environmental performance, in 2013, the Chinese government announced a pilot program on "trade old for remanufactured" (TOR) (NDRC, 2013). Subsequently, 10 automakers or engine manufacturers were selected as pilot enterprises to implement a TOR program (NDRC, 2015). The consumer who holds an old product can purchase a remanufactured product at a discounted price by returning his old product and obtain a government subsidy. In this context, the TOR pilot enterprises that have provided customers with TON service, such as FAW-Volkswagen, Weichai, Yuchai and DCEC, have the motivation, the ability, and the possibility of implementing TON and TOR programs simultaneously. Additionally, the customer owning old products can choose a TON program without a government subsidy or a TOR program with a government subsidy.

The coexistence of TON and TOR programs as well as new products and remanufactured products may lead to undesirable consumer reactions. On the one hand, the consumer who owns an old product may have three options: trade in his old product for a new one, trade in his old product for a remanufactured one, or retain the old product. On the other hand, the consumer who does not hold an old product may buy either a new one or a remanufactured one, or he may buy nothing. In such circumstance, consumers become savvier at planning their purchases of new or remanufactured products. Moreover, remanufactured products may cannibalize the demand for original products (Majumder and Groenevlt, 2001), such that the pricing decision of new and remanufactured products becomes more complicated because a multitude of factors will affect a consumer's purchasing decisions.

The purpose of this paper is to analyze the interaction between TON and TOR program and analyze whether a firm should offer TON and TOR programs simultaneously. Moreover, in view of the fact that the government's subsidy propping up the TOR program is subject to budget constraints, we also study the impact of the government's budget constraints on the firm's optimal strategy.

To study the effect of introducing TOR program on existing TON program, in this paper, we investigate the optimal pricing decisions of a profit-maximizing firm under the coexistence of TON and TOR programs in a single-period planning horizon. First, we use an individual consumer choice framework that models each consumer's purchasing or trade-in decisions based on his net utility. Second, we focus on the optimal pricing decisions of a firm that adopts TON and TOR programs simultaneously. The potential market consists of a known population of divided consumers, i.e., first-time buyers and replacement buyers. Based on the previous literature, we also assume that the replacement consumers only trade in their holding products and each consumer can only hold one product at a time (Ray et al., 2005).

To have a better understanding of whether a firm should offer TOR in addition to TON, when to offer and how the government budget constraints affect the firm's optimal strategy, we develop a model and attempt to answer these questions from the perspectives of both the firm and the consumers. More specifically, we focus on the following questions:

(1) Can the firm earn more profit when offering TOR and TON simultaneously rather than only providing TON?
(2) What are the optimal pricing decisions of the firm when offering both TON and TOR?
(3) How does the optimal strategy change with the budget constraints on the TOR subsidy?

From the firm's perspective, it is very crucial for the firm to choose its marketing strategy, i.e., only providing TON, only providing TOR or providing TOR and TON simultaneously; this concerns its competitive advantage in the market. From the consumer's perspective, this decision is also difficult between TON and TOR when they want to trade in their old products. Therefore, in this paper, we attempt to model the consumer's purchasing or trade-in decisions and choose the optimal marketing strategy for the firm.

The remainder of this paper is organized as follows. In the following section, we briefly review the previous work. Section 3 presents the description and construction of our model. Section 4 analyzes the optimal pricing decisions and the optimal strategy of the firm. Section 5 extends our model to the scenario in which there are budget constraints on the TOR subsidy. Section 6 is devoted to the discussion of the results. Section 7 concludes the paper. All proofs are provided in the Appendix A.

2. Literature review

This paper is built on several streams of literature, as reviewed below.

The management of CLSC has been a popular research topic in recent years because of its economic and environmental advantages (Savaskan et al., 2004; Krikke, 2011; Sheu and Talley, 2011; Chen and Chang, 2012; Ye et al., 2016). A natural classification is to divide CLSC decisions into strategic, tactical, and operational decisions. Strategic decisions have a long-term impact on the firms, such as for network design. The impact of tactical decisions can be measured in weeks or months, such as for inventory policies. Operational decisions only have short-term effects (Souza, 2013). In this paper, we focus on strategic and tactical decisions, including whether a firm should offer TOR and TON programs simultaneously and how to plan the production of new products and remanufactured ones.

A growing body of literature in operations management addresses the issue of CLSC management under the coexistence of new and remanufactured products s. In terms of whether a firm should focus on remanufacturing, the basic modeling framework to answer this question uses vertical differentiation models. It is concluded that the manufacturer should offer remanufactured products subject to specific conditions (Vorasayan and Ryan, 2006; Geyer et al., 2007; Debo et al., 2005).