경영학석사학위논문

Optimal Pricing with Return Policy under Valuation Uncertainty

가치 불확실성하의 환불 정책이 미치는 영향에 대한 가격이론연구

2015년 2월

서울대학교 대학원

경영학과 경영학 전공

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김종엽의 석사학위논문을 인준함

2014년 12월

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Abstract

Optimal Pricing with Return Policy under Valuation Uncertainty

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In this paper, I exhibit optimal pricing and refund rate to heterogeneous consumers with valuation uncertainties. I prove that when return policy does not exist, price of products will decrease, whereas when return policy does exist will increase. In the case of consumers, they will consume under valuation uncertainty, and will determine whether they will return the product after considering the valuation before a purchase and the product fit after a purchase. This paper shows through modelling the changes of optimal price and optimal refund rate depending on return policy and consumer heterogeneity.

I first show that when consumers are homogeneous, optimal price with no return policy is equal to θ, which is equal to ex ante consumer valuation or consumer type that is privately known by the consumer before the purchase. On the other hand, when there exists a return policy, the optimal price is higher than when there is no return policy. I then consider the case when consumers are heterogeneous. The model exhibits that the optimal price under return policy is higher than no return policy, which shows similar results as the homogeneous consumer case. In addition, my research shows that offering return policy is more efficient when consumers are heterogeneous. Return policy can serve as an effective and profitable operational tool that helps realize ex post efficiency for the firm with heterogeneous consumers. In particular, the refund amount can be an important strategic decision. The model shows that the optimal refund rate is 85% of the price. Compared to no return policy, when refund rate is 85%, optimal price increased by 17%, demand decreased by 30.6% and seller's profit increased by 33.3%. Furthermore, this paper will demonstrate the changes of price, demand and profit in regard to changes of refund rate.

Keywords: Optimal Pricing, Valuation Uncertainty, Return policy, Strategic Consumer Behavior, Consumer Heterogeneity

Student Number: 2013-20469

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1. Introduction

One way of looking at marketing is to understand, predict and influence the interaction between the firm and the customer. Specifically, marketers face many interrelated decisions among them. To solve these marketing problems, quantitative marketing tends to rely heavily upon economics, along with psychology and sociology. Economics in particular, encompasses these marketing decisions which involve strategic interactions. On the demand side, individual consumers consider how much and which brands to purchase. On the other hand, the supply side decides which products at what price to offer. For instance, consumers may care about whether a product has received favorable reviews, and the price change of the product. Firms also must consider the strategic reactions of the other players.

I study strategic interactions under return policy with consumer valuation uncertainty. In this paper, consumers have ex ante private information about the distribution of their valuations before purchasing the product. After purchasing the product, consumers will learn their ex post valuations individually. Consider the purchase of shoes. Consumers typically do not know their exact value for the shoes until they receive the product after the purchase. After the purchase they will realize their complete valuations for the shoes. In this paper, I set two key factors for these consumers. First, consumers are heterogeneous. As mentioned above, consumers differ in their value of the product. I assume that there are different types of consumers with various tastes. For example, in the market brand loyal consumers typically value a specific brand more highly than the other regular consumers. The second assumption is valuation uncertainty. Consumers are ex ante uncertain about their value and they do not know the exact value of the product when they purchase the product. These two assumptions ensure that my model represents the real market more precisely.

From the firm's perspective, when there is no return policy a firm only considers ex ante valuation for consumers and charges the price. However when there exists a return policy, the firm has to consider the expected value of consumers to set an optimal price. Therefore, it is crucial for the firm to design a return policy to sell to such heterogeneous consumers with uncertain valuations. By allowing a return policy, it enables consumers to make flexible choices by reducing the cost of bad decisions providing insurance to relieve their concern about valuation uncertainty. Furthermore, the return policy provides more advantages than disadvantages from the management perspective. The return policy reduces risk for the consumer and encourages the consumer to make purchases which leads to an increase of the firm's sales. Moreover, return policies reduce consumer dissatisfaction to improve the firm's image and reliability. As a result, these return policies vary across industries and services. The value of products that U.S. consumers return to retailers exceeds $100 billion each year (Su 2009). Thus, many firms are endeavoring to maximize their expected payoff by offering a return policy. When there exists a return policy, consumers consider the refund when they are purchasing the product. In this situation, as the refund increases, the consumers' willingness to pay also increases and this induces the firm to charge a higher price than with no return policy. However when the price is too high consumer demand decreases and this would negatively affect the firm's profit. Therefore, setting an optimal value for refunds is the critical factor to maintain their profits.

In this paper, I predict that when return policy does not exist, price of products will decrease, whereas when return policy does exist the price will increase. In the case of consumers, they will consume under valuation uncertainty and will determine whether they will return the product after considering the value before a purchase and the product fit after a purchase. This paper will prove through modelling the changes of optimal price and optimal refund rate depending on return policy and consumer heterogeneity. In the first model, I demonstrate the model of two type consumer case and in the second model I show the model of continuous type consumer case. From the continuous type model, I found that the optimal refund rate is 85% of the price. Compared to no return policy, when refund rate is 85%, optimal price increased by 17%, demand decreased by 30.6% and seller's profit increased by 33.3%. Furthermore, this paper will demonstrate the changes of price, demand and profit in regard to changes of refund rate.

Section 2 provides a general introduction and summary to literatures of return policy. In Section 3 I show the pricing model of two type consumer case with and without return policy. Section 4 examines the models of continuous consumer case. Section 5 concludes and discusses the limitation of this paper.

2. Literature Review

This paper is related to two streams of the research. The first stream is on various aspects associated with consumer return policy. The second is on valuation uncertainty on marketing literatures. I briefly review both streams in turn.

There exists a considerable amount of literature on the topic of consumer product returns. Pasternack (1985) first considered return policy under the single period inventory problem which is known as the newsvendor model. He asserts that return policy would affect positively on supply chain and increase retailer's expected profit. Padmanabhan and Png (1997) focuses on the strategic effect of return policy on retail competition. They show implication for manufacturers that when retailing is competitive and there is less uncertainty in demand, a return policy leads retailers to compete more intensely. There are other papers analyzing the insurance effect of product warranties which have a similar function with product returns. Moorthy and Srinivasan (1995) is a classical paper that demonstrates the product warranty model. They show how product warranty acts as signal of product quality. Day and Fox (1985) and Padmanabhan and Rao (1993) also give an analytical model on manufacturer warranty policy.

Unlike the papers mentioned above, which focus on retailer to manufacturer returns, several other papers examine the effects of consumer returns. My paper is more closely related to research on design of consumer return policy in various contexts. Che (1996) studies consumer return policy on experience goods. He assumes risk aversion consumers in his model and demonstrates that risk aversion is a critical factor for sellers in adopting return policy. In the marketing context, Davis et al. (1995) consider the probabilities of mismatching the product to consumers, which is also concerned in this paper. I consider consumer's taste or fit that is revealed to him only after the purchase. Hess et al. (1996) find that retailers can control inappropriate returns in a profitable way by imposing nonrefundable charges. Davis et al. (1998) employ a theoretical model that helps to show the impact of return policy and hassle cost. Chu et al. (1998) present an analysis of three refund policies “no question asked”, “no refunds” and “verifiable problems only” and show that “no questions asked” is the most efficient way to handle consumer opportunism.

A series of recent papers such as Shulman et al. (2010) and Anderson et al. (2009) consider consumer heterogeneity as in this paper. Shulman et al. (2010) exhibit the model of heterogeneous consumers who are completely uninformed about their preferences on the products before a purchase. In my research, I show consumer heterogeneity in two ways. The first model is the two type consumer case model which assumes that there are two types of consumers in the market: a high valuation type and a low valuation type. The second model is the continuous type consumer case which shows consumer heterogeneity more clearly. Anderson et al. (2009) not only demonstrate the behavior of heterogeneous consumers under return policy theoretically but also analyze the option value of return policy empirically.

Along with marketing researchers, operations researchers have also contributed to research on consumer return policy. Specifically, operation researchers focused on return policy considering supply chain management. Akan et al. (2009) assert that the manufacturer can design appropriate return policy when consumers observe their true valuations over time. Ketzenberg and Zuidwijk (2009) assume that single selling season is split into two periods; when to recover product returns and when to resell respectively. In my paper I also divided selling season into two different periods. However, I did not consider reselling strategy for the firm or salvage value. Alexandrov and Larviere (2012) consider reservation which has a similar function with return policy in some aspect. They focus on capacity constrained services such as restaurants.

The second stream that my research is related to is consumers' valuation uncertainty. Courty and Li (2000) demonstrate consumers' valuation uncertainty in sequential screening problems. Since the firms are unable to observe consumers' private valuations before their purchases, the firms face sequential screening problems. In Courty and Li (2000), they show why it is the optimal strategy for firms to offer return policy for sequential screening. Dana (1998) discusses more on valuation uncertainty and contends that price taking firms may offer advance-purchase discounts. Xie and Shugan (2001) demonstrate consumer valuation uncertainty specifically on the firms' advance selling. Liu and Xiao (2008) consider the valuation uncertainty and capacity constraint in their model and compare three forms of selling policies. They conclude that the firm is worse off by reducing consumer valuation uncertainty under the optimal return policy. Su (2009) shows the impact of full return policy and partial return policy on supply chain management. Su (2009) examines the situation in which consumers face uncertainty in their valuation for products and propose several alternatives that can support the supply chain under consumer return policy. My research is closely related to Liu and Xiao (2008) and Su (2009). However, there are several critical differences. Most importantly, Su (2009) considered only homogeneous consumers and Liu and Xiao (2008) considered only two type consumers. In my paper, I considered not only two valuation type consumers but also continuous type consumers that are closer to real market situations. I also develop a benchmark setting in which there are only homogeneous consumers and no return policy. This benchmark model would help understand the effect of a return policy intuitively. In addition, from the monopolistic firm side, I found the optimal price and refund rate to maximize the firm's profit. I then demonstrate the changes of price, demand and profit in regard to changes of the firm's refund policy.

3. Model I: Two Type Case

3.1 Decision Framework

In this section I demonstrate the model of two type consumer case. The model proposed in this paper is based on several assumptions. The first assumption is that a monopolist makes one product of equal quality with no capacity constraints. A monopolistic risk neutral firm intends to sell products of equal quality to consumers with uncertain valuations. The firm sets the price of the product p and the refund r to be paid if consumers choose to return the product. That is, due to uncertain valuations, consumers who find that the price they paid for the product exceeds their valuations for the product then they can return the product for refund r, with $0 < r \leq p$. The firm's objective is to decide the optimal price and refund to maximize the expected profit collected during the sale.

It is common that consumers buy a product despite uncertainty before realizing the exact value of the product. In this market, each consumer purchases one unit of the product, and shows heterogeneous valuations of the product by $V = \theta + \varepsilon$. Let θ represent the consumer valuation type that is only known by the consumer before purchasing the product. Let ε denote the consumer taste or fit that is revealed to him only after the purchase. In other words, the consumer does not fully know whether the product matches his taste and needs before experiencing it. To put it together, I state consumer's valuation as $V = \theta + \varepsilon$, where ε does not need to be considered when there is no return policy. That is, when the firm offers the refund, consumers consider returning the product after observing the consumer's realized valuation V. This notion of consumer valuation coincides with Su (2009), Anderson et al. (2009), and Liu and Xiao (2008). In my basic framework, with this notion of consumer valuation I model the changes of optimal price and optimal refund rate depending on return policy assuming uniform distribution. In this paper, consumers are heterogeneous in their consumer type θ as well as in their consumer taste ε. In my first model, to provide the simple basis for heterogeneity, I assume that there are two types of consumers: a high valuation type with θ, and a low valuation type with θ_L, where $0 < \theta_L < \theta$. Suppose that the proportion of high valuation consumer type is α and the proportion of low valuation consumer type is $1 - \alpha$ among the population. Consumers within each type are homogeneous in the first model. In section 4, I show continuous type consumers who have heterogeneity valuations in each. I assume that ε is identically and independently uniform distributed on $[-\theta, \theta]$. I use $G(\cdot)$ to denote the cumulative distributions of ε with density function $g(\cdot)$.

In my two period model, consumers have to decide whether to buy or not considering only their consumer valuation in the first period. In this period the firm offers return or no return policy to all consumers. The consumers would make their decision based on their utility which is defined as their total valuation of the product V minus the price p. Thus, the consumers would buy the product if and only if $V - p \geq 0$. When $V - p < 0$, consumers may find that the product is less desirable for themselves and will not purchase the product. In the second period, consumers will choose to keep or return the product. If a consumer buys a product at price p in the first period and learns that the product is a perfect fit for him in the second period, then the consumer will keep the product and his valuation is higher than the refund, $V = \theta + \varepsilon \geq r$. As mentioned before, after observing their realized valuation, consumers' strategies could be either keeping or returning the product. Not only do the firms seek to maximize their profits but also the consumers seek to maximize their expected surplus. In this model, specifically under return policy the consumer will purchase a product if and only if $Emax\,(V = \theta + \varepsilon, r) \geq p$. Thus, I can say that the consumers' expected utility will be $Emax\,(V = \theta + \varepsilon, r)$ and consumers will make decisions that will maximize their expected utility. Based on these assumptions, I now develop a model to determine an optimal price P^* and optimal refund r^* for the firm to maximize their expected payoff.

3.2 Pricing with Return Policy: Two Type Case

It is useful to understand the effect of a return policy in a simple setting before proceeding to a more general analysis. I develop a benchmark setting in which there exists only homogeneous consumers. In this benchmark scenario and all the more general scenarios, I go through the following steps. I first analyze when the firm does not offer return policy then I compare a no return policy scenario with a return policy scenario. In this paper, I compare the two cases in terms of monopolistic firm's profit and price.

First, I consider the outcome when consumers are homogeneous. Each consumer has the same valuation of $V = \theta + \varepsilon$. If the firm sets a product price p but does not accept returns, consumers purchase the product when $V = \theta + \varepsilon \geq p$. Thus expected profit of the firm is $\pi_{NR} = p(\bar{G}(p - \theta))$ and optimization problem can be written as

$$\pi_{NR} = p(\bar{G}(p - \theta)) \quad (1)$$

$$s.t.\ Emax\ (\theta + \varepsilon, 0)\ \geq p$$

In Equation (1), the constraint ensures the consumers' participation in purchasing the product. Recall that after all the consumers purchase the product, they privately observe their own realized valuations. Consumers prefer to buy the product if their expected surplus $Emax\ (\theta + \varepsilon, 0)$ is higher than the price of the product. Thus, the probability that a consumer purchases the product is $\bar{G}(p - \theta)$, where $G(\cdot)$ is the cumulative distribution of ε. The firm sets their price p and this leads to the firm's expected profit of selling to a consumer, which is $p\left(\bar{G}(p - \theta)\right)$. This explains Equation (1).

Given these consumers' strategies, I solve for the firm's optimal price below and present the summary in Proposition 1. As a consumer purchases the product when expected value is $Emax\ (\theta + \varepsilon, 0)\ \geq p$, the highest price that the firm can offer is $Emax\ (\theta + \varepsilon, 0)$ and the firm can set this value as an optimal price when there is no return policy.

$$P^*_{NR} = Emax\ (\theta + \varepsilon, 0) \tag{2}$$

Now consider the case where the firm sets a price p, and gives the consumer a refund r. As mentioned above, when there exists return policy, if a consumer has purchased a product and has figured out that the product is not a good fit for him, the only decision he can make is to return the product. That is, a consumer keeps the product when valuation $\theta + \varepsilon \geq r$ whereas a consumer with valuations $\theta + \varepsilon < r$ will return it. Now let me return to the first period and decide whether a consumer is willing to buy the product. When return policy exists, a consumer purchases the product if and only if $Emax\ (\theta + \varepsilon, r)\ \geq p$. Thus, similar to no return policy, the optimal price that firm can offer is

$$P^*_{R} = Emax\ (\theta + \varepsilon, r) \tag{3}$$

From comparing Equation (2) and (3) I can observe that when consumers are homogeneous, optimal price with return policy is higher than without return policy.

Proposition 1. When consumers are homogeneous, optimal price with return policy is higher than with no return policy.

Proof. See the Appendix

This proposition reveals that it is the optimal scheme for the monopolistic firm to raise their price when they are selling under return policy. By calculation of Equation (1), I can easily see that optimal price with no return policy is

$$P_{NR}^{*} = Emax(\theta + \varepsilon, 0) = \int_{-\theta}^{\theta}(\theta + \varepsilon)g(\varepsilon)d\varepsilon = \frac{1}{2\theta}\left[\varepsilon\theta + \frac{1}{2}\varepsilon^{2}\right]_{-\theta}^{\theta} = \theta \qquad (4)$$

This shows that optimal price with no return policy is equal to θ, which is equal to ex ante consumer valuation or consumer type that is privately known by the consumer before the purchase. On the other hand, when there exists return policy, if the firm gives refund r to induce consumers to buy, the highest price that the firm can charge is

$$P_{R}^{*} = Emax(\theta + \varepsilon, r) = rG(r - \theta) + \int_{r-\theta}^{\theta}(\theta + \varepsilon)g(\varepsilon)d\varepsilon = \theta + \frac{r^{2}}{4\theta} \qquad (5)$$

The one implication that Proposition 1 demonstrates is that when there exists return policy, consumers consider the refund r when they are purchasing the product. In this situation as refund r increases the consumers' willingness to pay also increases and this induces the firm to charge a higher price than no return policy. π_R represents the firm's profit over the two periods with return policy. The firm's objective is to determine decisions for price p and refund r so that profit is maximized. This is the profit function

$$\pi_R = p\left(\bar{G}(r-\theta)\right) + (p-r)G(r-\theta) \tag{6}$$

$$s.t.\ p = Emax\ (\theta + \varepsilon, r)$$

The constraint implies that the highest price that a firm could charge is $p = Emax\ (\theta + \varepsilon, r)$. This gives participation constraint for consumers to purchase the product. In Equation (6), similar to Equation (1) shows that the consumers with realized valuations greater than r will keep the product while those with realized valuations below r will return it. Therefore, the probability that a consumer returns is $G(r-\theta)$. I can also see that each unit that is sold and kept by the consumer yields revenue p and each returned unit yields $p - r$ from the consumer. The most interesting part of this equation is the amount of optimal refund.

Proposition 2. When consumers are homogeneous, no return policy is more efficient than with return policy.

Proof. See the Appendix

From solving Equation (6), the firm's optimal strategy is setting optimal refund as $r^* = 0$, which means no return policy is more effective than with return policy under homogeneous consumers. Other papers also exhibit the same results as my model. Su (2009) and Liu and Xiao (2008) provide similar implications. First, Su considers the salvage value s. From this model he proves that when consumers are homogeneous, there exists only one type of consumer in his model, thus it is the optimal strategy for sellers to choose $r^* = s$. His model shows that consumers with valuation above the salvage value keep the product, whereas those with lower valuations return it to the seller to be salvaged at s. In this paper, I did not concern the salvage value of the product which means that $s = 0$. Thus, the meaning of Proposition 2 has the same meaning as Su (2009). My model is more similar to that of Liu and Xiao (2008). Liu and Xiao assume that there is no salvage value in their model. They also make mention of Su's model and conclude that despite other modeling differences, they arrive at the same conclusion that the firm should not allow any returns if it faces or intends to serve homogeneous consumers. This conclusion also leads to Proposition 2 in this paper. Proposition 2 implies that the firm never finds it optimal to induce the homogeneous consumers to return the product for the refund. This is because the returns are an inefficient tool for firms to extract consumers' surplus. Furthermore, this surplus from consumers is insufficient for the firm to regain their profit. Thus, in a homogeneous consumer case the firm intends to minimize the loss by not allowing return policy to consumers.

I now consider two type consumer model. As mentioned above, I assume there are two types of consumers: a high valuation type with θ, and a low valuation type with θ_L, where $0 < \theta_L < \theta$. Suppose that the proportion of high valuation consumer type is α and the proportion of low valuation consumer type is $1-\alpha$ among the population. Consumers within each type are homogeneous in the first model. The firm should serve both valuation types of consumers. It is obvious that high valuation type consumers intend to pay a higher price than low type valuation consumers. However, if the firm charges a high price, low type valuation consumers may not purchase the product. Therefore, the firm should set the optimal price at low type consumers to sell their products to both types. Analysis will follow the same steps as the homogeneous consumer case. If the firm sets a product price p but does not accept returns, both types of consumers purchase the product when expected value is $Emax\,(\theta_L+\varepsilon,0)\ \geq p$, hence the highest price that the firm can offer is $Emax\,(\theta_L+\varepsilon,0)$ and it can set this value as an optimal price when there is no return policy. Therefore, optimal price without return policy under two type consumer is

$$p^*_{NR2} = Emax(\theta_L+\varepsilon,0) = \frac{1}{4\theta}(\theta+\theta_L)^2 \qquad (7)$$

Obviously, optimal price without return policy under two type consumer is different from the homogeneous consumer case. However, in Proposition 3 two type consumer case also shows a similar result with the homogeneous consumer case. Now consider the case where the firm sets a price p, and gives the consumer a refund r. The optimal price that the firm can offer is

$$p_{R2}^{*} = Emax\,(\theta_L + \varepsilon, r) \tag{8}$$

Recall from Proposition 1 that if the firm faces or intends to serve homogeneous consumers with ex ante uncertain valuations, its optimal strategy is simply to charge the price equal to θ. Thus, the consumer's uncertainty has no impact on the firm's pricing strategy. However, this implication no longer holds when the firm offers return policies to serve two valuation type consumers. I use Equation (8) as constraint to the firm's profit function to find optimal refund.

$$\pi_{Rh2} = \alpha[p\bar{G}(r - \theta_L) + (p - r)G(r - \theta_L) + (1 - \alpha)[p\bar{G}(r - \theta) + (p - r)G(r - \theta) \tag{9}$$

$$s.t.\;\; Emax\,(\theta_L + \varepsilon, r) \geq p$$

In this Equation (9) the first term is the profit of high valuation type consumers and the second term is the profit of low valuation type consumers. To put it together π_{Rh2} represents the firm's expected payoff from two valuation type consumers. The constraint guarantees that both types are willing to purchase the product. Furthermore, even if the firm is unable to know the exact type of consumers or inspect the consumers' uncertainty, it can design the appropriate return policy that maximizes their profit. From calculation of Equation (9), exact value of optimal refund under two valuation type consumer can easily be shown.

Proposition 3. When consumers are heterogeneous (two type consumers), return policy is more efficient than with no return policy.

$$Optimal\ refund\ r^{*} = (\theta - \theta_L)(1 - \alpha) \tag{10}$$

Proof. See the Appendix

This analysis suggests that return policy plays a crucial role for firms to maximize their profit under heterogeneous consumers. Return policy can serve as an effective and profitable operational tool that help realize ex post efficiency for the firm. In particular, the refund amount can be an important strategic decision. From Proposition 3, I see that the optimal return policy is to offer partial refund $r^{*} = (\theta - \theta_L)(1 - \alpha)$ to consumers rather than to offer no refund or full refund. This result identifies an intrinsic rationale for many firms that offer partial refund to heterogeneous consumers in the real market.

Using optimal refund r^{*}, I compare the optimal price without return policy and with return policy. Putting r^* to Equation (8) I easily get the optimal price with return policy.

$$p^*_{Rh2} = Emax\ (\ \theta_L + \varepsilon, (1-\alpha)(\theta - \ \theta_L)) \tag{11}$$

This leads to proposition 4.

Proposition 4. When consumers are heterogeneous (two type consumers), optimal price with return policy is higher than with no return policy.

Proof. See the Appendix

$$P^*_{R2} - P^*_{NR2} = \frac{(1-\alpha)(\theta - \ \theta_L)^2(3-\alpha)}{4\theta} \geq 0$$

Similar to Proposition 1, I can see that the firm chooses a higher price when return policy exists. Proposition 4 identifies that with return policy, to maintain their expected profit, the firm should increase the price to reduce the negative effect of consumers' return as in the case of giving refunds to consumers. Collectively, with return policy the monopolistic firm decides to offer partial refund and higher price to maximize their expected payoff. In section 4, similar results are shown under continuous consumer type case.

4. Model II: Continuous Type Case

4.1 Decision Framework

In section 4, I show the model of continuous consumer type case. This model also follows some of the same assumptions as the two type case model. The monopolists make one product of equal quality with no capacity constraints. Monopolistic risk neutral firm intends to sell products of equal quality to consumers with uncertain valuations. The firm sets the price of the product p and the refund r to be paid if consumers choose to return the product. That is, due to uncertain valuations, consumers who find that the price they paid for the product exceeds their valuations for the product, they can return the product for refund r, with $0 < r \leq p$. The firm's objective is to decide the optimal price and refund to maximize the expected profit collected during the sale.

However, the second model has a crucial difference in consumer valuations. In this model consumer i's valuation is composed of two parts, $V_i = \theta_i + \varepsilon_i$, where θ_i is ex ante privately observed by consumer i and ε_i will be realized after purchasing the product. As notified in the previous section, θ_i can be interpreted as consumer i's ex ante type that is privately known by the consumer before purchasing. For ε_i, which represents consumers' product taste or fit, is fully known after consumers buy and consume it. These information about consumers' valuation is never known to both firms and consumers until the consumer buys the product. Valuations are independent across different consumers. In this section in order to demonstrate continuous case, I assume that θ_i and ε_i are independently uniform distributed on [0, 1]. Given the independence between θ_i and ε_i, I use $F(\cdot)$ and $G(\cdot)$ to denote the prior distributions of θ_i and ε_i respectively, and use $f(\cdot)$ and $g(\cdot)$ to denote the corresponding density functions.

The second model also works in two periods. In this period the consumers would make their decision based on their utility which is defined as their utility V_i minus the price. The consumers would buy the product if and only if $V_i - p \geq 0$. In the second period, the consumer will choose to keep or return the product. The consumer will keep the product and when his valuation is higher than the refund and vice versa. Since the assumption in this section is very similar to that of the previous model, the model assumption and decision framework in this section are mentioned rather briefly.

4.2 Pricing with Return Policy: Continuous Type Case

I follow similar steps as section 3. I first analyze when the firm does not provide return policy. If the firm sets a product price p but does not accept returns, consumers purchase the product when $V_i = \theta_i + \varepsilon_i \geq p$. Then the firm provides a return policy with refund r. In this paper, I compare the two different policies in terms of firm's price and expected payoff.

In no return policy, consumers purchase the product when expected value is $Emax(V_i = \theta_i + \varepsilon_i, 0) \geq p$, thus optimal price that the firm can offer is

$$p^*_{NRC} = Emax\ (V_i, 0) = \int_0^2 V_i g(V) dV = 1 \tag{12}$$

Next, I consider the case where the firm sets a price p, and gives the consumer a refund r. Since the firm allows return policy, if the consumer keeps the product when valuation is $\theta_i + \varepsilon_i \geq r$ whereas those with valuations $\theta_i + \varepsilon_i < r$ will return it. The optimal price that the firm can offer is

$$p^*_{RC} = Emax\ (V_i, r) = rG(r) + \int_r^2 V_i g(V) dV \tag{13}$$

Proposition 5. When consumers are heterogeneous (continuous type consumers), optimal price with return policy is higher than with no return policy.

Proof. See the Appendix

This clearly reveals that when return policy does not exist, price of products will decrease, whereas when return policy does exist the price will increase. This result coincides with previous propositions; Proposition 1 and Proposition 4. Proposition 5 identifies a similar implication with previous sections. Despite differences in some assumptions, I arrive at the same conclusion that the price with return policy is higher than price with no return policy under consumer heterogeneity.

Recall from Proposition Equation (9), I use Equation (13) as constraint to the firm's profit function to find firm's optimal price and optimal refund to maximize expected payoff. The firm's profit function is

$$\pi_{RC} = p\,\overline{G}\,(r) + \,(p - r)\,G(r) \tag{14}$$

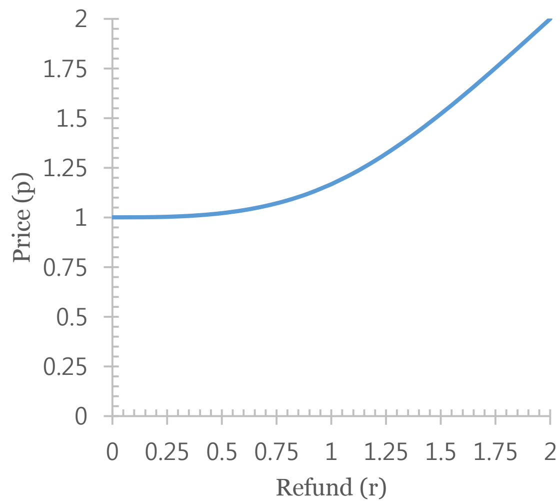
$$s.t.\;\; Emax(V_i, r) \geq p$$

In Equation (14), $G(r)$ represents the probability of return. As mentioned several times, the firm's objective is to decide the optimal price and refund to maximize the expected profit collected during the sale. From calculation of Equation (14), it is distinct to find out the firm's optimal price and relationship between price and refund.

Proposition 6. When consumers are heterogeneous (continuous type consumers), optimal price with return policy is

$$P^*(r) = \begin{cases} \frac{1}{6}r^3 + 1 & if\ 0 < r \le 1 \\ \frac{-r^3+6r^2-6r+8}{6} & if\ 1 \le r < 2 \end{cases} \quad (15)$$

Proof. See the Appendix



[Figure 1: Relationship between Refund & Price]

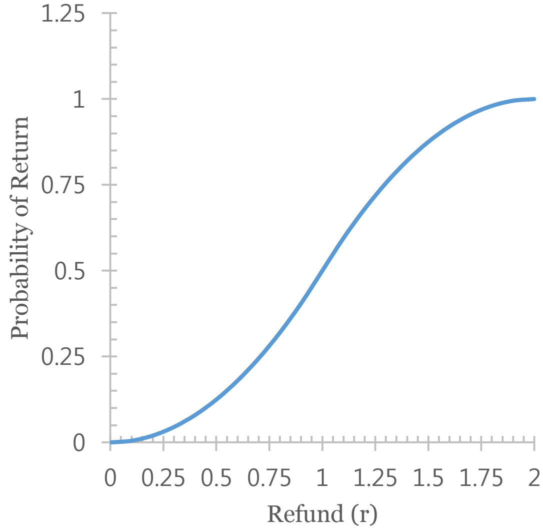
The relationship of refund and optimal price is shown graphically in Figure 1. The graph reveals that when there is no return policy (r = 0), the optimal price will be 1. In addition, when refund is 1, then the optimal price for the product should be 1.167. Figure 1 illustrates and proves the result of Proposition 5 that the optimal price of return policy is higher than the optimal price of no return policy.

My interpretation is that the firm tends to raise their optimal price to maximize their profit when they offer return policy. In this graph the firm offers higher price when the refund is high. This is obvious because when refund is high it is difficult for firms to maintain their profit. It is the firm who determines the refund rate. Thus offering proper return policy to consumers can serve as an effective tool that helps to gain expected payoff for the firm. Following demand function and probability of return function will show better understanding process of the firm's strategic decisions. Equation (14) also exhibits the function of probability of return and demand function.

Proposition 7. When consumers are heterogeneous (continuous type consumers), probability of return with return policy is

$$POR(r) = \begin{cases} \frac{r^2}{2} & if\ 0 < r \leq 1 \\ 1 - \frac{(2-r)^2}{2} & if\ 1 \leq r < 2 \end{cases} \tag{16}$$

Proof. See the Appendix



[Figure 2: Relationship between Refund & Probability of Return]

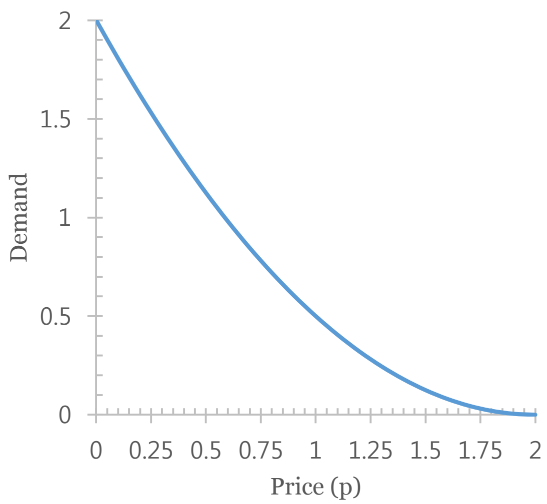
The relationship of refund and probability of return is shown graphically in Figure 2. In this graph, I observe that consumers' probability of return increases as amount of refund increases. When there is no return policy (r = 0), it is obvious that probability of return is 0%. As the firm offers return policy, for example when refund is 1, probability of return increases to 50%. This graph also shows that if there is full refund, probability of return would be 100%. That is, the consumer desire to return the product if there is full refund.

I have shown that a firm's choice of return policy affects the firm's decisions about the price of the product. On the other hand, firm's decision of return policy also affects consumers' purchasing and returning decisions. Specifically, a high refund gives the consumers an option to return the product more frequently in the market. Thus, it is crucial for firm to design proper return scheme to balance price and demand to maximize their profits.

Proposition 8. When consumers are heterogeneous (continuous type consumers), demand function with return policy is

$$D(p) = \frac{(2-p)^2}{2} \tag{17}$$

Proof. See the Appendix



[Figure 3: Demand Function]

The consumer demand is shown graphically in Figure 3. Figure 3 demonstrates how changing the price level affects the demand. Demand is convex in price as usual, which is intuitive. The graph reveals that when there is no return policy (r = 0), the consumer demand will be 0.5. When refund is 1, then the consumer demand is 0.347. The attractiveness of return policy depends on the demand uncertainty. If the firm has a good prediction about the amount consumers will be willing to pay for the product and how many consumers will arrive at the market, a high refund is attractive to the firm. However in the real market it is impossible to find out the exact value of consumers' willingness to pay. Thus high refund is usually unattractive for the firm due to its price raising effect because it leads to decrease in demand in the market.

Variable	Refund=0	Refund=1
Price	1	1.167
Demand	0.5	0.347
POR	0	0.5
Profit	0.5	0.67

[Figure 4: Summary Table]

The table provides general results, price, demand, probability of return and the monopolistic firm's profit. Specifically, when there is no return policy (r = 0), the firm's profit will be 0.5. In addition, when refund is 1, then the firm's profit for the product should be 0.667.

Collectively, from this continuous type model, I found that the optimal refund rate is 85% of the price. Compared to no return policy, when refund rate is 85%, optimal price increased by 17%, demand decreased by 30.6% and seller's profit increased by 33.3%. Thus, this model demonstrates that offering partial return policy is superior to offering no return or full return policy. Which suggests that when the refund rate is set properly, the return policy can act as a critical tool for the monopolistic firm to gain its expected payoff.

5. Conclusion

Return policies are an effective way to reduce consumer dissatisfaction by returning the cost of purchase to consumers. Return policies have a positive and negative effect on both consumers and firms. For consumers, it is the most effective method to resolve any dissatisfaction and consumer problems to play a positive role in consumer welfare. For firms, although it may increase costs of inventory and cost of reselling, by setting an optimal refund rate, the firm can maximize its profits.

In this paper, I characterize the optimal return policy to heterogeneous consumers with valuation uncertainties. I proved that when return policy does not exist, price of products will decrease, whereas when return policy does exist will increase. In the case of consumers, they will consume under valuation uncertainty, and will determine whether they will return the product after considering the deterministic value before a purchase and the product fit after a purchase. This paper shows through modelling the changes of optimal price and optimal refund rate depending on return policy and consumer heterogeneity.

The model demonstrates that when consumers are homogeneous, optimal price with no return policy is equal to θ, which is equal to ex ante consumer valuation or consumer type valuation that is privately known by the consumer before the purchase. On the other hand, when there exists a return policy, the optimal price is higher than when there is no return policy. The model shows that no return policy is more efficient when consumers are homogeneous. This is because the returns are an inefficient tool for firms to extract consumers' surplus and this surplus is insufficient for the firm to regain their profit. Thus, in the homogeneous consumer case the firm intends to minimize the loss by not allowing return policy to consumers.

I then consider the case when consumers are heterogeneous. The model exhibits that the optimal price under return policy is higher than no return policy, which shows similar results as the homogeneous consumer case. However, my research shows that offering return policy is more efficient when consumers are heterogeneous. Return policy can serve as an effective and profitable operational tool that helps realize ex post efficiency for the firm with heterogeneous consumers. In particular, the refund amount can be an important strategic decision. The model shows that the optimal refund rate is 85% of the price. Compared to no return policy, when refund rate is 85%, optimal price increased by 17%, demand decreased by 30.6% and seller's profit increased by 33.3%.

My analysis certainly has its limitations. For example, in my model I only demonstrate an analysis on a monopolistic firm assumption. However, in the real market, full or partial return policy may work in a more competitive environment. Therefore, in future research perhaps it would be interesting to consider competition between the firms. It would be meaningful to research on the understanding of the strategic role of return policy under oligopoly competition. In addition, risk aversion consumers must be incorporated in the future research. In this paper, the model only assumes that all consumers are risk neutral. The work of Che (1996) provides theoretical basis for this extension. Comparing optimal pricing strategy and refund rate under risk aversion to my model would enrich the research on consumer return policies and valuation uncertainty.

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Appendix

Proof of Proposition 1.

As a consumer purchases the product when expected value $Emax\,(\theta+\varepsilon,0)\ \geq p$, the highest price that the firm can offer is $Emax\,(\theta+\varepsilon,0)$ and the firm can set this value as an optimal price when there is no return policy.

$$p_{NR}^{*} = \mathrm{Emax}(\theta+\varepsilon,0) = \int_{-\theta}^{\theta}(\theta+\varepsilon)g(\varepsilon)d\varepsilon = \frac{1}{2\theta}[\varepsilon\theta+\frac{1}{2}\varepsilon^{2}]_{-\theta}^{\theta} = \theta$$

Similar to no return policy, the optimal price that firm can offer is

$$\begin{aligned} p_{R}^{*} &= \mathrm{Emax}(\theta+\varepsilon,r) = rG(r-\theta) + \int_{r-\theta}^{\theta}(\theta+\varepsilon)g(\varepsilon)d\varepsilon \\ &= r\cdot\frac{r-\theta+\theta}{2\theta}+\frac{1}{2\theta}[\varepsilon\theta+\frac{1}{2}\varepsilon^{2}]_{r-\theta}^{\theta} = \frac{r^{2}}{2\theta}+\frac{1}{2\theta}\left[2\theta^{2}-\frac{1}{2}r^{2}\right] = \theta+\frac{r^{2}}{4\theta} \end{aligned}$$

$$\therefore\ p_{R}^{*} - p_{NR}^{*} = \theta+\frac{r^{2}}{4\theta} - \theta \geq 0$$

$$\therefore\ p_{NR}^{*} \leq p_{R}^{*}$$

Thus, when consumers are homogeneous, optimal price with return policy is higher than with no return policy.

Proof of Proposition 2.

$$\pi_{R} = p(\overline{G}(r-\theta)+(p-r)G(r-\theta) \quad \mathrm{s.t.} \quad p = \mathrm{Emax}(\theta+\varepsilon,r)$$

$$= \mathrm{p}(1 - \mathrm{G}(\mathrm{r} - \theta) + (\mathrm{p} - \mathrm{r})\mathrm{G}(\mathrm{r} - \theta)$$

$$= \mathrm{p} - \mathrm{rG}(\mathrm{r} - \theta) = \mathrm{Emax}(\theta + \varepsilon, \mathrm{r}) - \mathrm{rG}(\mathrm{r} - \theta)$$

$$= \mathrm{rG}(\mathrm{r} - \theta) + \int_{\mathrm{r}-\theta}^{\theta} (\theta + \varepsilon)\mathrm{g}(\varepsilon)\mathrm{d}\varepsilon - \mathrm{rG}(\mathrm{r} - \theta)$$

$$= \int_{\mathrm{r}-\theta}^{\theta} (\theta + \varepsilon)\mathrm{g}(\varepsilon)\mathrm{d}\varepsilon = \frac{1}{2\theta}[\varepsilon\theta + \frac{1}{2}\varepsilon^2]_{\mathrm{r}-\theta}^{\theta} = \frac{1}{2\theta}\left[2\theta^2 - \frac{1}{2}\mathrm{r}^2\right] = \theta - \frac{1}{4\theta}\mathrm{r}^2$$

The constraint implies that the highest price that a firm could charge is $p = Emax\ (\theta + \varepsilon, r)$. This gives participation constraint for consumers to purchase the product. The probability that a consumer returns is $G(r - \theta)$.

Consequently, π_R is maximum when r=0. Thus, when consumers are homogeneous, no return policy is more efficient than return policy.

Proof of Proposition 3 & 4.

I assume there are two types of consumers: a high valuation type with θ, and a low valuation type with θ_L, where $0 < \theta_L < \theta$. Suppose that the proportion of high valuation consumer type is α and the proportion of low valuation consumer type is $1 - \alpha$ among the population. Consumers within each type are homogeneous.

$$\mathrm{V_H} = \theta + \varepsilon\,; \Pr(\theta) = 1 - \alpha$$

$$\mathrm{V_L} = \theta_\mathrm{L} + \varepsilon\,; \Pr(\theta_\mathrm{L}) = \alpha$$

$$\pi_{\mathrm{R2}} = \alpha[\mathrm{p}\overline{\mathrm{G}}(\mathrm{r} - \theta_\mathrm{L}) + (\mathrm{p} - \mathrm{r})\mathrm{G}(\mathrm{r} - \theta_\mathrm{L}) + (1 - \alpha)[\mathrm{p}\overline{\mathrm{G}}(\mathrm{r} - \theta) + (\mathrm{p} - \mathrm{r})\mathrm{G}(\mathrm{r} - \theta)$$

$$\text{s.t.}\quad E\max(\theta_L + \varepsilon, r) \geq p$$

$$\pi_{R2} = \alpha p - \frac{\alpha r^2}{2\theta} + \frac{\alpha r\theta_L}{2\theta} - \frac{\alpha r\theta}{2\theta} + p - p\alpha - \frac{r^2}{2\theta} + \frac{\alpha r^2}{2\theta} = p + \frac{\alpha r\theta_L}{2\theta} - \frac{\alpha r\theta}{2\theta} - \frac{r^2}{2\theta}$$

$$\therefore \pi^*_{R2} = p^* + \frac{\alpha r\theta_L}{2\theta} - \frac{\alpha r\theta}{2\theta} - \frac{r^{\ 2}}{2\theta}$$

To put it together π_{R2} represents the firm's expected payoff from two valuation type consumers. The constraint guarantees that both types are willing to purchase the product.

Put $p^* = E\max(\theta_L + \varepsilon, r)$

$$p^* = E\max(\theta_L + \varepsilon, r) = rG(r - \theta_L) + \int_{r-\theta_L}^{\theta} (\theta_L + \varepsilon)g(\varepsilon)d\varepsilon$$

$$= r\left(\frac{r-\theta_L+\theta}{2\theta}\right) + \frac{1}{2\theta}\left[\theta_L\varepsilon + \frac{1}{2}\varepsilon^2\right]_{r-\theta_L}^{\theta} = \frac{r^2 - r\theta_L + r\theta}{2\theta} + \frac{\theta_L\theta + \frac{1}{2}\theta^2 + \frac{1}{2}\theta_L^2 - \frac{1}{2}r^2}{2\theta}$$

$$= \frac{\frac{1}{2}r^2 - r\theta_L + r\theta + \theta_L\theta + \frac{1}{2}\theta^2 + \frac{1}{2}\theta_L^2}{2\theta}$$

$$\therefore \pi^*_{R2} = \frac{1}{4\theta}r^2 - \frac{\theta_L r}{2\theta} + \frac{r}{2} + \frac{\theta_L}{2} + \frac{1}{4}\theta + \frac{1}{4\theta}\theta_L^2 + \frac{\alpha r\theta_L}{2\theta} - \frac{\alpha r\theta}{2\theta} - \frac{r^2}{2\theta}$$

$$\frac{\partial\pi^*_{R2}}{\partial r} = -\frac{\theta_L}{2\theta} + \frac{1}{2} + \frac{\alpha\theta_L}{2\theta} - \frac{\alpha\theta}{2\theta} - \frac{1}{2\theta}r = 0$$

$$r = -\theta_L + \theta + \alpha(\theta_L - \theta)$$

$$\therefore\ r^*_{R2} = (1 - \alpha)(\theta - \theta_L)$$

Thus, when consumers are heterogeneous (two type), return policy is more efficient than with no return policy. Optimal refund is $r^*_{Rh} = (1 - \alpha)(\theta - \theta_L)$.

$$p^*_{NR2} = \text{Emax}\,(\theta_L + \varepsilon, 0) = \int_{-\theta_L}^{\theta} (\theta_L + \varepsilon) g(\varepsilon) d\varepsilon = \frac{1}{2\theta}[\theta_L \varepsilon + \frac{1}{2}\varepsilon^2]_{-\theta_L}^{\theta}$$

$$= \frac{1}{2\theta}[\theta_L\theta + \frac{1}{2}\theta^2 - \left[-\theta_L^2 + \frac{1}{2}\theta_L^2\right]] = \frac{1}{2\theta}[\frac{1}{2}\theta^2 + \theta_L\theta + \frac{1}{2}\theta_L^2] = \frac{1}{4\theta}(\theta + \theta_L)^2$$

$$P^*{}_{R2} = E(\theta_L + E, r^*) = r\,G(r - \theta_L) + \int_{r-\theta_L}^{\theta} (\theta_L + \varepsilon) g(\varepsilon) d\varepsilon$$

$$= \frac{1}{4\theta} r^2 - \left(\frac{\theta_L r}{2\theta} + \frac{r}{2}\right) + \frac{\theta_L}{2} + \frac{1}{4}\theta + \frac{1}{4\theta}\theta_L^2$$

$$P^*{}_{R2} - p^*_{NR2} = \frac{1}{4\theta} r^2 - \left(\frac{\theta_L r}{2\theta} + \frac{r}{2}\right)$$

Put $r^* = (1 - \alpha)(\theta - \theta_L)$

$$\therefore\ p^*_{R2} - p^*_{NR2} = \frac{(1-\alpha)(\theta - \theta_L)^2 (3 - \alpha)}{4\theta} \geq 0$$

$$\therefore\ p^*_{R2} \geq p^*_{NR2}$$

When consumers are heterogeneous (two type), optimal price under return policy is higher than optimal price of no return policy.

Proof of Proposition 5&6.

Valuations are independent across different consumers. In this section in order to demonstrate continuous case, I assume that θ_i and ε_i are independently uniform distributed on [0, 1].

$V_i = \theta_i + \varepsilon_i, \qquad \theta_i, \varepsilon_i \sim U[0,1]$

$$F(v) = \begin{cases} \frac{v^2}{2} & 0 \le v < 1 \\ 1 - \frac{(2-v)^2}{2} & 1 \le v < 2 \end{cases} \qquad f(v) = \begin{cases} v & 0 \le v < 1 \\ 2 - v & 1 \le v < 2 \end{cases}$$

Given the independence between θ_i and ε_i, I use *F(·)* and *G(·)* to denote the prior distributions of θ_i and ε_i respectively, and use *f(·)* and *g(·)* to denote the corresponding density functions.

(1) $p^*_{NRC} = E\max(V, 0) = \int_0^2 V_i g(V) dV = 1$

(2) $P^*_{RC} = E\max(V, r) = rG(r) + \int_r^2 Vg(V)dV$

i) $0 \le r < 1$

$$P^*_{RC} = r\frac{1}{2}r^2 + \int_r^1 V^2 dV + \int_1^2 V(2-V)dV = \frac{1}{6}r^3 + 1$$

ii) $1 \le r < 2$

$$P^*_{RC} = rG(r) + \int_r^2 Vg(V)dV = r\left(1 - \frac{(2-V)^2}{2}\right) + [V^2 - \tfrac{1}{3}V^3]_r^2 = \frac{-r^3 + 6r^2 - 6r + 8}{6}$$

$\therefore\ p_{NR} \le p_R$

When consumers are heterogeneous (continuous type), optimal price under return policy is higher than optimal price of no return policy.

(1) $\pi_{NRC} = p\left(\bar{G}(p)\right) = p\left(1 - G(p)\right)$

put $P^*_{NRC} = 1$

$$= 1\left(1-\left(1-\frac{(2-1)^2}{2}\right)\right) = \frac{1}{2}$$

(2) $\pi_{RC} = p\,\overline{G}\,(r) + (p-r)\,G(r) = p\,(1- G(r)) + (p-r)\,G(r) = p - rG(r)$

$$= \text{Emax}\,(V,r) - G(r) = rG(r) + \int_r^2 Vg(V)dV - rG(r) = \int_r^2 Vg(V)dV$$

i) $0 \leq r < 1$

$$\pi_{RC} = \int_r^1 VVdV + \int_1^2 V(2-V)dV = [\tfrac{1}{3}V^3]_r^1 + [V^2 - \tfrac{1}{3}V^3]_1^2 = 1 - \tfrac{1}{3}r^3$$

ii) $1 \leq r < 2$

$$\pi_{RC} = \int_r^2 v(2-v)dv = [v^2 - \tfrac{1}{3}v^3]_r^2 = \tfrac{4}{3} - r^2 + \tfrac{1}{3}r^3$$

This clearly reveals that when return policy does not exist, price of products will decrease, whereas when return policy does exist will increase. This result coincides with previous propositions. Furthermore, from calculation of π_{RC}, it is distinct to find out the firm's optimal price and relationship between price and refund.

국 문 초 록

가치 불확실성하의 환불 정책이 미치는 영향에 대한 가격이론연구

서울대학교 대학원
경영학과 경영학 전공
김 종 엽

본 연구는 가치 불확실성하의 환불 정책이 가격에 미치는 영향에 대하여 이론적인 분석을 통해 설명하고자 하였다. 기업들의 마케팅 활동 중 환불 정책이 차지하는 비중이 늘어나면서 환불 정책의 효과에 대한 정확한 연구의 필요성 또한 증대되고 있다. 직관적으로 살펴봤을 때 기업이 환불 정책을 제공하지 않을 경우에는 상품의 가격은 내려갈 것이고 환불 정책을 제공할 경우에는 상품의 가격이 올라갈 것이다. 또한 환불 정책이 실시될 경우 소비자들은 가치 불확실성의 상황에서 소비를 하게 된다. 즉, 상품을 구입하기 전부터 가지고 있던 그들의 내재적 가치와 상품을 구입한 뒤 느끼는 상품에 대한 만족감을 모두 고려하여 환불 여부를 결정하게 되는 것이다. 본 연구에서는 환불 정책의 실시 여부와 소비자 이질성 가정의 유무에 따라 달라지는 최적

가격과 최적 환불 정책에 대해 모델링을 통해 이론적으로 규명하였다.

본 연구의 모형은 환불금에 따라 변하는 최적 가격, 수요 그리고 기업 이익의 변화를 즉각적으로 보여준다. 또한 소비자 동질성 가정뿐 아니라 소비자를 특성별 집단으로 구분하여 그 집단에 따른 환불 정책의 효과가 어떻게 달라지는지를 살펴보고 있다. 결과적으로 소비자 이질성을 가정한 모형을 통해 분석한 결과 환불 정책하에서 구매대금의 85%를 환불해주었을 경우, 제품의 최적가격은 약 17% 증가했으며 제품에 대한 총 수요는 30.6%만큼 감소하였다. 그러나 최종적으로 기업의 이익이 33.3%가 증가하여 구매대금의 85%를 환불해주었을 경우가 최적 환불 정책임을 알 수 있었다. 본 연구 모형을 통해 환불 정책의 유무와 소비자 이질성의 유무에 따라 환불 정책의 영향력이 달라질 수 있기 때문에 기업 이익을 최대화하기 위해서는 시장의 특성과 소비자 집단의 특성을 고려한 적절한 환불 정책을 실행해야 한다는 시사점을 얻을 수 있었다.

주요어: 최적가격절정, 가치 불확실성, 환불 정책, 소비자 이질성

학번: 2013-20469