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Optimal pricing, EOL (end of life) warranty, and spare parts manufacturing strategy amid product transition

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Abstract

We study firm's strategy to determine its product price and warranty period, and plan the spare parts manufacturing so as to maximize its profit and at the same time to fulfill its commitment to providing the customer with the key part continuously over the relevant decision time horizon, i.e., *the product's life cycle plus its EOL service (warranty) period*. To examine the research question, we develop and solve a two-stage optimal control theory model. From the numerical analysis, we infer as follows. It is not always true that the longer the EOL warranty period, the better for the company's profitability, implying there exists an optimal EOL warranty period that balances all the relevant forces like market demand and cost structures. The relationship between optimal EOL warranty period and failure rate (defect rate) is concave: when the defect rate is moderate, the company has to increase its EOL warranty period as the defect rate increases so as to compensate for the deteriorating quality; but, when the defect rate is beyond a threshold level, the company needs to curtail its EOL warranty commitment as the defect rate increases in order to avoid excessive cost to service the failed parts. By depicting key dynamics in this managerial problem, this paper sheds light on how to make decision for optimal pricing and warranty when the product life cycle is finite and the company is obliged to provide after-sales services to customers for an extended period of time after the current product is no longer produced.

Keywords: EOL (end of life) services; Warranty; Manufacturing strategy

1. Introduction

As the competition intensifies in the global market, the product life cycle gets shortened fast and firms try to introduce new products more frequently as one of their key strategic responses. In addition, as the customers become more concerned about the product's entire life cycle rather than only the time when they purchase the product, e.g., whether and how to replace and/or recycle failed parts of the product throughout its total life, firms are offering more extensive warranty to customers in order to increase sales. For instance, by offering an

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extensive warranty for its cars, Hyundai Motor was able to change consumers' perception so that the market started to believe the company's quality has improved to match the very best in the industry (Business Week, 2004).

Consider a cellular phone manufacturer. This company manufactures and sells a series of cellular phones, each of which has a relatively short life cycle. The company considers developing a new model, NM-1. It estimates NM-1's life cycle will be T. That is, after T, the company will stop selling the model. NM-1 consists of multiple parts, one of which is the company's proprietary microprocessor, mp-1: all the other parts except for mp-1 can be found in the market, if spare parts are needed. That is, the company must produce mp-1 and guarantee providing it to customers for a certain period of time, i.e., the warranty period, τ: During the warranty period, the company must have mp-1 in stock so as to meet the demand for the microprocessor. Therefore, when a customer considers buying NM-1, she probably takes into account the length of the warranty period, during which she can get her cellular phone repaired when the key microprocessor breaks down. In effect, the warranty length can affect the customer's buying decision.

Consider a realistic context, when $T > \tau$ and a customer bought the product at t_u so that $t_u < T - \tau$. If the company services the product only for τ period after the customer bought the product, i.e., $t_u \leqslant t \leqslant t_u + \tau$, it might happen that the product cannot be serviced if it breaks down at t_r such that $t_u + \tau < t_r < T$, even though the company still sells the product until T. From the customer's point of view, this policy does not look appealing. Therefore, it is more reasonable to assume that if the product's life cycle, T, is relatively short, the warranty period, τ, should mean that, the company will service the customer with the key part until $T + \tau$. That is, the company guarantees availability of the key part for τ after it discontinues producing the current product at T. In effect, the company guarantees after-sales services without time limitation as long as the product is being sold in the market and also offers 'EOL (end of life)' services for τ period after the current product is discontinued. In this paper, we call this kind of arrangement 'EOL warranty': it seems realistic and reasonable, in particular when the product's life cycle is relatively short.

Now the company has to make decision on several variables. What should be the optimal warranty period? How much should the company charge for the product? How many spare parts should the company produce during the product's life cycle and also during the EOL warranty period, if any? These decisions are interrelated with each other, and the company has to take into account many factors when trying to find an optimal solution.

This paper is structured as follows. In the next section, we review relevant literature to put our research questions in a broader theoretical context. In Section 3, we develop a two-stage optimal control theory model in detail and put forth key theorems. Section 4 focuses on numerical analysis to visualize theoretical results from the optimal control theory model so as to derive managerial implications, which are fully elaborated in the concluding section.

2. Literature

In this paper, we are investigating the role of EOL (end of life) services in enhancing sales and pricing optimally. In the literature, researchers have long been suggesting the signaling role of warranty. In order to investigate the use of producer liability (warranty) as a policy instrument to improve market performance, Spence (1977) employed a simple model, which consisted of consumer's income level, product's failure rate, consumer's perception about the product failure rate, warranty level (liability), and consumer's utility function. The research showed that the warranty level has a positive signaling effect on the product's quality in the market. On the contrary, Gal-Or (1989) demonstrated through an example that in oligopolistic markets, it is only in special cases that warranties can serve as signals of quality. That is, warranties are perfect signals only in cases, where the intrinsic attributes of products are neither too clustered nor too widely spaced. Balachander (2001) employed a model similar with Gal-Or (1989)'s, but tried to explain the warranty effect by distinguishing market entrants from incumbents: he inferred that an entrant may offer an extended warranty longer than the level the customers are willing to pay for, and by doing so, it can distinguish itself from other entrants that have lower reliability. He further reasoned that since it is costly for a less reliable entrant to offer a longer warranty, offering an extended warranty itself can send a credible signal of quality, which is consistent with the signaling hypothesis in the literature.