Trade-in Remanufacturing, Customer Purchasing Behavior, and Government Policy

Introduction

Remanufacturing is the rebuilding of a product to specifications of the original manufactured product using a combination of reused, repaired, and new parts. The initial purpose of remanufacturing was to recover the residual value of the components and materials from used products. More recently, with growing awareness of sustainability, the environmental advantages of remanufacturing have also been widely recognized. As a result, remanufacturing has been increasingly adopted in industry to enhance a firm’s competitive edge. According to the U.S. International Trade Commission (2012), an integral component of the closed-loop supply chain for remanufacturing is core collection, i.e., the process of obtaining used products from customers. A common practice for core collection is to provide trade-in rebates that encourage customers to return their used products. For example, Apple offers both in-store and online trade-in programs, which allow customers to exchange their used iPhones, iPads, and Macs for credits to purchase new ones. Analogously, Amazon allows Kindle owners to trade in their old products for newer versions at a discount price. More examples of using trade-in rebates for core collection have been reported in industries such as furniture, carpets, power tools, etc.

It is quite common in practice that a customer needs to make the decision of whether to make an immediate purchase or to wait for better future opportunities (e.g., a price mark-down or a new technology). A customer is called strategic or forward-looking if she strategizes the purchasing decision to maximize her long-run utilities. In contrast, a myopic customer does not consider future opportunities and base her purchasing decision on the immediate utilities. Consumer purchasing behavior can be quite complex in the real world. It has been empirically verified that customers exhibit a mixture of strategic and nonstrategic purchasing behaviors in various markets (e.g., Li et al. 2014). So the actual customer purchasing behavior in a market should be somewhere between the two extremes of fully strategic and fully nonstrategic behaviors.

Trade-in remanufacturing and customer purchasing behavior naturally interact with each other. The trade-in program grants price discounts to repeat customers who return their used products, thus enabling the firm to price discriminate new and repeat customers. Under trade-in remanufacturing, strategic customers will anticipate a potential future price discount in the form of a trade-in rebate, which is ignored by myopic customers. As a consequence, different customer purchasing behaviors may lead to drastically different market outcomes under trade-
in remanufacturing. Although both strategic and nonstrategic customer behaviors have been widely acknowledged in the literature, it is not clear what role they will play under the trade-in remanufacturing setting.

Model

The primary goal of this paper is to analyze the impact of customer purchasing behavior and remanufacturing efficiency on the value of trade-in remanufacturing to different stakeholders. For this purpose, we develop a two-period model in which a profit-maximizing firm sells two generations of a product in a market. We use the customer discount factor to model the intensity of their forward-looking behavior. If this discount factor is large, the intensity of strategic customer behavior is high, and the customers make their purchasing decisions with serious considerations of anticipated future utilities. Otherwise, the customer discount factor is low, so customers care little about future utilities and are myopic to a large extent. In the first period, the firm sells the first-generation product in the market. In the second period, the firm sells the second-generation product to new customers (who have not purchased in the first period); meanwhile, the firm offers trade-in rebates that allow repeat customers (who have purchased in the first period) to exchange used products for new second-generation ones at a discount price. We explicitly model two benefits from remanufacturing and recycling used products: First, it generates economic value for the firm, which we also refer to as remanufacturing efficiency; second, it helps reduce the product’s negative impact on the environment.

Results

A key message of our paper is that both customer purchasing behavior and remanufacturing efficiency have important implications for the value of trade-in remanufacturing. From the firm’s perspective, we find that the profit improvement from adopting trade-in remanufacturing is more significant under more strategic customers. In other words, the firm will have more incentives to use remanufacturing in a market with strategic rather than myopic customers. Furthermore, in contrast to the common belief that forward-looking behavior is detrimental to firm profit, we show the firm’s profit may increase with the intensity of strategic customer behavior under trade-in remanufacturing. This is because when remanufacturing is efficient enough, the trade-in rebate in the second period will be sufficiently high to ensure a higher surplus for repeat customers than for new customers. As a result, customers are willing to pay a higher first-period price if they are more strategic, which could improve the total profit of the firm. These findings indicate that trade-in remanufacturing helps exploit strategic customer behavior, a new benefit not explored before. Moreover, this benefit will be elevated by a more efficient remanufacturing process.

As for the environment, we find that the impact of trade-in remanufacturing also depends critically on customer behavior and remanufacturing efficiency. With highly strategic customers, adopting trade-in remanufacturing may aggravate the negative impact on the environment. As
discussed above, under intensive forward-looking customer behavior, the trade-in opportunity offers customers a strong incentive to purchase early, which prompts the firm to increase production quantities if adopting trade-in remanufacturing. The increased production quantities may outweigh the environmental advantage of remanufacturing under general circumstances. Hence, trade-in remanufacturing generally hurts the environment with highly strategic customers. Such effect of trade-in remanufacturing to hurt the environment is more intensive with more efficient remanufacturing. However, with a sufficiently low intensity of strategic customer behavior, trade-in remanufacturing can be beneficial to the environment. In this case, new customers would be more profitable than repeat customers in the second period; this drives the firm to decrease the first-period production quantity to serve more new customers in the second period. These results call for caution when adopting the trade-in remanufacturing strategy. In particular, understanding customer purchasing behavior and remanufacturing efficiency is essential in evaluating the strategy, both for the firm and for the environment.

From the above results we can see that with strategic customers and efficient remanufacturing, the adoption of trade-in remanufacturing may create a tension between profitability and sustainability. That is, trade-in remanufacturing can greatly improve firm profit but meanwhile worsen the environmental impact. This motivates us to study how government intervention can achieve the socially optimal outcome in a market where trade-in remanufacturing is commonly adopted and highly strategic customers prevail. Recently, we have seen an increasing number of government interventions of markets based on environmental issues. For instance, starting from the year of 2011, the Chinese Ministry of Finance maintained a fund for the treatment of waste electrical and electronics equipment (WEEE), to which OEMs contribute in the form of taxes. This fund is used to subsidize the recycling and remanufacturing of used electrical and electronic products.

We focus on the use of a subsidy/tax policy by the government to regulate the practice of trade-in remanufacturing. The government is modeled as a central planner who aims to maximize the social welfare, i.e., the sum of firm profit and customer surplus less environmental impact. We consider a comprehensive linear subsidy/tax scheme for the production of both product generations and recycling/remanufacturing. We show that, for any customer purchasing behavior, such linear subsidy/tax scheme, if designed properly, can alleviate the profitability-sustainability tension and induce the social optimum. The socially optimal government policy aims to provide incentives to counter strategic customer behavior and, thus, induces the social-welfare-maximizing equilibrium, which is independent of how strategic customers are. Moreover, the government should provide more subsidies to encourage the adoption of trade-in remanufacturing if remanufacturing efficiency improves. To summarize, our proposed government policy well resolves the tension between profitability and sustainability under trade-in remanufacturing when customers are strategic.

Key words: customer behavior; trade-in rebates; remanufacturing; environment; government policy