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Models to explore remanufacturing as a competitive strategy under duopoly ☆

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ABSTRACT

Remanufacturing is a product recovery option that upgrades the quality of returns to "as-good-as-new" conditions. Remanufactured products cost less, and are sold with the same or better warranty as for new products. In this paper, we consider a duopoly environment with two manufacturers in direct competition selling their respective new products on the primary market. Specifically, we address the question: In case one manufacturer decides to remanufacture and sell remanufactured products on the price-sensitive secondary market, will it get a competitive advantage over the other manufacturer? We develop theoretical models for a single period and two periods, and show that under the stated assumptions, remanufacturing is almost always more profitable than when there is no remanufacturing. Although remanufacturing may cannibalize new product sales, the combined profitability and market share of the (re)manufacturer on account of new and remanufactured product sales improve over new product sales only. For the competitor, we get mixed results. In some situations, its profitability improves; in some others, it worsens. We also conduct sensitivity analyses with respect to the substitution parameters, price-sensitivity of the secondary market, rate of return of used products (cores), relative market shares of the manufacturers, and relative sizes of the primary and secondary markets. We conclude the paper with managerial implications and directions for future research.

1. Introduction

Remanufacturing is one of the product recovery options where the quality of returns is upgraded to the quality level of a new product. The cost of remanufacturing is 40–60% of the cost of manufacturing a new product. Further, a remanufactured product is sold at 30–40% discount with the same or better warranty as applicable for a new product [11,34]. Remanufacturers also benefit from government subsidies in the form of tax credits [15], and, therefore, besides addressing environmental concerns, remanufacturing does make a sound business proposition for manufacturers. Many industries such as auto, aircraft, machine tools, photocopiers, computers, toner cartridges, single-use cameras, and construction and mining equipment are engaged in remanufacturing. Original equipment manufacturers (OEMs) such as GE, GM, Boeing, Bosch, Xerox, Fuji, HP, IBM, Kodak and Caterpillar have already made remanufacturing a part of their corporate strategy. According to a report, the U.S. remanufacturing industry is worth $53 billion with 73,000 firms employing 480,000 people [19].

However, critics say remanufacturing leads to the cannibalization of new product sales, and since corporate profitability and marketing incentives are generally linked with the revenues generated by new product sales, remanufacturing receives a lower priority vis-à-vis manufacturing of new products [1]. On the other hand, proponents of remanufacturing say that remanufacturing may not necessarily lead to cannibalization for all categories of products [17], and even if it leads to cannibalization, the combined profitability, sales volume and market share of manufacturers for new and remanufactured products tend to increase over new product sales only [21]. Also, by remanufacturing, manufacturers can successfully counter cheap import substitutes and preempt competition from independent third-party (3P) remanufacturers, who may not care about the brand name and quality of the products, and may even counterfeit them [3,31]. Literature on the competition between OEMs and 3P remanufacturers shows that OEMs are always better off in terms of profitability and dealing with 3P competitors when they themselves engage in remanufacturing activities [2,10,12,13,24,35]. Subramoniam et al. [32] identify four strategic factors, namely product strategic planning processes, physical distribution structures, plant location and production systems, and cooperation among remanufacturing supply chain stakeholders, based on literature review, that impact OEMs' priorities for remanufacturing in the context of the

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automotive aftermarket business. The authors argue that remanufacturing may lead to increased profitability, save resources and energy, reduce environmental impacts, protect intellectual property, create new market opportunities, and attract government subsidies. However, the authors also note that remanufacturing may not be feasible for many product categories, such as automotive components, because of their shorter life cycles. In such situations, the authors note, remanufacturing may be useful in bringing back used products to same-as-new conditions with future upgrades if the products are originally designed to remanufacture. The authors present propositions based on the four strategic factors, as mentioned above, in relation to decision-making for remanufacturing. The propositions are tested through a case study of two products of a major automotive components supplier wherein the authors find that many strategically important factors for remanufacturing, such as reverse logistics, product life cycles, customer requirements and so on, have not been considered in the product development stage. Based on the findings from the case study, the authors present new propositions, and provide a foundation for further research in the area of remanufacturing aftersales/aftermarket automotive components.

In this paper, we consider a duopoly environment where two manufacturers are in direct competition with each other and sell their partially substitutable new products on the primary market. In the base case, although there exists a secondary market of price-sensitive customers, none of the manufacturers engages in remanufacturing. We develop theoretical models for a single period and two periods, and through these models, try to answer this question: If one manufacturer decides to remanufacture and sell its remanufactured products on the secondary market, will it get an advantage over its competitor and benefit from remanufacturing? Heese et al. [20] note that by selling remanufactured products, a manufacturer can increase both profit margins and sales – to the detriment of a non-interfering competitor. Atasu et al. [2] observe that remanufacturing is more beneficial under competition than in a monopoly setting. The authors also note that remanufacturing allows a manufacturer to defend its market share via price discrimination.

The contributions of this paper are as follows. We consider differentiated pricing strategies for new and remanufactured products sold to two market segments – quality-conscious primary customers and price-sensitive secondary customers, respectively, with the possibility of substitution of new products by remanufactured products by some of the environment-conscious primary customers. Therefore, the setting is different from that in Majumder and Groenevelt [24], Ferrer and Swaminathan [13], Zhou and Yu [36] and Qiang et al. [27], who consider undifferentiated products offered in an unsegmented market where customers are indifferent between new and remanufactured products. Debo et al. [10], Ferguson and Toktay [12], Ferrer and Swaminathan [14], Chen and Chang [8], and Wu [35] consider differentiated products; however, there is no clear market segmentation. A customer can buy either a new or a remanufactured product depending on his net utility, i.e. the difference between his valuation and the actual price of the product. In our models, there is clear market segmentation in the sense that while there may be mobility of environment-conscious primary customers to the secondary market, price-sensitive secondary customers never substitute remanufactured products by more expensive new products. Therefore, while demand for new products is modeled as a function of the price of new products only, demand for remanufactured products is modeled as a function of the prices of both new and remanufactured products. Moreover, in this paper, we have considered direct OEM competition. Most of the previous papers, as mentioned above, have considered competition between OEMs and 3P remanufacturers. Therefore, the intricate competitive dynamics in new product sales by OEMs and cannibalization of new product sales by remanufactured product sales for the (re)manufacturer have not been simultaneously captured in these papers. We have tried to address this research gap in our paper. The competitive dynamics and new sales cannibalization are a highly debated topic in the remanufacturing industry. The concern that remanufacturing will impact new product sales negatively has prevented many OEMs to move forward with remanufacturing. However, recent surveys are shifting top management thinking. For example, according to the Consumer Returns Benchmarking Trend Report [9], 79% of those surveyed believe that the secondary market will not impact new product sales, and 14% of the respondents, who feel they are cannibalizing new product sales in the secondary market, estimate the cannibalization level at only 20%. Also, there is increasing confidence that the availability of remanufactured products, such as remanufactured/refurbished cell phones, will increase brand loyalty for consumers, who cannot afford new products.

Heese et al. [20] and Atasu et al. [2] have considered direct OEM competition with only one manufacturer engaged in remanufacturing activities. However, there are certain differences in terms of problem settings. Heese et al. [20] do not consider the secondary market within the purview of model development, and assume that the price of remanufactured products is exogenously determined. Also, in their problem context, customers return cores to OEMs in return for a price discount on new products (This is equivalent to trade-in. Manufacturers are increasingly offering, and customers are increasingly adopting, trade-in and leasing. Manufacturers use the returned cores of traded-in and leased products for remanufacturing and other product recovery options. For a comparison between trade-in and leasing as strategies for shortening customers' product upgrade cycles and gaining control over the secondary market, readers are referred to Li and Xu [22]). We, in fact, in our models, have made the secondary market an integral part of the system, and treated the price of remanufactured products as an endogenous variable along with the price of new products. We have also assumed that the return of cores and the demand for new products are independent. Atasu et al. [2], on the other hand, consider that there is a threshold price of remanufactured products above which the primary and “green” market segments are independent and under OEM competition, the price charged by the other OEM is lying somewhere between the prices of new and remanufactured products of the (re) manufacturer, giving primary customers of the (re)manufacturer an opportunity to buy cheaper alternative products from the other OEM. The other OEM faces competition from both new and remanufactured products of the (re)manufacturer when the price of remanufactured products is below a certain threshold level. In our paper, we have relaxed the new product pricing restriction between the (re)manufacturer and other OEM, and made sure that there is substitutability between the new products of the (re) manufacturer and other OEM and between the new and remanufactured products of the (re)manufacturer at all price points.

The rest of the paper is organized as follows. The problem description is given in Section 2. Section 3 presents model formulations, numerical experimentations, sensitivity analyses and discussion of results. Finally, managerial implications and concluding remarks, including the directions for future research, are presented in Section 4.

2. Problem description

We consider a duopoly where two manufacturers (say, M1 and M2) sell their new products, which are substitutable, on the primary market. One of the manufacturers (say, M1) decides to