Price competition and co-operation in a duopoly closed-loop supply chain

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ABSTRACT

This paper studies co-operation and competition issues in a closed-loop supply chain. The supply chain comprises of two manufacturers who compete for selling their new product as well as for collection of the used-products for remanufacturing through a common retailer. To analyze the situation, mathematical models are developed here for three different cases (i) Non-co-operative system (ii) Channel-co-operative system and (iii) Global-co-operative system. For each of the cases, we have characterized optimal wholesale price and fraction of collection of used product. To draw more managerial insights, we also examine the sensitivity of various parameters such as market size, acquisition cost and transfer price on total channel profit. A numerical study is carried out to illustrate the model, and the results reveal that global-co-operative system is the best among all the three cases considered here. Weighted Shapely Value mechanism is used for sharing of surplus generated in the system due to channel-co-operation.

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1. Introduction

In the light of increasing environmental consciousness and stricter legislation, disposal of plentiful end-of-life (EOL) products has become a critical issue (Gengui et al., 2012). The aim of EOL product recovery is to minimize the amount of waste through landfills by recovering materials and parts from old or outdated products by means of recycling and remanufacturing (Gungor and Gupta, 1999). Re-manufacturing is the process where some components of used products are disassembled, cleaned, reprocessed, inspected, and reassembled to be used again.

A remanufacturing system not only helps in reducing the environmental burden but also helps in reducing the production costs. According to a recent survey made by Kelly Service analysis (2012), manufacturing in Indian automotive industry is growing at 13%, and by 2016, it is forecasted to reach US $120–159 billion. The rate of return of used product is 5% costing US $12–15 billion in India (Thomas, 2012). The trend of growth in remanufacturing is also present in other industries such as computer and its accessories (Jorjani et al., 2004; Shi et al., 2011), cameras (Savaskan and Van Wassenhove, 2006), electrical equipments, consumer electronics, and furniture (Hauser and Lund, 2008) across the world. Customer may return their product due to variety of reasons during and after the product life cycles such as due to warranty, repair return, end-of-

use return, and EOL returns. The product take-back system and reuse of outdated product depend on the product characteristics. For example, Kodak that develops films for customers also collects used cameras from large retailers, and recovers 76% of the weight of a returned camera for the production of a new one (Savaskan and Van Wassenhove, 2006).

When a manufacturer adopts remanufacturing practices, it is important for the manufacturer to adjust his sales strategies in response to remanufacturing. In some cases, the manufacturers assign product collection activities to their distribution partner or retailer. However, in today's competitive business environment, it is common that a retailer would try to sell similar/substitutable kinds of product produced by two or more different manufacturers to attract more customers. The retailer at the same time is also responsible for collecting the used-products of the two (or more) different manufacturers. Similar to the case of competition in forward selling, the manufacturers will also compete to collect the used product from the retailer. Singh and Vives (1984) addressed on price and quantity competition in a differentiated duopoly. In a duopoly situation, firms produce homogeneous good and marginal costs are equal and constant for both the firms. Savaskan and Van Wassenhove (2006) addressed the interaction between a manufacturer's reverse channel choice to collect used product and a strategic product pricing decision in the forward channel under duopolistic competition with a retailer. Shulman et al. (2011) studied the pricing and restocking decisions of two competing firms under differentiated product. They have devolved a model considering duopoly facing consumers who have a heterogeneous taste of the product. They have found that restocking fees can be

more severed when the firms get less information from the consumer about fit and preference of the product. Gu and Gao (2012) addressed that there is few research have been done on price competition in closed-loop supply chains (CLSC) under duopoly competition. They have studied the management of the whole sale price, the retailer price and the collecting prices for the two competitive closed-loop supply chains under deterministic demand. Several strategies have been discussed in the literature to integrate the business activities of different members of a decentralized CLSC to ensure system wide performance improvement in terms of acquisition cost, transfer price, product delivery and customer service. The previous studies have also focused on price competition within a closed-loop supply chain in the absence of co-operation (Atasu et al., 2008; Debo et al., 2005; Hsueh, 2011; Pokharel and Liang, 2012). However, the issue of co-operation and competition in a close loop supply chain is not yet addressed in the prior literature.

This paper considers a CLSC where two different manufacturers producing the substitutable products compete to sell new product and collect the used products through a common retailer. The price of one product can affect the sales of the other product. We have studied the following three cases for the above described problem (i) when all the three members individually maximize their profit (non-co-operation). (ii) both the manufacturers coordinate separately with the retailer, and both the integrated channels compete with each other on choosing the product prices in response to the other channel to maximize the channel profit (channel-co-operation) and (iii) finally; all the members of the system collate to form a global-co-operation. There is a lack of research on co-operation of a closed-loop supply chain in price competitive duopoly manufactures with a common retailer. Thereby, it is unique and makes the contribution in the existing literature of CLSC.

The paper is organized as follows. A brief review of literature is included in Section 2. Section 3 is devoted to the key assumptions and notation of the modeling frame work. The mathematical models are developed in Section 4 and Surplus sharing mechanism is described in Section 5. In Section 6, numerical study and managerial insights drawn from the study are presented. Finally, conclusions and future scope of study are presented in Section 7.

2. Literature review

The past decade has seen an enormous increase in research on remanufacturing and CLSC. Guide and Van Wassenhove (2002) addressed on the business aspects of developing and managing profitable CLSC. Many analytical and empirical studies have been carried out in different areas of remanufacturing such as production planning & control, inventory management, methods of collection, product categorization, acquisition management, pricing policy, and network design, etc. (Fleischmann et al. 1997; Savaskan et al. 2004; Guide and Van Wassenhove., 2009; Shi et al. 2011; Toktay and Wei, 2011; Ozkir and Basligil, 2012). Koh et al. (2002) have studied on stationary demand, which is satisfied by remanufacturing the product as well as by externally purchasing brand new products. The model was validated by considering examples of two remanufacturing products: drinking bottle and bullet jackets. Zhou and Yu (2011) examined both manufacturing and remanufacturing system in which inventory control strategy is an automatic order based production control system. Choi et al. (2007) developed a mathematical model where market demand is satisfied by newly purchased product and remanufactured product. Savaskan et al. (2004) have studied price decisions and collection efforts in a supply chain with three different types of reverse channel for remanufacturing. The study examined the incentive to the customers to improve the collection of used product. Atasu et al.

(2008) addressed marketing strategy for remanufacturing by considering green-market segment, competition with new products, and product life cycles. The study has shown that remanufacturing product is more profitable in green market segment. Hong and Yeh (2012) have studied collection method where the retailer collects EOL products, and the manufacturer co-operates with a third party to handle the used product. Shi et al. (2011) presented the hybrid systems in the sense of manufacturing brand-new products and remanufacturing returns as like as new one with pricing and production decisions, that satisfy the market demand. They developed a mathematical model to maximize the overall expected profit of the system by simultaneously considering the selling price, the production quantities for two-channel systems, and acquisition price of the return product considering uncertain situations. Chen and Chang (2013) have studied the management of two differentiated version of the same product. They developed an analytical model and observed that the pricing strategy typically depends upon the types of market. Benitez and Muriel (2013) studied the wholesale price and buy-back contract between a manufacturer and retailer considering retailer price exogenously under stochastic demand.

From the perspective of economic theory, a large number of research papers are available on market competition. Most of these papers deal with either quantity competition or price competition, and their primary focuses are on applying game theory to derive equilibrium under varied assumption. Majumder and Groenevelt (2001) developed a two period model of remanufacturing in the face of competition between original equipment manufacturer and local remanufacturer under many reverse logistics configurations for the returned items. Ferguson and Toktay (2006) developed a model to support a manufacturer's recovery strategy in the face of the competitive threat on the remanufactured market. This study examined the competition between new and remanufactured product produced by a manufacturer and identify the favorable condition under which the firm would not take an interest for remanufacturing. Mitra and Webster (2008) studied the price competition between new and remanufactured product in the market under the effect of government subsidies. Bernstein and Federgruen (2005) examined the equilibrium behavior of decentralized supply chains with competing retailers and a single supplier under demand uncertainty in two-echelon distribution systems. They have considered that retailers are non-identical in nature. Xiao and Gilbert (2007) have shown that the linear quantity discount scheme can coordinate the supply chain with two competing retailers. McWilliams (2012) studied competition between the retailers considering the quality under heterogeneous reservation price. He has developed the model for high and low quality retailer considering signal theory. In this model, the author has found that the low-quality retailer gains and the higher quality retailer lose under the case in which MBGs are not offered. Chen and Grewal (2013) addressed the competition between the retailers to refund the customer return policy considering a common manufacturer. They have developed a model considering Nash and Stackelberg game approach under competitive strategy. The analysis revels the degree to which the customer accepts the refund product for the new entrant retailers under competitive market strategies. This research might need a different contract instead of the wholesale price contract to incentivize the new entrant retailer.

In the management of the supply chain with chain-to-chain competition, Boyachi and Gallego (2004) developed a game theoretic model to study customer service competition. Kurta et al. (2007) have investigated channel pricing in multiple channel distributions considering the competition between a national, and a store brand product where the national brand product can be distributed through both direct and indirect channel whereas the store brand product can be distributed only through an indirect channel. Guide et al. (2006) addressed a single CLSC that consists of one manufacturer and one retailer. In their study, they have found that retail price and whole sale