# Behavioral price discrimination in Return Policy

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**Abstract**

The return policy is one of the most crucial marketing strategies for retailers to attract loyal consumers. However, consumers can take advantage of those return policies. Wardrobing is known as one of the most widespread abuses for the consumers to take advantage of the return policy. When a consumer is allowed to return the product and get a refund, the consumer has the incentive to use the product fraudulently. Because of this, the firm wants to use the information to customize the return policy for different types of consumers. In this paper, we discuss three types of consumer: the consumer always return(wardrobing), consumer return if they dislike the product and the consumer always keep the product. We analyze the firm's optimal product price and return payment with different consumers in a static game. We also analyze the equilibrium(pooling, separating, or semi-separating) in a 2 stage dynamic game.

**Keywords: Return Policy, Signaling Game, Behavioral Price Discrimination**

# 1 Introduction

According to the National Retail federation's statistics, an estimated $428 billions in merchandise were returned to the retailers in 2020, which is more than ten percent of total sales in the United States (NRF (2021)). The return rate for the e-commerce industry is more than 30 percent. A report by Invespro shows that almost half of the online retailers offered free returns for a certain period. They also suggested that the consumers prefer stores with free return policies (Saleh (2021)). Different retailer stores reacted differently with varying policies of return based on consumers' return behavior. Most retailers permit returns within a certain period (15 days, 30 days, 90days, etc.), and after that, a restocking fee or shipment is charged to the consumer (Saleh (2021)).

On the consumer side, they can return the product if they find out they do not like them. Also, the consumer can take advantage of the return policy. Wardrobing is one of the most recognized types of return policy abuse. The consumer can buy the merchandise to use for a certain period and return the merchandise with a full refund. According to a survey by Secure Authentication Brand LLC, nearly 40 percent of consumers admitted to wardrobe (Duhs (2022)). Most retailer stores do not clarify the return limitations. However, many retailers take action if a consumer has the potential to be wardrobing. Amazon monitors consumer returns and sends a warning or an account limited and banned if a consumer regularly returns (Thomas (2021)). Costco also punished wardrobing behavior by revoking the membership (Wida (2018)). Some other stores, such as Bestbuy, use the strategy of not permitting returns when they find wardrobing behaviors.

In this paper, we discuss the return policy of a firm for three different types of consumer. The first type of consumers never return the product. The second type of consumers return the product when they find they do not like it. The second type of the consumer need to experience the product to decide whether they like the product or not. The third type of consumers always return and use the product entirely. In this environment, we want to investigate the following questions: First of all, what is the relationship between a firm's product price and its optimal return policy? Secondly, how do different types of consumers behave under different policies? Thirdly, in a static environment, how does a firm's the optimal price depends on the types of consumers it serves? At last, in a two periods dynamic environment, how does a firm use the information in the first stage to maximize the profit?

To answer the questions above, We discuss the market cases with only one type of consumer or mixed with two or three different types. In different scenarios, the firms can use the pricing strategy to serve different types of consumers. We first analyze our model in a static environment. Later in the paper, we analyze the model in a two-period dynamic model. From our static model, we find out the firm is more profitable with the consumer returning the production rationally than the customer who never returned the product, and the third type(wardrobing) is the least profitable.

In the next section, we review the existing literature that addresses the retailer's return policy issue. After that, we start our analysis in a static environment and discuss the cases of markets with three different types of consumers and the situation of mixture types. We generalize our model in a two-period dynamic environment based on our static model. In the dynamic game, we discuss a perfect Bayesian Equilibrium with the possibility of pooling, separating, and semi-separating scenarios.

# 2 Literature review

This section reviews the literature that studied the retailer's return policies. The early research by Che(1995) shows that the return policy could improve the profit, and the necessary condition is the consumer's risk aversion. Lots of literature also support this argument that the return policy has a positive effect on the firms(Davis(1998), Yan(2009), Pei(2014)). Table 1 shows the list of literature that studied retailer's return policies:

Table 1: Literature of retailer return polices

| Literature | Addressed Research |
|---|---|
| Che(1995) | Studied a monolopoly firm's choice of return policy or no return policy. With full refund policy and risk averse consumer, the monopolist can charge more. |
| Davis et al.(1998) | Analysis the causes for the retailer's return policy especially the low-hassle return policy that have the potential to improve the profit. |
| Sarvary and Padmanabhan (2001) | Shows that the return policy can help the retailer and manufacturer to learn the demand of the new product. |
| Mukhopadhyay and Setaputra (2006) | Studied the relationship between the quality and the return policy of the product. Consumer prefers the high quality product and the less likely to return product and the return policy. |
| Yan (2009) | Investigate the optimal return policy for the online business and found that the partial return would benefit the retailers. |
| Li et al.(2013) | Analyzed the impact from the return policy, quality of the product to the consumer's behavior of purchasing and returning. They also categorize the consumer by the level of demand. |
| Pei et al.(2014) | Studied the effect of return depth on consumer's purchase and return behaviors. |

A considerable amount of the literature studied how the monopoly firm set the product price and return. However, only Li et al.(2013) studied the heterogeneity among consumers (Li et al. (2013)). In their research, the consumers are differentiated by the different demand levels. However, in our study, the consumers have different types due to their behavior. We assume that the demand for the product is perfectly elastic. The firm receives the information of returning behavior from the consumer, and the consumer can choose to reveal or hide their type in a dynamic environment. The return policy which we studied is customized based on the consumer's behavior. From Freixas et al.'s study, the ratchet effect refers to the central planner's dynamic incentive scheme over two periods (Freixas et al. (1985)). On the one hand, similar to Freixas et al.(1985)'s classic paper, the firm can use a return policy as an incentive scheme to get more consumer surplus. When analyzing the firm's return policy, the dynamic policy for wardrobing behavior might also induce the ratchet effect. On the other hand, the customized return policy for a different type of consumer is also related to behavioral-based price discrimination by Fudenberg and Villas-Boas (2006)'s research. The firm can use the information of the consumer's previous behavior to customize the return policy.

Our research differs from the existing literature in the following ways: First, the consumers are differentiated by "hassle" costs for returning the product. The wardrobing consumers have a "hassle" of zero while others' costs are favorable. Secondly, we discussed the asymmetric information between the consumers and sellers, and possibly, the seller can use the signal to choose the optimal reactions.

# 3 Model setups

Consider a set with one monopoly firm that sells one product to three types of consumers. Consumer types $i$, $i = 1, 2, 3$, has population $\lambda_i$ consumers. The first type of consumer always keeps the product and never returns it. The second type of consumer returns the products if they do not like them. The third type of consumer always returns the product. We assume that both the firm and the consumer's idiosyncratic valuation $v$ of the product is uniformly distributed from $[0,\ V]$. The type of the consumer differs by a "hassle" cost $h$, representing the time and dis-utility of returning a product. Type 1 consumers have endless hassle, $h_1 = \infty$, which means they never return the product. Type 2 consumers have a positive hassle cost, $h_2 > 0$, and their experience value of the product is $\beta v$, where $0 < \beta < 1$, during the exchange period. Type 3 consumers have a zero-hassle cost ($h_3 = 0$), and they experience the entire value $v$ of the product during the exchange period.

For each returned product, the firm's salvage value is $s$, and the firm experiences a restocking cost $c_r$. The salvage value for type 2 and type 3 can be assumed to be different.

Due to wardrobing, the type 3 consumer is incentivized to use the product fraudulently. Therefore, we need $s_2 > s_3$. We assume that the marginal cost of producing a product is $c_0$. Based on the costs and consumer behavior, the firm chooses the product price $p$ and the payment $r$ for the returned product. If the return is free, then $r = p$. In the static environment, the firm cannot distinguish the types of consumers if there is more than one type of consumer in the market. From our static model, we find out the firm is more profitable with the consumer returning the production rationally than the customer who never returned the product or returned fraudulently. When the firm cannot distinguish the type of consumers, they can control the price level and the return payment to choose to serve different customers.

Table 2: Tables of notation in this paper

| | |
|---|---|
| $r$ | return payment |
| $p$ | product price |
| $h$ | hassle cost |
| $v$ | consumer's valuation |
| $u$ | consumer's utility |
| $c_0$ | product marginal cost |
| $c_r$ | seller's restocking cost |
| $s_2,\ s_3$ | product salvage value for type 2 and type 3 |
| $\lambda_i$ | proportion of type i consumer |
| $\delta$ | discount factor |

# 4 Static Model

In the static environment, we first look at three different markets with only one type of consumer. After that, we discuss what happens when the market has more than one type of consumer. In the end, we analyze the case with all three types and how the firm sets the optimal product price and return payments.

## 4.1 Market with only type 1 consumer: $\lambda_1 = 1$

Assume there is a unit mass of type 1 consumers in the market. The utility of the consumer keep a product is:

$$u_1^k = v - p,$$

and the utility of return a product is:

$$u_1^r = v - p + r - h_1.$$

According to the assumption, $h_1$ is close to infinity, therefore, $u_1^r < u_1^k$. The individual rationality condition is:

$$p_1 = V - \int_0^V F(v)dv, \tag{1}$$

with uniform distribution of $v$, we have:

$$p_1^* = \frac{V}{2}$$

The optimal profit of this case is:

$$\pi_1^* = (p - c_0)\lambda_1 = (\frac{V}{2} - c_0)\lambda_1. \tag{2}$$

When $\lambda_1 = 1$, $\pi_1^* = \frac{V}{2} - c_0$. In this market,

## 4.2 Market with only type 2 consumer: $\lambda_2 = 1$

Assume there is a unit mass of type 2 consumers in the market. For this case, the consumer return the product if the utility of returning the product is high than keeping it. In order to find out the threshold, we look the utility of keeping and returning the product[1]:

$$u_2^k = v - p,$$
$$u_2^r = \beta v - p + r - h.$$

The parameter $\beta$ represents the discount factor of the returning cycle that the consumer uses the product. Therefore, the consumer needs to use the product and find out if they like it or not. Also, they need to evaluate the cost of returning the product. Therefore, a type 2 consumer keeps a product if and only if:

$$v - p > \beta v - p + r - h,$$
$$\Rightarrow v > \frac{r-h}{1-\beta}.$$

The expected utility of type 2 consumer is:

$$E[u_2] = \int_0^{\frac{r-h}{1-\beta}} (\beta v + r - h) f(v) dv + \int_{\frac{r-h}{1-\beta}}^{V} v f(v) dv - p,$$
$$= V - \beta \int_0^{\frac{r-h}{1-\beta}} F(v) dv - \int_{\frac{r-h}{1-\beta}}^{V} F(v) dv - p.$$

The individual rationality condition for type 2 is:

$$p = V - \beta \int_0^{\frac{r-h}{1-\beta}} F(v) dv - \int_{\frac{r-h}{1-\beta}}^{V} F(v) dv, \tag{3}$$

with uniform distribution:

$$p_2^* = \frac{V}{2} + \frac{(r-h)^2}{2V(1-\beta)}.$$

[1]Since $h_1$ is infinity and $h_3 = 0$, we just denote $h_2 = h$

Here $\frac{(r-h)^2}{2V(1-\beta)} > 0$. This tells us that the market with type two consumers only has a higher product price:$p_2^* > p_1^*$. Notice that:

$$\frac{(r-h)^2}{2V(1-\beta)} = (1-\beta)\int_0^{\frac{r-h}{1-\beta}} F(v)dv,$$

which is the extra price paid by the consumer for experiencing the product. This extra price increases when $\beta$ increases. The more the consumer experience the product, the higher price they need to pay.

At the side of the firm, the profit maximization problem is:

$$max_{p,r}\pi_2 = \lambda_2(F(\frac{r-h}{1-\beta})(p-c_0+s_2-r-c_r)+(1-F(\frac{r-h}{1-\beta}))(p-c_0))$$
$$= \lambda_2((p-c_0)+(s_2-r-c_r)F(\frac{r-h}{1-\beta})).$$

By solving the first order condition, we have:

$$\begin{aligned} r_2^* &= s_2 - c_r, \\ \pi_2^* &= \frac{V}{2} - c_0 + \frac{(s_2-c_r-h)^2}{2V(1-\beta)}, \\ &when\ \lambda_2 = 1. \end{aligned} \tag{4}$$

Compare the profit between type 2 consumer and type 1 consumer, we have the following proposition:

**Proposition 1** *At same population($\lambda_1 = \lambda_2$), the type 2 consumers are more profitable to a monopoly firm($\pi_2^* > \pi_1^*$) than the type 1 consumer.*

Proposition 1 tells us that, when we allow the return, the monopoly firm can increase the price for the type 2 consumer. This result is consistent with Che (1995). The optimal return is determined by the salvage value $s_2$ and the restocking cost $c_r$. For the return payment, the optimal return $s_2 - c_r$ must satisfy the following lemma:

**Lemma 1** *The optimal return payment for the market with type 2 consumer only must satisfy:* $h < r_2^* = s_2 - c_r < h + (1-\beta)V$.

Lemma 1 constraints the level of return payment in this market. On the one hand, no consumer returns the product when the return payment is smaller than the hassle cost. On the other hand, the indifference threshold of keeping and returning should not be higher than the maximum valuation of the product.

## 4.3 Market with only type 3 consumer: $\lambda_3 = 1$

Assume there is a unit mass of type 3 consumers in the market. The type 3 consumer never keeps the product due to the zero "hassle" cost. The utility of keep and return is:

$$u_3^k = v - p,$$
$$u_3^r = v - p - h_3 + r.$$

Since $h_3 = 0$, then $u_3^r > u_3^k$ always hold. If the individual rationality condition bind then:

$$\begin{aligned} V - \int_0^V F(v)dv &= p - r, \\ \Rightarrow p = V - \int_0^V F(v)dv + r. \end{aligned} \tag{5}$$

with uniform distribution:

$$p_3^* = \frac{V}{2} + r_3^*.$$

We can see that if the market only has a type 3 consumer, the price of the product increases while the return payment increases. The consumer returns the product with any positive value of the return payment. The optimal profit of the firm is:

$$\pi_3^* = \lambda_3(p - c_0 - r - c_r + s_3) = \frac{V}{2} - c_0 + s_3 - c_r, \ \textit{when } \lambda_3 = 1. \tag{6}$$

We can see that the profit function does not depend on the return payment. The optimal profit for the type 3 consumer is independent of the return amount. For any positive return, payment makes the market make the type 3 consumer return the product. From (6), we can see that, when $s_3 > c_r$, the type 3 consumer is profitable, and compared to type 1, the type 3 consumer is even more profitable. In this case, a type 3 consumer is more like a renter. They pay the $p - r = \frac{V}{2}$ to the seller and use the product for a certain period. However, this scenario might not happen because we assume the type 3 consumer uses the product fraudulently. Therefore, the salvage value could be close to 0. In this case, if $\pi_3^* < 0$. The firm does not permit returns, and the type 3 consumers are indifferent about joining the market or not.

**Proposition 2** *When $s_3$ is close to zero or more negligible than the restocking cost $c_r$, the type 3 consumer is the least profitable.*

By comparing through, $\pi_3^*$ and $\pi_1^*$, we can easily prove proposition 2. Therefore, the profit for type 3 consumers depends on whether they use the product fraudulently or not. The following section discusses the relationship between product price and returns payment.

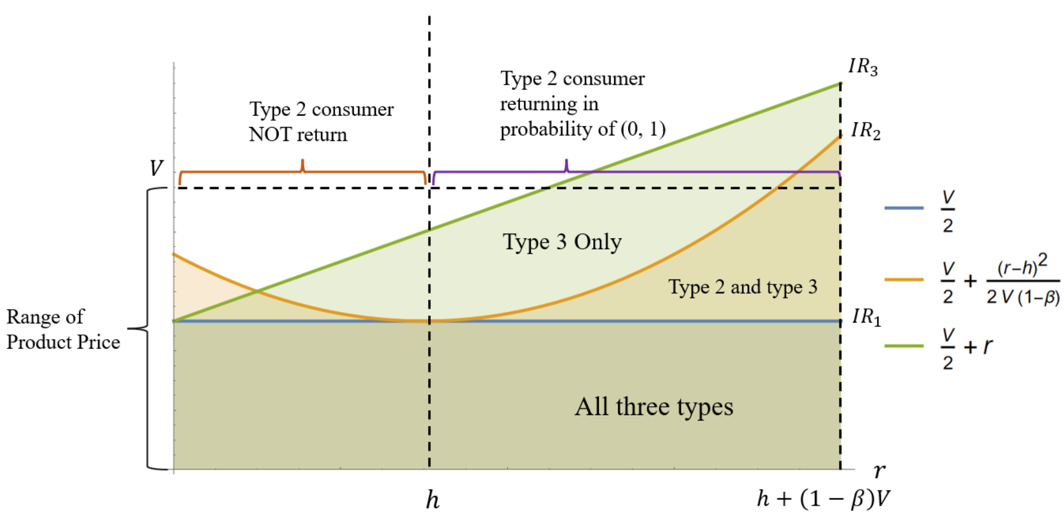
## 4.4 Discussion of Return policy

The three cases in the previous sections are extreme in that the market only has one type of consumer. Now let us consider that the market has all three types of consumers. The firm only knows the priors ($\lambda_1, \lambda_2$ *and* $\lambda_3$). When the firm adjusts the product prices and the return payment, the different types of consumers choose to join in or not. First, we can look at the optimal price for each type of consumer. Those optimal prices are derived from the individual rationality constraints for each type of consumers[2]:

$$
\begin{aligned}
p_1^* &= \frac{V}{2}, \\
p_2^* &= \frac{V}{2} + \frac{(r_2^* - h)^2}{2V(1-\beta)}, \\
p_3^* &= \frac{V}{2} + r_3^*.
\end{aligned}
$$

We know that product price for the market with only type 1 consumers is not related to the return payment. Therefore, type 1 consumers do not join the market if the product price is higher than $\frac{V}{2}$. Meanwhile, the type 2 and type 3 consumers do not join the market if the individual rationality constraints are not satisfied. Figure 1 shows a representative case of the product price and returns payment. When the product price is low(less than $\frac{V}{2}$), all three types of consumers join the market. Therefore, if a firm wants to serve type 1 consumers, the other two types might join in.

Figure 1: Relationship between price and return payment




According to Lemma 1, when the return payment is less than the type 2 consumer's hassle cost $h$, there is no type 2 consumer in the market since the no return behavior happens. In this case, if the product price is smaller than $\frac{V}{2}$ and any positive return which is smaller

[2]In order to simplify the analysis, we consider the valuation $v$ is uniformly distributed.

than hassle cost makes the firm serve the type 1 and type 3 consumers. When the return payment is higher than the hassle cost and the product price is smaller than $\frac{V}{2}$, the firm has to serve all three types of consumers. Therefore we have the following proposition:

**Proposition 3** *Using a positive pricing strategy and return payment, the firm cannot choose only to serve type 1 consumers in a static environment.*

Proposition 3 tells us that if the firm cannot identify the type of the consumer. They cannot isolate type 1 consumers. If the firm wants to serve type 1 consumers only, the only way is not to permit the return or set $r = 0$. However, from proposition 2, we know that type 2 consumer is more profitable than type 1 consumer. Therefore, the firm has no incentive to choose to serve the type 1 consumer only. By the same logic, we compare type 2 and type 3 consumers and have the following proposition:

**Proposition 4** *The firm cannot serve the type 2 consumer only with the return payment that makes the probability of type 2 consumer:* $p \in (0, 1)$.

From figure 1, we can see the range of type 2's constraints of return payments. The idea of the proof for Proposition 4 is to show that when the indifference curve for type 2 and type 3 consumers crosses, the price bundles are not achievable[3]. When the firm cannot distinguish the type of consumers, the firm is hard to ban the wardrobing behavior in a static environment. Proposition 3 and 4 tell us that if the firm wants to serve type 1 or type 2, the type 3 consumer joins the market in a static environment. If the firm cannot distinguish the type by using the pricing strategy, the firm can only choose the following cases: first, serving type 3 only, and secondly, serving type 2 and type 3—furthermore, third, serving all three types. The following sections discuss the optimal return and product price when the firm chooses to serve more than one consumer.

[3]See the proof in Appendix A.

## 4.5 Firm choose to serve type 2 and type 3 consumers:

The profit of the firm is:

$$\pi_{2,3} = (\lambda_2 + \lambda_3)(p - c_0) + (\lambda_2 F(\frac{r-h}{1-\beta}))(s_2 - r - c_r) + \lambda_3(s_3 - r - c_r).$$

From proposition 4, we know that the type 2 consumer determines the individual rationality constraint. Therefore, when the individual rationality condition binds for type 2 consumers, type 3 consumers also join the market. That is:

$$p^*_{2,3} = p^*_2 = V - \beta \int_0^{\frac{r-h}{1-\beta}} F(v)dv - \int_{\frac{r-h}{1-\beta}}^{V} F(v)dv. \tag{7}$$

The first order condition gives:

$$r^* = s_2 - c_r + (1-\beta)\frac{\lambda_3}{\lambda_2}[\frac{F(\frac{r-h}{1-\beta})}{f(\frac{r-h}{1-\beta})} + \frac{1}{f(\frac{r-h}{1-\beta})}], \tag{8}$$

with uniform distribution:

$$r^*_{2,3} = \frac{\lambda_2}{\lambda_2 - \lambda_3}(s_2 - c_r - \frac{\lambda_3}{\lambda_2}((1-\beta)V - h)).$$

The return payment for this market need also satisfy the following condition:

$$h < r^*_{2,3} < h + (1-\beta)V.$$

By solving this inequality, we can find the following lemma:

**Lemma 2** *If the market has both type 2 and type 3 consumers, then the net salvage value* ($s_2 - cr$) *must satisfy:*

$$h + \frac{\lambda_3}{\lambda_2}(1-\beta)V < s_2 - cr < h + (1-\beta)V, \tag{9}$$

*where* $\lambda_3 < \lambda_2$[4].

### 4.6 Firm choose to serve all three types of consumer

When the platform serves all three types of consumers, the type 1 consumer decides the individual rationality condition. The maximization problem is:

$$\max_{p,r} \pi_{1,2,3} = \sum_{i=1}^{3} \lambda_i(p - c_0) + \lambda_2 F(\frac{r-h}{1-\beta})(s_2 - r - c_r) + \lambda_3(s_3 - r - cr).$$

If the firm wants to serve type 1 consumers, they have to decrease the price to let the type 1 consumer join in. Therefore, the product price is:

$$p^*_{1,2,3} = p^*_1 = V - \int_0^V F(v)dv.$$

The first order condition solves the return payment:

$$r^*_{1,2,3} = s_2 - c_r - (1-\beta)(\frac{F(\frac{r-h}{1-\beta})}{f(\frac{r-h}{1-\beta})} + \frac{\lambda_3}{\lambda_2}\frac{1}{f(\frac{r-h}{1-\beta})}),$$

with the uniform distribution:

$$r^*_{1,2,3} = \frac{1}{2}(s_2 - c_r + h - \frac{\lambda_3}{\lambda_2}(1-\beta)V). \tag{10}$$

### 4.7 Discussion

In this static model, the firm cannot distinguish the type of consumers. The choices for the firm is serving the following market with different pricing profile: serving all three types, serving type 2 and type 3 consumers, and serving type 3 consumer only. In all three scenarios, the firm cannot fire type 3 consumers. We need to compare the cases serving all three types or only type 2 and type 3. First, when serving all three types, the product price is lower

[4] We can show that when $\lambda_3 > \lambda_2$, we have $s_2 - cr > h + V(1-\beta)$, which is contradict to Lemma 1

than only types 2 and 3. For the return payment:

$$r^*_{1,2,3} - r^*_{2,3} = \frac{(\lambda_2 + \lambda_3)((h - (s_2 - cr))\lambda_2 + (1 - \beta)V\lambda_3)}{2\lambda_2(\lambda_2 - \lambda_3)} < 0.$$

According to Lemma 2, $h + \frac{\lambda_3}{\lambda_2}(1 - \beta)V < s_2 - c_r$, then $r^*_{1,2,3} - r^*_{2,3} < 0$. Therefore, we can show that when the firm chooses to serve the type 1 consumer, they need to lower the return payment. When type 1 consumers join the market, the product price decreases, and more consumers do not return the product. In order to maximize the profit, the return payment must be lower. Now, we can evaluate the profit of $\pi_{2,3}$ with the optimal price from the market serving all three types. By taking the difference with $\pi^*_{2,3}$, we have:

$$\pi_{2,3}(p^*_{1,2,3}, r^*_{1,2,3}) - \pi^*_{2,3} = \frac{(\lambda_2 + \lambda_3)((h - (s_2 - cr))\lambda_2 + (1 - \beta)V\lambda_3)^2}{4V(\beta - 1)\lambda_2(\lambda_2 - \lambda_3)} < 0.$$

When the firm chooses to lower the price and serve type 1 consumers, the profit from type 2 and type 3 consumers decreases, therefore we can conclude the following proposition:

**Proposition 5** *When the firm choose the serve all three types of consumers,the population of type 1 consumer must satisfy:*

$$\lambda_1 > \frac{(\lambda_2 + \lambda_3)((h - (s_2 - cr))\lambda_2 + (1 - \beta)V\lambda_3)^2}{4V(1 - \beta)\lambda_2(\lambda_2 - \lambda_3)} \frac{2}{V - 2c_0} \equiv \lambda_1^l. \tag{11}$$

Proposition 5 tells us the firm chooses to serve all three types if the type 1 consumer is profitable or the proportion of the type 1 consumer is large enough. The comparative statics of this threshold is[5]:

$$\frac{\partial \lambda_1^l}{\partial h} > 0, \ \frac{\partial \lambda_1^l}{\partial \beta} > 0. \tag{12}$$

First of all, when the hassle cost increases, the firm is more willing to increase the return payment.$\frac{\partial r^*_{2,3}}{\partial h} > 0$. However, if the firm chooses to serve type 1 consumers, the firm needs to lower both product price and return payment. Therefore, to have the optimal profit, the

[5] see Appendix B

population of type 1 consumers needs to be large enough. Secondly, when $\beta$ increases, the type 2 consumer experience the product more. We also know that:

$$\frac{\partial \pi^*_{2,3}}{\partial \beta} = \frac{(s_2 - cr - h)^2 \lambda_2^2 - (1-\beta)^2 V^2 \lambda_3^2}{2V(1-\beta^2)(\lambda_2 - \lambda_3)} > 0.$$

When $\beta$ increases, the profit from the market with type 2 and type 3 consumers is higher. Also, since $\frac{\partial r^*_{2,3}}{\partial \beta} > 0$, the return payment needs to be higher. However, by the same logic, the return payment is lower if the firm chooses to serve type 1 consumers. Therefore, when $\beta$ increases, the population of type 1 consumers needs to be large. We can learn from this static game: first, the firm cannot use a pricing strategy to ban wardrobing in a static environment if the firm cannot distinguish the consumers. Second, the firm would prefer to serve type 2 consumers rather than type 1 consumers.

# 5 Future Research on Dynamic Model

In this section, we discuss a scenario with two periods denoted as: $t = 1, 2$. The firm have the information of the priors: $\lambda_1^1, \lambda_2^1, \lambda_3^1$. We define the pricing strategy of firm:$\{p^t, r^t\},\ t = 1, 2$. At each period the consumer can choose to return or keep the product. is The timing of the dynamic game is following:

1. At the beginning the first period, the firm chooses the pricing$\{p^1, r^1\}$.
2. The consumer can choose to return or keep the product.
3. Base on the reaction, the firm updates it belief $\lambda_i^2$ and give the price strategy $\{p^2, r^2\}_{p^1, r^1, \lambda_i^2}$.

The strategy of the firm is the price and return payment. The consumer's strategy is the whether return the product which denote as $A_i^t \in \{R, K\}$. The belief of the firm is the function of the consumer's action from the first period:$\lambda_i^2(A_i^1)$. From the previous sections, we know that type and type 3 consumers do not change their behaviors over time: $A_1^1 = A_1^2 = k$ and$A_3^1 = A_3^2 = R$. The type 2 consumers can decide whether they want to pool with type 1 or type 3 at first stage. Once the firm set their belief, the second stage game can be solved as a static situation. The consumer maximize the utility over the time:

$$\max U_i = u_i^1(A_i^1, p^1, r^1) + \delta u_i^2(A_i^2, p^2, r^2).$$

The firm maximize the profit over the two period:

$$\max \Pi = \pi^1(p^1, r^1) + \delta \pi^2(p^2, r^2),$$

where $\delta$ is the discount factor over two period. Assume that the discount factor is same for firm and consumers.

## 5.1 Define the equilibrium

The definition of the equilibrium is following:

**Definition 1** *A. The perfect Bayesian equilibrium is a set of (pure or mixed) strategies* $\{\{p^t, r^t\}, A_i^t\}$ *and belief* $\{lambda_i^2\}$ *satisfy:*

1. $\forall i$, $A_i^2$ *maximize the second period utility* $u_i^2$*, where* $i = 1, 2, 3$.
2. $\{p^2, r^2\}$ *maximize the expectation of* $\pi^2$*, give the belief* $\lambda_i^2$.
3. $\forall i$, $A_i^1$ *maximize the total utility* $U$ *given second period strategies.*
4. $\{p^1, r^1\}$ *maximize the expectation of* $\Pi$

*B. The belief* $\lambda_i^2$ *is Bayes-consistent with the prior* $\lambda_i^1$ *and consumer's first period strategy* $A_i^1$, $\forall i = 1, 2, 3$

According to the equilibrium above, we can analysis the following scenarios: First, $\lambda_3 = 0$, the market only have type 1 and type 2 consumer.

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# Appendix A.

**Proof.** In this proof, we show that when the type 2 consumer's individual rationality constraint satisfied, the pricing bundle also satisfy type 3's individual constraint. By setting $\frac{V}{2} + r = \frac{V}{2} + \frac{(r-h)^2}{2V(1-\beta)}$, we have the following solution:

$$r_l = V(1-\beta) + h - V(1-\beta)\sqrt{\frac{2h}{V(1-\beta)} + 1},$$
$$r_h = V(1-\beta) + h + V(1-\beta)\sqrt{\frac{2h}{V(1-\beta)} + 1}.$$

From lemma 1, we know that:

$$h < r_2 < h + V(1-\beta).$$

It is easy to show that

$$r_l = V(1-\beta) + h - V(1-\beta)\sqrt{\frac{2h}{V(1-\beta)} + 1)} < h,$$
$$and\ r_h = V(1-\beta) + h + V(1-\beta)\sqrt{\frac{2h}{V(1-\beta)} + 1} > h + V(1-\beta).$$

we can conclude that both $r_l$ and $r_h$ are not achievable. Therefore, for any reasonable price bundle for that type 2 consumer join in the market, it also make type 3 consumer join in the market. ■

# Appendix B.

**Proof.** Proof of comparative statics:

$$\frac{\partial \lambda_1^l}{\partial h} = -\frac{(\lambda_2 + \lambda_3)((h - (s_2 - cr))\lambda_2 + (1-\beta)V\lambda_3)}{(V - 2c_0)(1-\beta)V(\lambda_2 - \lambda_3)} > 0.$$

$$\frac{\partial \lambda_1^l}{\partial \beta} = \frac{(\lambda_2 + \lambda_3)((h - (s_2 - cr))\lambda_2 + (1-\beta)V\lambda_3)((h - (s_2 - cr))\lambda_2 - (1-\beta)V\lambda_3)}{(V - 2c_0)(1-\beta)^2 V(\lambda_2 - \lambda_3)} > 0.$$

$$\frac{\partial \lambda_1^l}{\partial \lambda_3} = \frac{((h - (s_2 - cr))\lambda_2 + (1-\beta)V\lambda_3)(\lambda_2^2(h + (1-\beta)V - (s_2 - cr)) + \lambda_2\lambda_3(1-\beta)V - \lambda_3^2(1-\beta)V)}{(V - 2c_0)(1-\beta)V(\lambda_2 - \lambda_3)^2},$$

where $(\lambda_2^2(h + (1-\beta)V - (s_2 - cr)) + \lambda_2\lambda_3(1-\beta)V - \lambda_3^2(1-\beta)V) > 0$. Therefore $\frac{\partial \lambda_1^l}{\partial \lambda_3} > 0$.

$$\frac{\partial \lambda_1^l}{\partial \lambda_2} = \frac{((h - (s_2 - cr))\lambda_2 + (1-\beta)V\lambda_3)A}{2(V - 2c_0)(1-\beta)V\lambda_2^2(\lambda_2 - \lambda_3)^2},$$

where

$$A = ((c_r - s_2 + h)\lambda_3^3 - (2(c_r - s_2 + h) + (1-\beta)V\lambda_2^2\lambda_3 - ((c_r - s_2 + h) + 2(1-\beta)V\lambda_2\lambda_3^2 + (1-\beta)V\lambda_3^3) < 0.$$

Therefore, $\frac{\partial \lambda_1^l}{\partial \lambda_2} < 0$ ■