Consumer Search and Product Returns

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Abstract

We study how a firm should design a product return policy when a consumer has uncertain match with a product but can conduct costly search to resolve this match. If processing returns is costly for the firm and consumer search cost is low enough, the firm induces consumer search such that the consumer bears the cost of finding a match. However, if search cost is high enough, then the price distortion in inducing consumer search is significant, such that the firm chooses to bear the cost of processing the return — in this case, the ability to search increases expected consumer surplus. We find conditions under which the firm may offer no return policy, a full-refund return policy or a partial-refund return policy; a partial-refund return policy arises only if search is potentially inconclusive. Our model explains a wide range of pricing and return policies used by sellers, and associated search and return behaviors of consumers.

1 Introduction

Prior to purchasing a product, a consumer is often uncertain about whether the product matches her needs. Due to this, sellers offer return policies so that consumers can return products that do not match their needs. For instance, the retailer Zappos that sells shoes online is well-known for its liberal return policy,[1] under which product returns are accepted essentially no questions asked. Effectively, the retailer is encouraging the consumer to purchase the product without extensive search, but if the product does not match then the consumer can easily return it. In this situation, the retailer is using a generous return policy to postpone determining product match until *after* the purchase. As an industry article on product returns states: "In this new world of returns, we're finding that the purchase decision that you think is made in-store may actually be made at home."[2]

Indeed, product returns are an important phenomenon in retailing — the National Retail Federation estimates that in the United States approximately 10% of products are returned (by dollar value)[3] — and many retailers use return policies with varying characteristics. First, most, but not all, retailers allow returns. For instance, stores like Dollar Tree do not allow returns.[4] Second,

[1] https://www.shipstation.com/blog/makes-great-e-commerce-returns-policy/
[2] https://knowledge.wharton.upenn.edu/article/high-cost-of-returns-should-retailers-rethink-policies/
[3] https://bit.ly/3FryjIR
[4] The return policy of Dollar Tree, available at https://www.dollartree.com/company-faq-return-policy, states: "we ... do not offer refunds, and consider all sales final."

different retailers charge different amounts of fee for returns, which can be zero, small or large as a percentage of the product purchase price. Third, retailers often add clauses to the return agreement; for instance, the product should be unused and have original tags, the product should be in its original packaging, it should be returned within a certain number of days (e.g., fourteen days), it should be dropped off at a particular location even if purchased online, etc.[5]

Consumers generally like return policies because these policies save the search effort and assure that if consumers do not like a product after purchasing it, they do not have to permanently keep it. This is reflected in the following quote from the same industry article referenced earlier: "Shoppers love the kind of liberal return policy that makes it easy for them to buy whatever they want in store or online with the confidence that a retailer will take products back without hassle."[6] In fact, the narrative is often that there are too many consumer returns and retailers must be watchful of the negative impact of return policies on their net profits (Robertson et al. 2020).

In most situations, however, consumers are able to search for information about the product before purchasing it. The search exercise, while costly, may help the consumer in obtaining a clearer idea of whether the product will match her needs or not. The information that a consumer searches may be obtained at the seller's website and store, through online consumer reviews, through conversations with consumers, by inspecting the product, etc. Some retailers go to extensive lengths to enable consumers to determine their match with a product. For instance, the retailer Warby Parker, that sells eye glasses online, has a "Home Try On" program[7] under which a consumer can choose up to five frames from the Warby Parker website to be shipped to her for free. The consumer can experience these five frames in-person for five days after which she must send them back to the firm, and then she can choose to purchase (with prescription glasses) any of these frames or another one, or make no purchase. In this situation, the retailer is enabling consumer search to facilitate determination of a product match by the consumer *before* she purchases the product, which is in contrast to a strategy of facilitating determination of a product match after purchasing. When and why would retailers follow these different approaches to product match determination?

[5] See https://money.usnews.com/money/personal-finance/spending/articles/stores-with-the-best-return-policies-and-worst-return-policies for a discussion of "best and worst" return policies of different stores. Interestingly, the fashion retailer Alexander Wang has a return policy with full refunds, yet with all of the characteristics mentioned here. On the other hand, the retailer Costco has an extremely liberal return policy for most products with full refunds and relaxed or no clauses.

[6] https://knowledge.wharton.upenn.edu/article/high-cost-of-returns-should-retailers-rethink-policies/

[7] https://www.warbyparker.com/home-try-on

Clearly, consumer search and product returns are interact. Both consumer search and offering returns can resolve the consumer's match uncertainty and thus enable the firm to charge a high price on consumers with high ex post valuation. Offering returns (in particular, with a liberal policy like free returns) allows the firm to charge a higher price, because the consumer can return the product if it turns out to be ill-matched after purchase. The downside of offering returns, however, is that it can be costly for the firm (e.g., the firm needs to incur return processing costs to resell the returned products). Therefore, the firm may have the incentive to transfer the cost of determining a match to the consumer by inducing consumer search before purchase rather than incur the cost of processing a mismatched returned product. However, search is costly to the consumer, which implies that if the firm wants to induce the consumer to search before purchasing, then the price of the product can not be too high because otherwise the consumer may not conduct search at all. Overall, it is not clear when it is optimal for the seller to solely induce consumer search before purchasing without offering returns, when it is optimal for the seller to soley use a return policy without inducing search, and when it is optimal for the seller to use both.

These observations lead to a number of questions about return policies. What is the impact of consumer search on return policy and the firm's profit? Why do different firms offer different return policies? Why consumers in many cases conduct extensive search before purchase even when a firm offers a (sometimes very liberal) return policy? If the seller could control the informativeness of search, would it set it low or high?

In this paper, we address the above and other questions by developing an analytical model of consumer search and product returns. We assume that there is a monopolistic seller who sets the price of the product and chooses whether or not to offer a return policy and also chooses the return fee if the policy is offered. The consumer decides to search to determine match or not, and then decides to purchase the product or not. After purchase, the consumer may decide to return the product if the return option is available. In our focal model, we assume that search fully resolves match uncertainty and there is no hassle cost of returning product. In extensions, we soften these assumptions by considering inconclusive search (i.e., search may not always reveal match) and non-trivial hassle costs.

We obtain several interesting insights from the model which also explain industry practice. First, we find that consumer search can benefit the firm only when the search cost is low and the firm's marginal production cost and return processing cost are not low. A high production cost motivates the firm to charge a high price. Therefore, to charge a high price, the firm can help the consumer resolve match uncertainty either by allowing product returns or by inducing the consumer to search before purchasing. On the one hand, consumer search reduces the number of returns and costs for the firm; on the other hand, due to search cost, the firm has to charge a relatively low price (compared to offering returns) to induce the consumer to search. Overall, when the search cost is low and both marginal production cost and the return processing cost are high, the first effect dominates and thus the firm chooses to transfer the cost of determining a match to the consumer (i.e., inducing consumer search) rather than offering returns and incurring the cost of processing a mismatched returned product. In this case, the firm can benefit from consumer search. This scenario basically corresponds to the Warby Parker example, where return processing costs for prescription glasses can indeed be high. The home try-on program of Warby Parker allows the consumer to search for product match information efficiently, while Warby Parker charges a not-too-low price so that the consumer would not buy if they did not find a match through search (while Warby Parker allows returns, the home try-on program reduces the incidence of desired returns, which reduces the use and relevance of the return policy.)

When the search cost is not low, inducing consumers to search may not be beneficial to the firm because the firm's pricing capability to extract surplus from consumers is limited. For instance, if the search cost is medium, if the firm wants to induce consumer search, then the price can not be high because the search cost is not low enough, whereas if the firm wants to induce consumer to buy without search but does not allow returns, then it has to charge a very low price because the search cost is not high enough to deter consumer search. Then, if the return processing cost is not high, the firm is motivated to offer free returns to induce consumer to buy without search and charge a high price. In other words, consumer search in this case hurts the firm, but return policy can be used to offset the negative impact on pricing caused by consumer search. This scenario basically corresponds to the Zappos example where Zappos offers a very liberal return policy and charges a relatively high price for its shoes, and it can be surmized that the search cost is non-trivial and the return processing cost (such as refurbishing cost) for durable goods such as shoes is not too high.

Next, if both the return processing cost and the search cost are high, the firm would not allow product returns and would simply adopt a low-price strategy to encourage the consumer to buy without search. One example of this is the retailer Dollar Tree which adopts a low-price strategy for its products and does not accept product returns. The low price strategy can not support a large number of returns.

Overall, our main model clarifies the interaction between, and the roles played by, return policies and consumer search. A key takeaway is that consumer search can be used to reduce returns and save the return processing costs for the firm, whereas return policy can also be employed to offset the negative impact of consumer search on the firm's pricing capability. Another key takeaway is that by taking into account the interplay between search and product returns, we are able to explain a wide range of pricing and return policies observed in the market.

As extensions, we incorporate into our model inconclusive search (i.e., search may not always reveal match), consumer's hassle cost of returning, and complexity design for return policy (i.e., adding clauses to the policy such as requiring original packaging, completely unused product, 14-day limit, etc.) — each of these explains aspects of return policies observed in reality but not captured by the main model. We also study endogenous search informativeness design by the firm (e.g., how much information a firm may provide on its official web pages or in its ads).

First, we find that the presence of inconclusive search leads to an equilibrium scenario where the consumer chooses to search even when the firm allows returns. In other words, search and returns can coexist in equilibrium, which is observed in reality but is an equilibrium not produced in our main model and is also in contrast with previous literature which suggests that allowing product returns would always discourage consumer search (e.g., Matthews and Persico 2007). The untuition is that consumer search can help resolve the match uncertainty to some extent and thus under an intermediate return processing cost, the firm has the incentive to induce the consumer to search first, which helps to reduce the number of returns and thus reduce the return processing costs for the firm. Furthermore, the firm allows product returns so that consumers would still buy even when their search fails to provide information. This aligns well with the observation in the industry that consumers in many cases conduct extensive search to obtain information about the product before purchasing it even when a firm offers a return policy (Bechwati and Siegal 2005, Sahoo et al. 2018, Ibragimov et al. 2022, Zhang et al. 2022).

In the cases where the hassle costs are not trivial to consumers, we find that the return policy would become generous (i.e., generally lower, including zero, return fee). The intuition is that when the hassle cost is not low, the firm has to offer a generous return policy to induce consumes to search and buy when their search fails. This further implies that the consumer can benefit from a higher hassle cost. In other words, reducing hassle cost can hurt the consumer but benefit the firm, and thus the firm actually has the incentives to reduce the consumer's hassle cost (e.g., offering return shipping label).

In another extension where the firm can determine the complexity of return policy (e.g., requiring original packaging, completely unused product, 14-day limit, etc.), we find that if the firm offers a return policy it always offers a full refund but, under different conditions, it adds different levels of complexity (i.e., different numbers of clauses of different intensities) to the return policy. We note that this aligns well with market practice where companies often offer "free returns" but various clauses are added to the return policy.

Finally, when the firm allows returns and can decide the search informativeness as well, the firm may want to increase or decrease search informativeness under different conditions, and it wants to set the search informativeness to one of the possible extremes (i.e., maximum possible or minimum possible search informativeness).

Our research is related to the literature on consumer return policies (e.g., Che 1996, Davis et al. 1998, Moorthy and Srinivasan 1995, Shieh 1996, Anderson et al. 2009, Shulman et al. 2009, 2010, 2011, Ofek et al. 2011, Hsiao and Chen 2012, Petersen and Kumar 2009, 2015, Janakiraman et al. 2016). A main theme that runs across these papers is that returns have option value for consumers as they provide consumers the ability to return a product after purchasing, and many of these papers also include a hassle cost of returning a product. There is also a large literature on consumer search; we refer the reader to Honka et al. (2019) for a comprehensive review of this literature. We note that search in our setting should be interpreted as information acquisition about one product rather than information acquisition about multiple products. Previous work in a single-product setting has used the "search" terminology as well (e.g., Branco et al. 2012, 2016). The papers listed above, however, do not connect return policy with consumer search before purchase, while we study the impact of consumer search on the optimal choice of price and return policy. We show that the design of return policy depends on the cost and effectiveness of consumer search and that, under certain conditions, the firm can leverage consumer search to save on product return processing costs.

A number of papers do study consumer search and firm return policy jointly. As mentioned earlier, Ibragimov et al. (2022) and Zhang et al. (2022) empirically show that consumers conduct pre-purchase search to obtain information about the product, which reduces product return rate. On the theoretical side, Matthews and Persico (2007) is a working paper that is closely related to ours. Matthews and Persico (2007) find that a monopoly may induce consumers to stay uninformed before purchase by offering the return policy, and when consumers do search a return policy is not needed because search perfectly reveals valuation. Whereas Matthews and Persico (2007) do not allow search to be inconclusive, Ibragimov et al. (2022) show that in many cases consumers return products after searching, which implies that search must not have determined match conclusively in these cases. In our paper, we allow potentially inconclusive search, which we show is an important component of explaining real-world return policies and consumer search behavior. In particular, the existence of potentially inconclusive search produces cases in which consumers may search while the return policy may still be used, as in Ibragimov et al. (2007). In these cases (and only in these cases), the optimal return policy in our model exhibits a partial refund, which induces the consumer to search and purchase under potentially unsuccessful search. Another important difference between our paper and Matthews and Persico (2007) is that we consider return policy complexity (i.e., restrictive clauses, such as original packing, 14-day return window, etc., added to return policies by firms), which is a dimension of return policies not considered in previous work.

Other papers that jointly study consumer information acquisition and return policies are Petrakaite (2018) and Hinnosaar and Kawai (2020). However, unlike our formulation, in these papers consumers do not actively do pre-purchase information acquisition. In Petrakaite (2018), consumers purchase competing products sequentially to find a match, and can return a product if there is no match and go on to the next product. In Hinnosaar and Kawai (2020), consumers are exogenously differently informed before purchase about their product valuations and can return the product if they don't find a match after purchasing; furthermore, in this paper, the firm maximizes guaranteed profit (robust optimization). Choi et al. (2021) study an emerging ship-then-shop retail strategy in which a firm's prediction algorithm substitutes consumer search and ships products to consumers under a free return policy.

More broadly, our work is also related to supply chain return policies (Padmanabhan and Png 1997, Chen and Chen 2017, Nageswaran et al. 2020). This stream of research focuses on the choice of return policy between manufacturer and retailers, while we focus on the interplay between the firm's return policy and consumer search behavior. There is also a literature on the idea that the firm may strategically prevent or encourage information acquisition by consumers (Crémer and Khalil 1992, Lewis and Sappington 1997, Crémer et al. 1998, and Bergemann and Valimaki 2002, Jerath and Ren 2021). Adding to this literature, we show that the return policy can also be a profitable tool for the firm to prevent or encourage information search by consumers, and we show how the design of return policy varies with the consumer search characteristics such as search cost and search effectiveness.

The rest of the paper is organized as follows. In Section 2, we describe our main model where search fully resolves match uncertainty. In Section 3, we explain our analysis and discuss our key results and insights. In Section 4 and 5, we consider various extensions to our main model to develop further insights. In Section 6, we conclude with a discussion. We provide proofs of all our results in the Appendix.

2 Model

We develop a model with one firm selling one product and one consumer who buys at most one unit of the product. The product may or may not match the consumer's needs. If the product matches the consumer's needs then she obtains consumption utility of 1, and if the product does not match her needs then she obtains consumption utility of w, where $0 < w < 1$. Prior to purchase, the consumer knows the product price $0 \leq p \leq 1$ but is uncertain about the match of the product. We assume that the product match is resolved after purchase. The prior probability that the product matches the consumer's needs is given by $0 \leq q \leq 1$, and this is shared as prior belief by the consumer and the firm.

If the consumer purchases the product and finds out that the product matches her needs, then she obtains net utility $1 - p$. If the consumer purchases the product and it turns out to not be a match, then if the firm does not allow product return, the consumer cannot return the ill-matched product and thus obtains utility $w - p$; instead, if the firm allows the product return, then the consumer can return the ill-matched product and obtains net utility $-\gamma$, where γ is return fee set by the firm (note that the consumer would receive a refund of $p - \gamma$). We assume away a hassle cost of returning the product (in an extension, we discuss how a hassle cost affects the equilibrium outcome). We assume that the utility of the consumer's outside option is 0. For easy exposition, we denote a binary variable $\theta \in \{0, 1\}$ as the firm's return policy. Specifically, if $\theta = 1$, it means that the firm allows product return; if $\theta = 0$, it means that the firm does not allow product return.

If the consumer returns a product, the firm incurs a return processing cost $\xi > 0$. After incurring this cost, the firm can sell the product to a different consumer. For simplicity, we assume that consumers do not associate any reduced valuation with such products, i.e., a matching product still gives consumption utility of 1 and an ill-matched product gives consumption utility of w. (Allowing for a reduced valuation of buying previously-returned products will have no qualitative impact on our results and insights.) We assume the firm's marginal cost of production of the product is $\psi \geq 0$.

Prior to purchase, the consumer can also incur a search cost $c > 0$ to search information to reduce the uncertainty about product fit. We assume that the consumer fully resolves the match once she conducts the search. Therefore, the consumer would find a match with probability q and find no match with probability $1 - q$.

The timing of the game is the following. First, the firm decides the price p and whether or not to allow product return (i.e., either $\theta = 1$ or $\theta = 0$); if the firm allows the product return, it also sets the return fee γ. Next, the consumer decides whether or not to search. If the consumer searches, the consumer would buy if they find a match and would not buy otherwise. If the consumer buys without search and the firm allows product return, then the consumer decides whether or not to return the product by paying the return fee γ to the firm. We solve for the subgame-perfect equilibrium of the game.

3 Analysis

Before analyzing the main model above, we analyze a benchmark model in which consumer search is exogenously shut down and the firm decides price and return policy. Then, a comparison with the solution of the main model with consumer search enabled allows us to crystallize the role of consumer search in the design and impact of a return policy.

3.1 Benchmark

In this benchmark, consumer search is exogenously disabled. Observing the firm's decisions on price and return policy, the consumer decides whether or not to buy. If she buys, then the expected consumption utility, based on prior belief, is given by (we denote benchmark quantities by the subscript b):

$$EU_{\text{prior},b} = \underbrace{q(1-p_b)}_{\text{match}} + \underbrace{(1-q)(\overbrace{(1-\theta_b)(w-p_b)}^{\text{return not allowed}} + \overbrace{\theta_b(-\gamma_b)}^{\text{return allowed}})}_{\text{no match}},$$

where $0 \leq \theta_b\gamma_b \leq \theta_b(p_b - w)$ so that the consumer actually returns. The consumer will buy if and only if $EU_{\text{prior},b} \geq 0$. Therefore, the firm solves the following problem:

$$E\pi_b^* = \max_{p_b,\theta_b,\gamma_b} qp_b + (1-q)((1-\theta_b)p + \theta_b(\gamma_b - \xi)) - (\theta_b q + (1-\theta_b))\psi$$
$$\text{s.t. } EU_{\text{prior},b} \geq 0 \text{ and } 0 \leq \theta_b\gamma_b \leq \theta_b(p_b - w)$$

Note that the total production cost is given by $(\theta_b q + (1-\theta_b))\psi$. If the firm does not allow product returns (i.e., $\theta_b = 0$), the total number of products the firm produces is 1; instead, if the firm allows returns (i.e., $\theta_b = 1$), the firm only needs to produce q products because we assume that consumers do not depreciate returned products and are willing to wait for a later purchase.[8]

For this problem, if the firm chooses to offer a return policy (i.e., $\theta_b = 1$), the optimal solution is: $p_b^* = 1$, $\gamma_b^* = 0$,[9] and $E\pi_b^* = q(1-\psi) - (1-q)\xi$ (the expected costs of the firm processing returns is $(1-q)\xi$).[10] If the firm does not offer a return policy (i.e., $\theta_b = 0$), then the optimal solution is: $p_b^* = q + (1-q)w$, and $E\pi_b^* = q + (1-q)w - \psi$.

On the one hand, by allowing produt returns, the firm can charge a high price and obtain a high profit margin on the consumer with high ex-post valuation, and the consumer with low ex-post valuation can avoid an ex-post mistake. On the other hand, product returns are costly for the firm.

[8] If the consumer is impatient, then the firm may produce more than q products for consumers to buy at the beginning. This complicates the analysis without changing our insights qualitatively.

[9] Strictly speaking, there exist an infinite number of solutions that satisfy the condition $\frac{q}{1-q}(1-p_b^*) \geq \gamma_b^* \geq 0$. However, one can show that if there exits an arbitrarily small size of consumers who know the match, then there only exists one unique solution $p_b^* = 1$ and $\gamma_b^* = 0$.

[10] Initially, the firm produces q products. At the nth period, the expected costs of the firm processing returns is $q(1-q)^n\xi$. By summing up the costs in each period, we have the total expected costs $(1-q)\xi$.

Therefore, under $\xi \le \psi - w$ (i.e., the return processing cost is small), the firm allows product return and is able to charge a high price (i.e., $p_b^* = 1$) to target the consumer with high ex post valuation. The consumer with low ex post valuation would return the product for free (i.e., $\gamma_b^* = 0$). This corresponds to Region (a) in Figure 1.

Under $\xi > \psi - w$ (i.e., the return processing cost is high), the firm would choose not to allow product returns and would instead charge a low price (i.e., $p_b^* = q + (1-q)w < 1$) to attract all consumers to buy the product. This corresponds to Region (b) in Figure 1.

Furthermore, we find that the expected consumer surplus is always zero. This is because that the firm can appropriate the full consumer surplus through price and return policy designs. Specifically, under $\xi \le \psi - w$, the firm allows product returns and extracts full surplus from consumers with high ex post valuation by charging a high price; under $\xi > \psi - w$, the firm extracts full expected surplus by charging a price that is equal to the prior utility. We summarize the results in the following proposition.

Proposition 1 *When consumer search is exogenously shut down,*

(a) If $\xi \le \psi - w$ (return processing cost is low), the firm allows product return, charges a high price $p_b^* = 1$, and the consumer can return the product for free. The firm obtains profit $E\pi_b^* = q(1-\psi) - (1-q)\xi$ and the expected consumer surplus is zero. This corresponds to Region (a) in Figure 1.

(b) If $\xi > \psi - w$ (return processing cost is high), the firm does not allow product return, charges a low price $p_b^* = q + (1-q)w$, and the consumer buys without returns. The firm obtains profit $E\pi_b^* = q + (1-q)w - \psi$ and the expected consumer surplus is zero. This corresponds to Region (b) in Figure 1.

3.2 Main analysis and results

Next, we analyze our main model where consumer search is possible. First, given the firm's decisions on p, θ and γ, we analyze the consumer search and purchase decision. On the one hand, if the consumer buys the product without search, then with probability q, the purchased product matches the consumer's needs and thus the consumer gets utility $1-p$; with probability $1-q$, the purchased

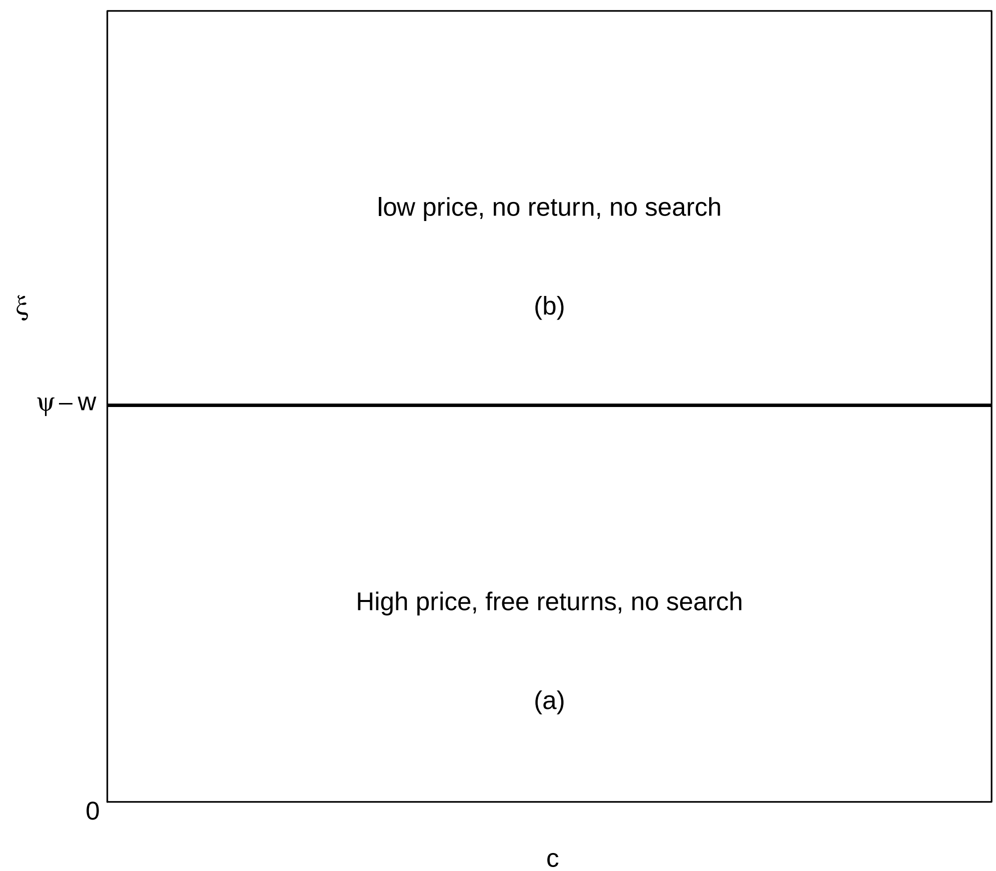

Figure 1: Equilibrium outcomes w.r.t. search cost (c) and return processing cost (ξ) when consumer search is exogenously shut down ($w = 0.2; q = 0.5; \psi = 0.4$).

product does not match, and the consumer gets utility $w - p$ if $\theta = 0$ or gets utility $-\gamma$ by returning the product if $\theta = 1$. Therefore, the expected consumption utility based on prior belief is given by

$$EU_{\text{prior}} = \underbrace{q(1-p)}_{\text{match}} + \underbrace{(1-q)(\overbrace{(1-\theta)(w-p)}^{\text{return not allowed}} + \overbrace{\theta(-\gamma)}^{\text{return allowed}})}_{\text{no match}} \tag{1}$$

Without search, the consumer would buy the product if and only if $EU_{\text{prior}} \geq 0$. Therefore, we denote the expected utility of not searching by $EU_{\text{ns}} \equiv \max\{EU_{\text{prior}}, 0\}$.

On the other hand, if the consumer searches before purchase, the consumer finds a match and buys the product with probability q; with probability $(1 - q)$, the consumer finds that the product does not match and thus she does not buy the product and then obtains the utility zero. Therefore, the expected utility of search is given by

$$EU_{\text{s}} = q(1-p) + (1-q)0 - c.$$

Note that the consumer will purchase the product in the following scenarios:

1. If $EU_{\text{s}} \geq EU_{\text{ns}}$, the consumer would search and buy the product only if she finds a match through search. In this case, the consumer can fully resolve the match uncertainty before purchase.

2. If $EU_{\text{s}} < EU_{\text{ns}}$ and $EU_{\text{prior}} \geq 0$, the consumer would buy the product without search. In this case, the consumer can fully resolve the match uncertainty after purchase.

Next, we discuss the firm's optimal strategies to induce the two purchase scenarios above. For the first purchase scenario where the consumer searches product information and buys the product only if she finds a match through search, the firm can obtain profit $E\pi_{(1)} = q(p-\psi)$ (the firm only needs to produce q products), and thus it solves the following profit maximization problem:

$$E\pi^*_{(1)} = \max_{p} \, q(p-\psi)$$
$$\text{s.t. } EU_{\text{s}} \geq EU_{\text{ns}}$$

For the second purchase scenario where the consumer buys without any search, with probability $1-q$, the consumer will find that the product does not match, and she can return the ill-matched product if the firm allows product returns. So the firm solves the following profit maximization problem

$$E\pi^*_{(2)} = \max_{p,\theta,\gamma} \, qp + (1-q)((1-\theta)p + \theta(\gamma-\xi)) - (\theta q + (1-\theta))\psi$$
$$\text{s.t. } EU_{\text{s}} < EU_{\text{ns}} \text{ and } EU_{\text{prior}} \geq 0 \text{ and } 0 \leq \theta\gamma \leq \theta(p-w)$$

The following proposition shows the equilibrium outcomes and Figure 2 shows the regions where the different equilibrium outcomes obtain.

Proposition 2 *When both consumer search and return policy are allowed, the following holds:*

1. *If $c \geq q(1-q)(1-w)$ (search cost is sufficiently high), then*

   (a) *If $\xi > \psi - w$ (return processing cost is high), the firm does not accept product returns ($\theta^* = 0$), charges a low price (i.e., $p^* = q + (1-q)w$) to induce the consumer to buy without search, and obtains expected profit $E\pi^* = q+(1-q)w-\psi$. The expected consumer surplus is zero. This corresponds to Region 1(a) in Figure 2.*

   (b) *If $\xi \leq \psi - w$ (return processing cost is low), the firm offers returns without charging any return fee to induce the consumer to buy without search, charges the highest price (i.e., $p^* = 1$), and obtains expected profit $E\pi^* = q(1-\psi) - (1-q)\xi$. The expected consumer surplus is zero. This corresponds to Region 1(b) in Figure 2.*

2. *If $c < q(1-q)(1-w)$ (search cost is sufficiently low), then:*

   (a) *If $\xi \geq \frac{c}{1-q}$ and $c(\frac{1}{1-q}+1) \leq q(1-\psi)+\psi-w$ (return processing cost is high while search cost is low), the firm induces the consumer to search and to buy only if she finds a match through search; it charges a relatively high price $p^* = 1-\frac{c}{q}$ (note that $p^* > q+(1-q)w$), there is no product return, and it obtains expected profit $E\pi^* = q(1-\psi)-c$. The expected consumer surplus is zero. This corresponds to Region 2(a) in Figure 2.*

   (b) *If $\xi < \frac{c}{1-q}$ and $q(1-\psi)-(1-q)\xi \geq \frac{c}{1-q}+w-\psi$ (return processing cost is not too high while search cost is neither too low nor too high), the firm allows product return without charging any return fee, i.e., $\theta^* = 1$ and $\gamma^* = 0$, induces the consumer to buy without search, charges the highest price $p^* = 1$, and obtains expected profit $E\pi^* = q(1-\psi) - (1-q)\xi$. The expected consumer surplus is zero. This corresponds to Region 2(b) in Figure 2.*

   (c) *If $c(\frac{1}{1-q}+1) > q(1-\psi)+\psi-w$ and $q(1-\psi)-(1-q)\xi < \frac{c}{1-q}+w-\psi$ (return processing cost is high while search cost is medium), the firm does not allow product returns, induces the consumer to buy without search, charges a very low price $p^* = \frac{c}{1-q}+w$ (note that $p^* < q+(1-q)w$), and obtains expected profit $E\pi^* = \frac{c}{1-q}+w-\psi$. The expected consumer surplus is $q(1-w)-\frac{c}{1-q}$, which is higher than zero. This corresponds to Region 2(c) in Figure 2.*

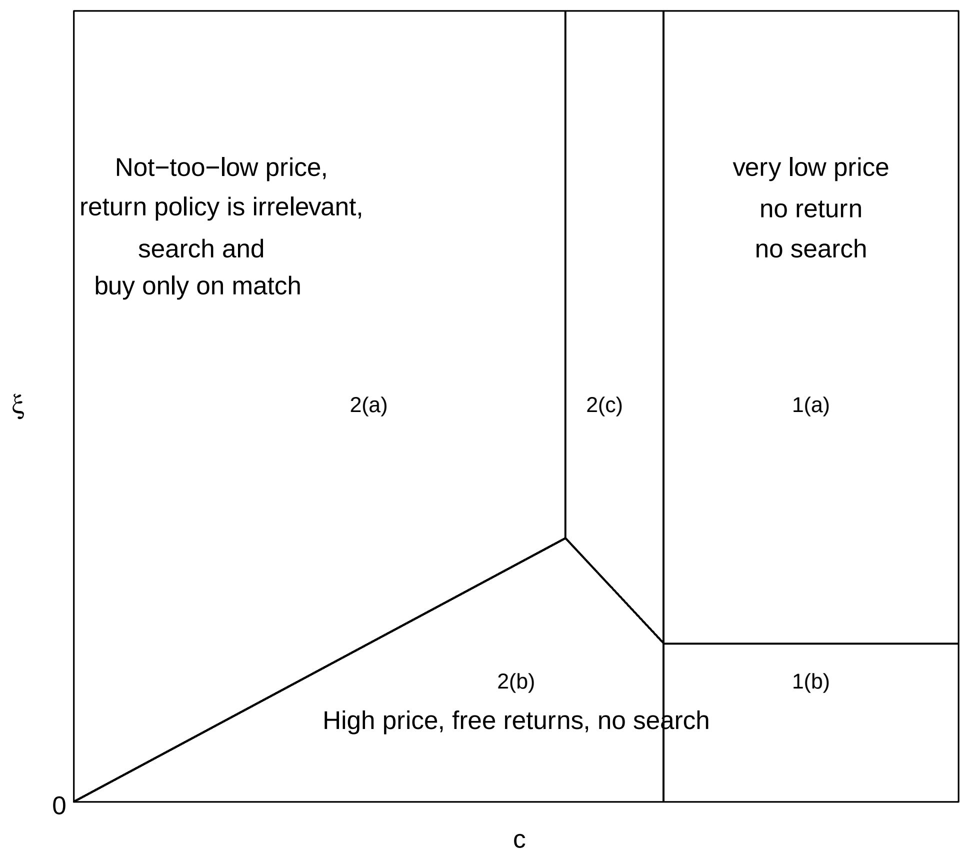

Figure 2: Equilibrium outcomes w.r.t. search cost (c) and return processing cost (ξ) ($w = 0.2; q = 0.5; \psi = 0.4$).

In Regions 1(b) and 2(b), the equilibrium solutions are identical. Here, the return processing cost is not high (and the search cost is not too low). The firm allows product returns to induce consumers to buy without search, charges a high price to extract full surplus from the consumer with high ex post valuation, and the consumer with low ex post valuation can return product for free. This scenario basically corresponds to the Zappos example that we discussed in the introduction where Zappos offers a very liberal return policy and charges a relatively high price for its shoes, and it can be surmized that the search cost is not low and the return processing cost (such as refurbishing cost) for durable goods such as shoes is not too high.

In Region 2(a) where search cost is low and return processing cost is high, the firm induces the consumer to search and invest in resolving the uncertainty before purchase because returns are costly for the firm. This scenario corresponds to the Warby Parker example discussed before. The home try-on program of Warby Parker allows the consumer to search for product match information efficiently, while Warby Parker charges a not-too-low price so that the consumer would not buy if they did not find a match through search. However, while Warby Parker allows returns, the home try-on program reduces the incidence of desired returns, which reduces the use and relevance of the return policy.

In Regions 1(a) and 2(c), where search cost is high and return processing cost is high, the firm charges a very low price to induce the consumer to buy without search, and it does not allow product returns because the low price can not support a large number of returns. This corresponds to some retailers, like Dollar Tree, which adopts a low-price strategy and does not allow product returns, and consumers in this case typically do little search for the product because of the low price. Furthermore, it is worth noting that in Region 2(c), the price is so low that the consumer can obtain a positive expected surplus (in other regions, the surplus is zero).

Next, we aim to understand how consumer search affects the return policy design and the firm's profit. Therefore, we compare the equilibrium results in the main model with those in the benchmark, as shown in Figure 3. There are eight regions in Figure 3 and we discuss them one by one. Before that, we note that in the regions shared dark grey (Regions I and II) the firm makes higher profit with search than in the benchmark scenario, in the regions shaded light grey (Regions III, IV and V) the firm makes lower profit with search than in the benchmark scenario, and in the unshaded regions (Regions VI, VII and VIII) the firm makes the same profit with search as in the benchmark scenario.

As mentioned earlier, we find that compared to the benchmark, consumer search improves the firm's profit in Regions I and II. First, note that these regions exist only if the firm's marginal product cost is large enough, specifically, $\psi > w$. Under this condition, the firm's profit is higher in the main model compared to the benchmark if the consumer's search cost (c) is small and the firm's return processing cost (ξ) is relatively high (Regions I and II in Figure 3). First, a high marginal production cost motivates the firm to charge a high price. Therefore, to charge a high price, the firm can either allow product returns or induce the consumer to search and resolve match uncertainty before purchasing. In Region I, the firm induces the consumer to search without returns in the

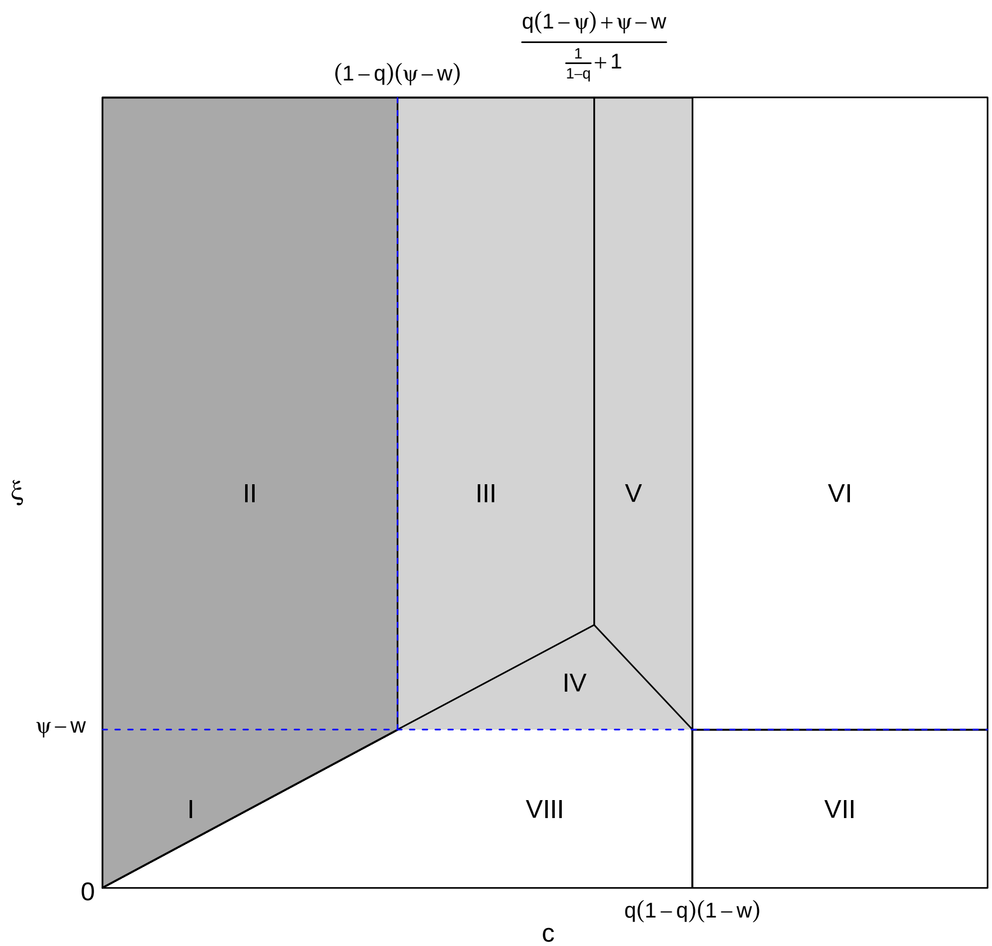

Figure 3: Comparison between main model and benchmark ($w = 0.2; q = 0.5; \psi = 0.4$).

main model while it allows product returns (to charge a high price) in the benchmark. On the one hand, consumer search resolves the match uncertainty before purchase, and thus there would be no returns and no return processing costs for the firm — essentially, the firm transfers the cost of determining a match to the consumer rather than incur the cost of a mismatched returned product. On the other hand, due to search cost, the firm has to lower the price (compared to the benchmark) to induce the consumer to search. Overall, when the search cost is low, the first effect dominates and thus the firm can benefit from consumer search.

In Region II, where the return processing cost is quite high, the firm avoids returns — it induces the consumer to search before purchasing in the main model while it induces the consumer to buy without returns in the benchmark. In this case, consumer search benefits the firm because it allows the firm to charge a higher price and obtain a higher profit margin than that in the benchmark. Overall, in both regions, the firm can obtain a higher profit than in the benchmark.

Said differently, in both Regions I and II, the consumer searches and buys only on match in the main model but, in the benchmark, product returns are allowed in Region I and not allowed in Region II. Compared to the benchmark, in Region I the firm's higher profit is coming from saving on return costs, while in Region II they are coming from higher price.

In all other regions, i.e., Regions III to VIII, the firm makes (weakly) less profit under search compared to the benchmark because search cost is high and if the firm wants to induce search it has to reduce price. Following this logic, Region III is similar to Region II, except that the search cost is higher in Region III and thus the firm has to charge a lower price to induce the consumer to search (although the price is still higher than that in benchmark). Since the price is not high and the consumer buys only when they find a match through search, the firm's profit is lower than that in the benchmark.

In Region IV, the firm does not offer returns in the benchmark, whereas it is motivated to offer product returns in the main model. The motivation for the firm to allow product returns in this case is that the consumer search limits the firm's pricing capability and thus the firm would like to allow product returns to induce consumers to buy without search. By doing this, it can charge a high price, i.e., $p^* = 1$. Note that although the firm can charge a high price by allowing returns, the return processing cost is high and thus the firm's profit is still lower than that in the benchmark.

In Region V, the firm does not allow product returns as in the benchmark. However, because the consumer can search, the firm has to charge a very low price to induce the consumer to buy without search. This leads to a lower profit for the firm compared to the benchmark. The consumer can benefit from such a low price and obtain a positive expected surplus (in all other regions, the consumer surplus is zero.)

Finally, in Region VI, VII and VIII, the firm adopts the same strategy and obtains the same profit as in the benchmark. We summarize the key insights in the following corollary.

Corollary 1 *When the consumer can search, compared to the benchmark without search:*

1. *Depending on the search cost and return processing cost, the consumer search can deter the*

firm from offering returns (Region I) or encourage the firm to allow returns (Region IV).

2. *Consumer search improves the firm's profit only when the marginal production cost is relatively high, the search cost is small and the return processing cost is relatively high (Regions I and II).*

3. *The consumer can benefit from a high search cost (Region V).*

4 Inconclusive search

In the main model, we assume that the search can fully resolve the match uncertainty. Therefore, in the equilibrium where the consumer chooses to search, there would be no return policy. In other words, inducing consumer to search and allowing product returns do not coexist in equilibrium. However, we observe in reality that consumers in many cases conduct search to obtain information about the product before purchasing it even when a firm offers a return policy (Bechwati and Siegal 2005, Sahoo et al. 2018, Ibragimov et al. 2022, Zhang et al. 2022). Furthermore, Ibragimov et al. (2022) and Zhang et al. (2022) document that consumers often return products even after searching before purchasing. This implies that pre-purchase search does not always fully resolve product valuation for the consumer as effectively as experiencing the product post-purchase can. Therefore, we intuit that if there is some chance that the search fails to provide conclusive information to the consumer, then allowing product returns in this case may induce the consumer to buy even if the search turns out to not provide a conclusive resolution to the match (as she can return the ill-matched product).[11]

Therefore, the main goal of this section is to incorporate inconclusive search into the main model and investigate the conditions when search and returns coexist. With everything else being the same as the main model, we assume that with probability δ the search is successful/conclusive in the sense that the consumer would perfectly know the product fit and, in particular, the consumer would find a match with probability q and find no match with probability $1-q$; however, with probability $1-\delta$ the search is unsuccessful/inconclusive in the sense that the consumer gets no new information through search and thus can not update her belief in this case. We call $0 \leq \delta \leq 1$

[11] This is similar to Dukes and Liu (2016) where consumers can do a partial search. The main difference is that in Dukes and Liu (2016) consumers deliberately do a partial search, while in our case the search may randomly fail to provide conclusive match information.

the "search informativeness."[12] It is common that consumers may not be able to find out the product information that matters to them after conducting the search. For example, suppose that a consumer is looking for product information on a product reviews website. Although there may be hundreds of product reviews for the product, few of them may mention the attributes that the consumer cares about. Therefore, after conducting a search on dozons of reviews, the consumer may still not be able to obtain the information she is looking for (and she has limited time and thus can not read all of the available reviews).[13] In our analysis, we show that some specific types of return policy can exist only when the search is inconclusive (i.e., $\delta < 1$) and thus modeling the unsuccessful search outcome is necessary for us to comprehensively understand the interaction between return policy and consumer search.

As in the main model, the expected consumption utility based on prior belief is given by

$$EU_{\text{prior}} = \underbrace{q(1-p)}_{\text{match}} + \underbrace{(1-q)(\overbrace{(1-\theta)(w-p)}^{\text{return not allowed}} + \overbrace{\theta(-\gamma)}^{\text{return allowed}})}_{\text{no match}} \tag{2}$$

The consumer would buy the product without search if and only if $EU_{\text{prior}} \geq 0$. Therefore, we denote the expected utility of not searching by $EU_{\text{ns}} \equiv \max\{EU_{\text{prior}}, 0\}$.

If the consumer searches before purchase, with probability δ the search is conclusive and provides match information. I.e., with probability δq the consumer finds a match and thus she purchases the product and obtains the utility $1-p$; with probability $\delta(1-q)$, the consumer finds that the product does not match and thus she does not buy the product and then obtains the utility zero. With probability $1-\delta$ the search is inconclusive, and the consumer finds no new information and makes a purchase if and only if $EU_{\text{prior}} \geq 0$. Therefore, the expected utility of search is given by

$$EU_{\text{s}} = \underbrace{\delta(q(1-p) + (1-q)0)}_{\text{conclusive search}} + \underbrace{(1-\delta)EU_{\text{ns}}}_{\text{inconclusive search}} - c.$$

Note that the consumer will purchase the product in the following three scenarios:

[12]We assume δ to be exogenous. In the extensions, we discuss the cases where the firm can endogenously set δ within limits.

[13]Li et al. (2019) model the offering of free samples to consumers as providing a signal which can perfectly reveal product quality with some probability and is uninformative otherwise; this is similar to our setup for consumer search. Ibragimov et al. (2022) document that consumers often return products even after searching extensively before purchasing; this implies that pre- purchase search does not always fully resolve product valuation for the consumer as effectively as experiencing the product post-purchase can.

1. If $EU_{\text{s}} \geq EU_{\text{ns}}$ and $EU_{\text{prior}} < 0$, the consumer would search and buy the product only if she finds a match through search. In this case, there is no need to return product.

2. If $EU_{\text{s}} \geq EU_{\text{ns}}$ and $EU_{\text{prior}} \geq 0$, the consumer would search and buy the product if they find a match through search or if the search is inconclusive (because $EU_{\text{prior}} \geq 0$). In this case, the consumer can return the ill-matched product if the firm allows product return.

3. If $EU_{\text{s}} < EU_{\text{ns}}$ and $EU_{\text{prior}} \geq 0$, the consumer would buy the product without search.

Next, we discuss the firm's optimal strategies to induce the three purchase scenarios above. First, consider the firm's strategy to induce the first purchase scenario where the consumer searches product information and buys the product only if she finds a match through search. In this case, there would be no product return (and thus we assume that the firm would not offer return policy). The firm can obtain profit $E\pi_{(1)} = \delta q(p - \psi)$, and thus solves the following profit maximization problem:

$$E\pi^*_{(1)} = \max_{p} \delta q(p - \psi)$$
$$\text{s.t. } EU_{\text{s}} \geq EU_{\text{ns}} \text{ and } EU_{\text{prior}} < 0$$

Next, consider the firm's strategy to induce the second purchase scenario where the consumer searches and buys the product either if she finds a match through search (this will occur with probability δq) or if the search happens to be inconclusive (this will occur with probability $1 - \delta$). In this case, the consumer can return the ill-matched product if $\theta = 1$ and can not return it if $\theta = 0$. So, the firm solves the following profit maximization problem:

$$E\pi^*_{(2)} = \max_{p,\theta,\gamma} q(p - \psi) + (1 - \delta)(1 - q)((1 - \theta)(p - \psi) + \theta(\gamma - \xi))$$
$$\text{s.t. } EU_{\text{s}} \geq EU_{\text{ns}} \text{ and } EU_{\text{prior}} \geq 0 \text{ and } 0 \leq \theta\gamma \leq \theta(p - w)$$

Note that the firm only needs to produce q products under $\theta = 1$ (i.e., offering returns), whereas it needs to produce $q + (1 - \delta)(1 - q)$ products under $\theta = 0$ (i.e., not offering returns).

Finally, consider the firm's strategy to induce the consumer to buy without any search. In this case, with probability $1 - q$, the consumer will find that the product does not match, and she can return the ill-matched product if the firm allows product returns. So the firm solves the following profit maximization problem

$$E\pi^*_{(3)} = \max_{p,\theta,\gamma} q(p-\psi) + (1-q)((1-\theta)(p-\psi) + \theta(\gamma-\xi))$$
$$\text{s.t. } EU_{\text{s}} < EU_{\text{ns}} \text{ and } EU_{\text{prior}} \geq 0 \text{ and } 0 \leq \theta\gamma \leq \theta(p-w)$$

The equilibrium outcomes are specified in the following proposition and illustrated in Figure 4.

Proposition 3 *When inconclusive search is considered, the following holds:*

(A) If return processing cost is low and search cost is neither too low nor too high, the firm offers a generous return policy without charging any return fee (i.e., $\theta^* = 1, \gamma^* = 0$) to induce the consumer to buy without search, charges the highest price (i.e., $p^* = 1$), and obtains expected profit $E\pi^* = q(1-\psi) - (1-q)\xi$. This corresponds to Region A in Figure 4.

(B) If search cost is small and the return processing cost is intermediate, the firm induces the consumer to search and to buy the product if she finds a match or if the search is inconclusive; it charges a relatively high price $p^* = 1 - \frac{c}{\delta q}$, allows product return (i.e., $\theta^* = 1$) with a return fee $\gamma^* = \frac{c}{\delta(1-q)}$, and obtains expected profit $E\pi^* = q - c - (1-\delta)(1-q)\xi - q\psi$. This corresponds to Region B in Figure 4.

(C) If the search cost is small and the return processing cost is high, the firm induces the consumer to search and to buy only if she finds a match through search; it charges a relatively high price $p^* = 1 - \frac{c}{\delta q}$, there is no product return, and obtains expected profit $E\pi^* = \delta q(1-\psi) - c$. This corresponds to Region C in Figure 4.

(D) If the search cost is intermediate and the return processing cost is high, the firm induces the consumer to search and to buy if she finds a match or if the search happens to be inconclusive; it charges a low price $p^* = q + (1-q)w$, does not allow product return, i.e., $\theta^* = 0$, and obtains expected profit $E\pi^* = (\delta q + 1 - \delta)(q + (1-q)w - \psi)$. This corresponds to Region D in Figure 4.

(E) If the search cost is high and the return processing cost is high, the firm does not accept product returns ($\theta^* = 0$), charges a low price (i.e., $p^* = \min\{q + (1-q)w, \frac{c}{\delta(1-q)} + w\}$) to

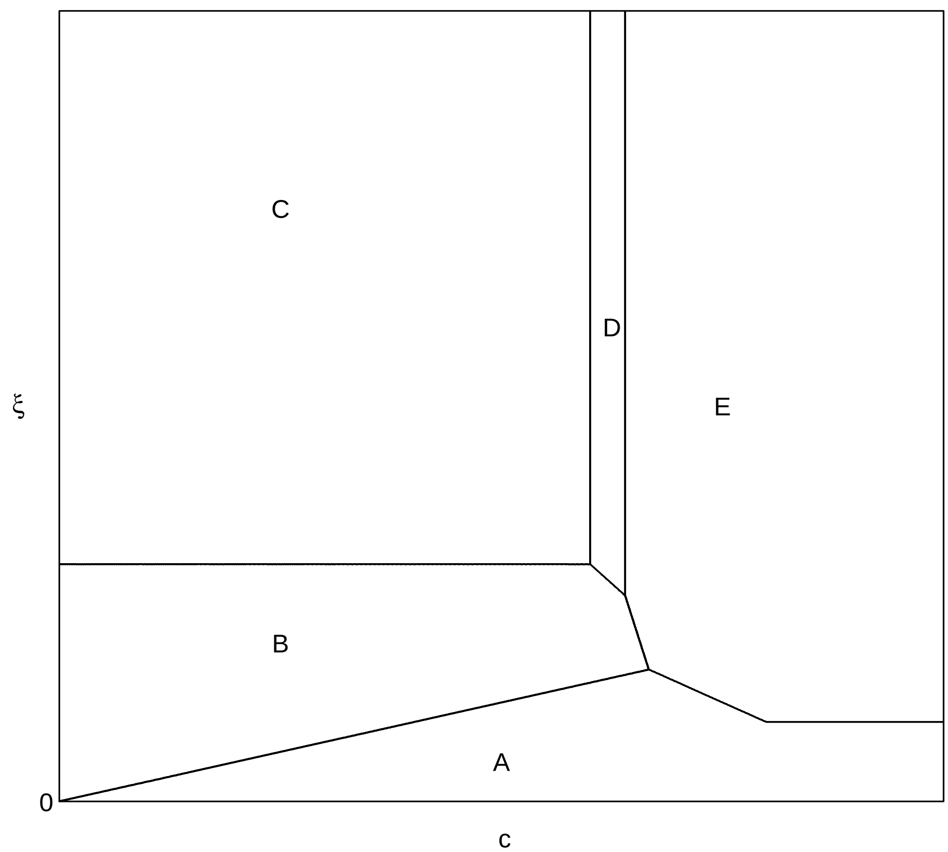

Figure 4: Equilibrium outcomes w.r.t. search cost (c) and return processing cost (ξ) ($w = 0.2; q = 0.5; \delta = 0.8; \psi = 0.4$).

induce the consumer to buy without search, and obtains expected profit $E\pi^* = \min\{q + (1 - q)w - \psi, \frac{c}{\delta(1-q)} + w - \psi\}$*. This corresponds to Region E in Figure 4.*

Three cases (i.e., Region A, C and E) are similar to the main model where search is always conclusive. Specifically, when the returning processing cost is low and the search cost is not low (Region A), the firm charges a high price and offers a generous return policy under which the consumer can return an ill-matched product for free; when the returning processing cost is high and the search cost is small (Region C), the firm induces the consumer to search and only buy when they find a match through search. Thus, there is no need for return and return policy becomes irrelevant; when the returning processing cost is high and the search cost is high (Region E), the firm charges a very low price to induce the consumer to buy without search and without returns.

The other two cases (Region B and Region D) are new due to inconclusive search. In particular, when return processing cost is intermediate and the search cost is low (Region B), the firm offers a price that is not too low along with a return policy with a moderate fee, and the consumer conducts the search and buys on match or on unsuccessful search. This corresponds to the practices for many retailers' where the retailers price such that consumers search for match information and also accept product returns with a return fee. Interestingly, return policy and consumer search can coexist in this case. This is because consumer search can help resolve the match uncertainty and thus under an intermediate return processing cost, the firm has the incentive to induce the consumer to search first and also offers returns if search fails to provide information for some consumers. By doing so, the firm can still charge a relatively high price and also consumer search helps reduce the number of returns and thus reduce the return processing costs for the firm. It is also intereting to note that the return fee needs to be moderate in this case. It cannot be zero or too low because the consumer will simply buy the product without any search and then the firm will receive a large number of returns. Also, it cannot be too high because the consumer will then not buy the product when search fails. Therefore, the optimal return fee is relatively moderate. Furthemore, the return fee would decrease as the search becomes more efficient (i.e., smaller c or larger δ). This is because as search is more efficient, the consumer still wants to search under a lower returning fee, and a lower returning fee allows the firm to charge a higher price. We summarize the above insights in the following corollary.

Corollary 2 *When search can be inconclusive, if return processing cost is intermediate and the search cost is low, consumer search and product returns can coexist, and the firm offers a return policy with moderate returning fee. The returning fee decreases with the search efficiency.*

When return processing cost is high and search cost is intermediate (Region D), the firm does not allow product returns but charge a not-too-low price to induce the consumer to search first and buy even if search fails to provide information. The intuition is that by lowering the price (compared to Region C), the firm can increase purchases from inconclusive search. Furthermore, the consumer can obtain a positive expected surplus because the price has to be low to induce the

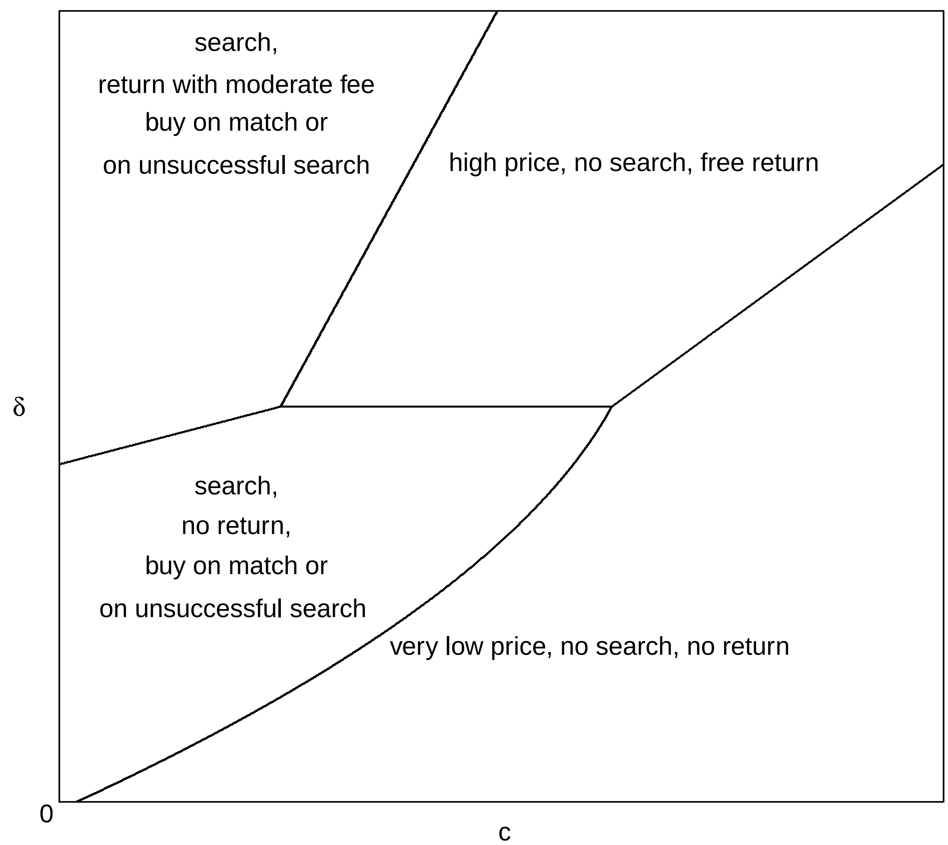

Figure 5: Equilibrium outcomes w.r.t. search cost (c) and search informativeness (δ) ($w = 0.2; q = 0.5; \xi = 0.1; \psi = 0$)

consumer to buy when search fails and thus the consumer can obtain a positive surplus when they find a match through search (when the product matches, the consuemr only needs to pay the price $p^* = q + (1 - q)w$. So the surplus is $1 - p^*$).

Next, with the aid of Figure 5, we discuss how the search efficiency (i.e., search cost c and search informativeness δ) affect the optimal return policy. In general, when the search is efficient, i.e., c is low and δ is high, if the firm wants to induce the consumer to buy without search and without returns, then it has to charge a very low price. Therefore, when the search is moderately efficient, instead of inducing consumer to buy without returns and without search, the firm wants to offer a generous return policy to invite consumers to buy without search and thus charge a high price on the consumers with high ex post valuation. When the search becomes very efficient, the firm would not only offer a return policy with moderate returning fee but also invite the consumers to search first (because this can help reduce the number of returns without sacrificing the price too much.) Overall, the firm allows product returns if the consumer search is efficient and does not allow product returns if the search is inefficient.

5 Other extensions

In the following, we extend our analysis to consider the consumer's hassle cost of returning produts, complexity design for the return policy, and endogenous search informativeness by the firm. For easy exposition, we asume the marginal production cost is zero, i.e., $\psi = 0$, in this section.

5.1 Hassle cost

Building on the model in Section 4, we assume that consumers incur a hassle cost $h > 0$ to return the products. With a hassle cost, we find that our main insights still hold and some new insights about return policy also arise, illustrated with the help of Figure 6. (We provide the detailed solutions and the proofs in the appendix.)

Specifically, in the region B1, consumers are induced to search and the return policy is generous (no return fee, $\gamma^* = 0$). Note that this is differnt from the model without hassle cost in which if consumers are induced to search and a return policy is offered, then the return fee is not zero. However, this is consistent with our observation that firms often charge no return fee but consumers still conduct search before purchase. The intuition is that when the hassle cost is not low, the firm has to offer a generous return policy to induce consumes to buy when their search fails.

Interestingly, we find that in this case the consumers can also obtain a positive surplus and would benefit from higher hassle cost and from a lower chance of match (the expected user surplus is given by $EU^* = \delta(1-q)h - c$). The intuition is that as the hassle cost becomes higher or there is a lower chance of match, the firm has to charge a lower price to induce consumes to search and buy when their search fails (return fee is endogenously set to be 0). Therefore, the consumers can benefit from higher hassle cost and lower chance of match. This also explains why sometimes a firm has the incentives to reduce the consumer's hassle cost (e.g., offering return shipping label). We

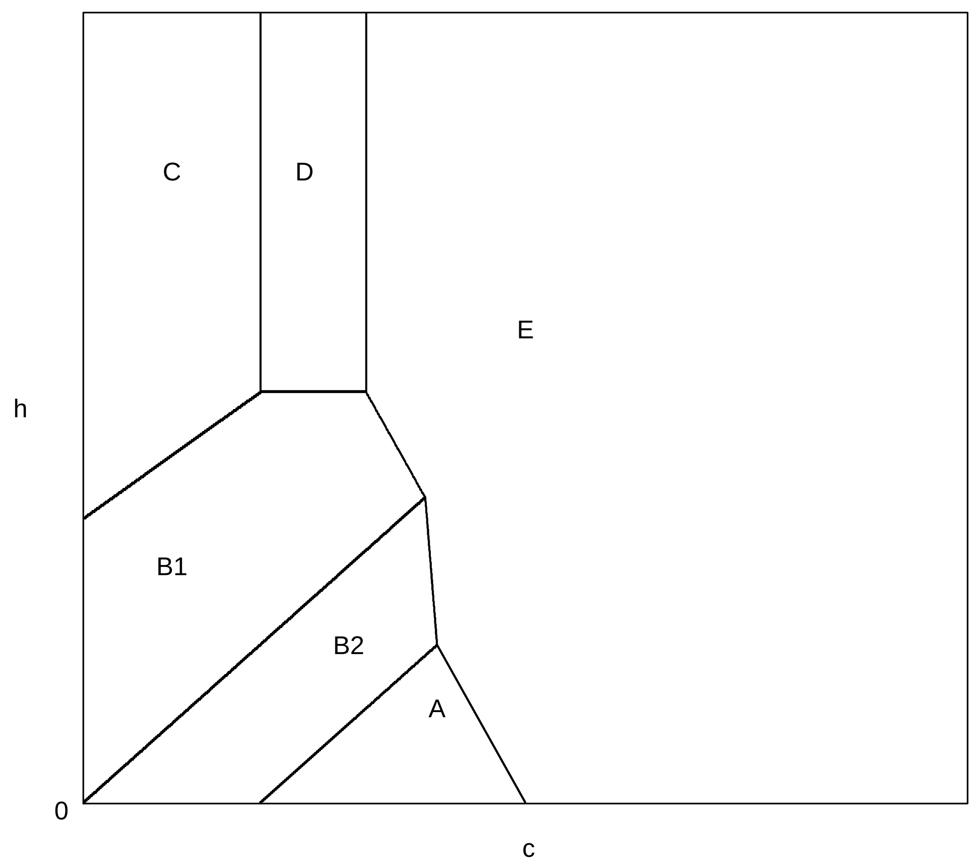

Figure 6: Equilibrium outcomes w.r.t. c and h ($w = 0.2; q = 0.5; \delta = 0.8; \xi = 0.1$. Region A corresponds to the equilibrium case: no search and generous return policy is offered ($\gamma^* = 0$); Region B1 corresponds to the equilibrium case: search and generous return policy is offered ($\gamma^* = 0$); Region B2 corresponds to the equilibrium case: search and strict return policy is offered ($\gamma^* > 0$); Region C corresponds to the equilibrium case: search and buy only if find a match and return policy is irrelevant; Region D corresponds to the equilibrium case: search and buy if find a match or if the search fails and no return policy; Region E corresponds to the equilibrium case: no search and no return policy.)

summarize the discussion above in the following proposition.

Proposition 4 *When there is a hassle cost of return, the consumer may benefit from a higher hassle cost and a lower chance of match. This happens in the equilibrium where the firm offers a generous return policy and the consumer is induced to search and buy even if the search fails.*

5.2 Complexity of return policy

It is common that a firm may accept a product return only under certain conditions (e.g., "must return within 14 days after purchase," "must return in the original packaging," "must have the original receipt," etc.). We call such conditions as the "complexity" of the return policy. The more complex the return policy is (i.e., the more conditions the return policy has), the more difficult and thus less likely it is for consumer to return the ill-matched product. Therefore, the question arises that when does the firm have incentives to complicate or ease the return process to affect the probability of product return?

In this section, we extend our model to allow the firm to choose the complexity of the return policy along with other decisions in the main model. Specifically, we allow the firm to choose any value $\theta \in [0, 1]$ (in our main model, the firm can only choose either $\theta = 1$ or $\theta = 0$). θ can be perceived as the probability of the consumer being able to return the ill-matched product. A more complex return policy implies a lower θ. For instance, the more complex the return policy is, i.e., the more conditions it has, the more likely it is that the consumer randomly violates the policy (e.g., the consumer randomly misplaces the receipt or loses the original packaging). The timing of the game in the extended model is the same as in the main model.

Following analysis similar to that in the main model, we can get the equilibrium outcomes as shown in Figure 7. An interesting new finding is that in Regions A and B where the firm offers return policy, it makes the return policy complex to some degree (i.e., $0 < \theta^* = 1 - \frac{\frac{c}{(1-q)\delta}}{1-w-\frac{c}{q\delta}} < 1$) so that there is positive probability, given by $1 - \theta^*$, that the consumer is not able to return the ill-matched product. However, at the same time, the firm will always offer a full refund (i.e., $\gamma^* = 0$) to the consumer if the consumer is able to return the ill-matched product (which occurs with probability θ^*). The intuition is that the firm always prefers no return because the returned product has lower value for the firm than if it is not returned. Therefore, the firm increases the complexity of return

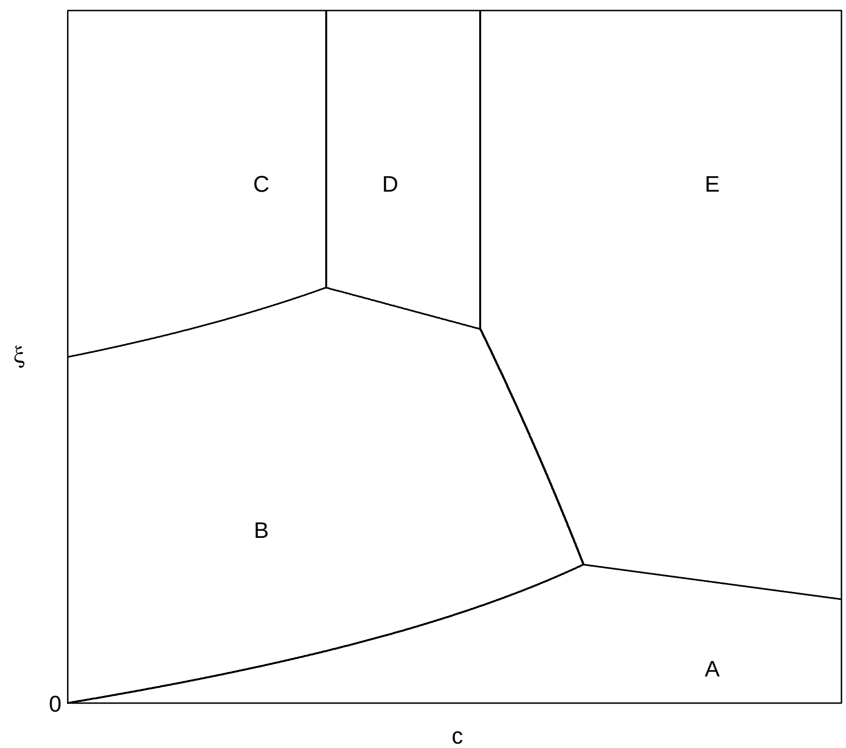

Figure 7: Equilibrium outcomes w.r.t c and ξ ($w = 0.2; q = 0.5; \delta = 0.8$). In Region A, the firm offers a generous return policy with some complexity, and the consumer does not search. In Region B, the firm offers a generous return policy with some complexity, and the consumer searches and buys on a match or on an unsuccessful search. In Region C, the firm does not offer returns and the consumer searches and buys only on a match. In Region D, the firm does not offer returns and the consumer searches and buys on a match or on an unsuccessful search. In Region E, the firm does not offer returns and the consumer buys without search.

policy and thus reduces the chance of returning as much as possible. However, to achieve this, the firm has to decrease the return fee to maintain the attractiveness of return policy to the consumer. Eventually, the firm keeps increasing the complexity of return policy until the commensurate return fee becomes zero.

It is also worth noting that the complexity of the return policy increases as search becomes less efficient for the consumer (i.e., θ^* decreases in c and increases in δ). The intuition is that the firm designs a return policy such that the consumer is indifferent between search and buying without search. Therefore, if search becomes less efficient for the consumer, the firm has the incentive to increase the complexity of their return policy so that the consumer will still be indifferent. We summarize the discussion above in the following proposition.

Proposition 5 *In the equilibrium where the firm decides to offer the return policy, it adds some complexity to the return policy (i.e.,* $0 < \theta^* = 1 - \frac{\frac{c}{(1-q)\delta}}{1-w-\frac{c}{q\delta}} < 1$*) with full refund (i.e.,* $\gamma^* = 0$*) so that the consumer may not be able to return the ill-matched product with some probability but can get full refund if she is able to. The complexity of return policy increases in search cost* c *and decreases in* δ*.*

The main takeaway from this extension is that when the firm can add complexity to the return policy (by adding clauses to the policy that the consumer may not be able to always meet, e.g., original packaging, original receipt, limited return window, etc.), then if it offers a return policy it offers a full refund but, under different conditions, it adds different levels of complexity (i.e., different numbers of clauses of different intensities) to the return policy. We note that this aligns well with market practice where companies often offer "free returns" but various clauses are added to the return policy.

5.3 Endogenous search informativeness

Under return policy, does the firm have incentives to increase or decrease the search informativeness (i.e., δ in our model)? Specifically, the firm can often decide how much information to provide on its official web pages or in its ads. The more information is provided by the firm, the more likely it is for a consumer to find useful information during search to update her belief. Furthermore, offering return policy can also be perceived as a way to provide information to consumers after purchase.

Therefore, it is natural to ask whether or not the firm has the incentives to provide information for consumer to search, if return policy is offered?[14]

To answer this question, we extend the main model by allowing the firm to choose δ along with other decisions in the main model. Specifically, the firm can choose $\delta \in [\underline{\delta}, \overline{\delta}]$, where $\underline{\delta}$ is the minimum level of search informativeness that the firm can choose (e.g., consumers may also search product information on other channels such as third-party reports and product reviews sites, and $\underline{\delta}$ is the search informativeness on these other channels that are not controlled by the firm), and $\overline{\delta}$ is the upper bound the firm can increase the informativeness to. If the firm chooses $\delta = \underline{\delta}$, then it means that the firm does not provide extra product information and the consumer can only search information through other channels. However, if the firm chooses $\delta > \underline{\delta}$, then it means that the firm provides further information to increase the search informativeness for the consumer. In addition to δ, the firm also chooses product price p, whether or not to offer a return policy, i.e., either $\theta = 0$ or $\theta = 1$, and in the latter case the return fee γ. We assume for simplicity that there is no cost for the firm to provide information. The timing of the model is the same as in the main model. We state the key result from this analysis in the following proposition.

Proposition 6 *Suppose the firm can choose $\delta \in [\underline{\delta}, \overline{\delta}]$. If $\underline{\delta} > \frac{c}{q(1-q)(1-w)}$ and c is small, the firm increases search informativeness such that $\delta^* = \overline{\delta}$. Otherwise, the firm decreases search informativeness such that $\delta^* = \underline{\delta}$.*

Interestingly, as shown in Proposition 6, we find that on the one hand, if the external search informativeness $\underline{\delta}$ is high and the search cost c is low, then the firm has the incentive to further increase the search informativeness such that $\delta = \overline{\delta}$ to induce the consumer to search, and it may also allow product returns given the return processing cost is not too high. The intuition is that a high $\underline{\delta}$ and a low search cost will induce the consumer to search product information and thus the firm has the incentives to further increase the search informativeness so that the consumer is less likely to buy an ill-matched product and it can thus charge a higher price. Furthermore, given the return processing cost is not too high, the firm will further allow product returns so that the consumer will still buy the product even if the search happens to be inconclusive, which increases the sales.

[14] The consumer may also be able to endogenously determine the search informativeness by exerting costly effort. We find that our insights do not change qualitatively in this case.

On the other hand, if the external search informativeness $\underline{\delta}$ is low or the search cost c is high, the consumer has low motivation to search and thus it is not profitable for the firm to induce consumer search by providing information. Instead, the firm will decrease search information and choose the strategy to induce the consumer to buy without search and, if the return processing cost for the firm is low, it may offer generous return policy to induce the consumer to buy without search.

The main takeaway from this extension is that, when there is a return policy, the firm may want to increase or decrease search informativeness under different conditions, and it wants to set the search informativeness to one of the possible extremes.

6 Discussion and Conclusions

When a consumer does not know her match with a product, she can conduct a search that could give her a better idea of the match before making the purchase decision. Alternatively, if the seller offers a return policy then, depending on the terms of the policy, the consumer may be less inclined to search before purchase because she can return an ill-matched product after purchase. Therefore, it is natural to study consumer search and firm return policy together. In this paper, we build an analytical model in which consumers can conduct costly search before purchase and a seller can determine price and return policy. Due to the rich insights that we obtain, and the alignment of our results with reality, our model can be used to guide managers on why, when and how they should help a consumer resolve the match uncertainty (by product returns, by search or by both), and how they can expect consumers to react to these policies.

Our analysis reveals that the search cost, marginal production cost and return processing cost are important parameters that determine a firm's pricing and return policy. A key takeaway is that consumer search can be used to reduce returns and save the return processing costs for the firm, whereas return policy can also be employed to offset the negative impact of consumer search on the firm's pricing capability.

Furthermore, we are able to explain a variety of pricing and return policies that firms use, such as accepting free returns with almost no conditions (e.g., Zappos), facilitating pre-purchase search to reduce consumer reliance on returns (Warby Parker), not accepting returns (e.g., low-priced stores such as Dollar Tree), and accepting returns with a partial refund (most retailers). On the last policy, we find that firms can equivalently accept returns with a partial refund, or offer full refunds but add clauses to the return policy (e.g., original packaging, completely unused product, return within 14 days, etc.) that make it less likely that a consumer will be able to return the product, where the latter is a policy that is quite widely adopted by sellers. We also note that while it might appear that it must be that liberal return policies (e.g., with full refunds) are offered due to intense competition among firms, we show that such policies arise in a monopolistic situation and, in fact, they are always optimal if the firm can adjust the complexity of the policy by adding various clauses to the policy. Finally, we also show that consumer search and product returns can coexist when search is inconclusive, a higher hassle cost can benefit the consumer, and the firm has the incentive to increase or decrease the level of information available to consumers from search and this is determined jointly with its return policy.

We propose several directions for future work. First, we model search as a one-step process done before purchase which either succeeds (in which case the consumer knows the match perfectly) or fails (in which case the consumer gets no new information). Search could alternatively be modeled as a sequential process with the informativeness determined by the effort exerted in the search (as in Jerath & Ren (2021)) and could potentially be conducted both before and after purchase. Second, we model inconclusive search as search randomly providing no information or full information. We could model this on the lines of Dukes and Liu (2016) where consumers can strategically do search that reveals only partial information. Third, studying a situation with firms offering multiple products could be insightful into consumer behavior, and how firms should respond optimally. For instance, at the online shoe retailer Zappos, which has a very liberal return policy, consumers often buy multiple products with the intention to only keep one of them and return all others. Our current model does not capture this situation but can be extended to capture it. Fourth, extending our framework to a situation with multiple firms would be useful to understand how our main results and insights might be modified or qualified in a competitive scenario.

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Appendix

Proof of Proposition 1

First, suppose the firm allows product returns (i.e., $\theta = 1$). Then $EU^1_{\text{prior}} = q(1-p) + (1-q)(-\gamma)$. The consumer will buy if and only if $EU^1_{\text{prior}} \geq 0$ (that is, $\gamma \leq \frac{q}{1-q}(1-p)$). Note that we also have the constraint $0 \leq \gamma \leq p - w$ (this ensures that the consumer will indeed return the mismatched product). The firm's profit function is given by $E\pi = q(p-\psi) + (1-q)(\gamma - \xi)$. Note that given price p, the firm has the incentives to increase γ as much as possible and the following condition must be satisfied: $\gamma = \frac{q}{1-q}(1-p) \leq p - w$. To see this, suppose instead $\gamma = p - w \leq \frac{q}{1-q}(1-p)$, then the firm's profit is given by $E\pi = q(p-\psi) + (1-q)(\gamma-\xi) = p - (1-q)w - (1-q)\xi - q\psi$. So the firm has the incentives to increase p until $\gamma = \frac{q}{1-q}(1-p) \leq p - w$. Then, the firm can always get the maximal profit $E\pi = q(p^* - \psi) + (1-q)(\gamma - \xi) = q(1-\psi) - (1-q)\xi$ where the optimal solutions p^* and γ^* satisfy that $q + (1-q)w \leq p^* \leq 1$ and $\gamma^* = \frac{q}{1-q}(1-p^*)$. One can also show that if there exits an arbitrary small size of consumers who know the match at prior, then there only exists one unique solution $p^* = 1$ and $\gamma^* = 0$.

Next, suppose the firm does not allow product returns (i.e., $\theta = 0$). Then $EU^1_{\text{prior}} = q + (1-q)w - p$. In this case, it is easy to see that the firm wants to charge the optimal price $p^* = q + (1-q)w$ and the consumer will buy the product and the firm can get optimal profit $E\pi^* = p^* - \psi = q + (1-q)w - \psi$.

Finally, it is straightforward to see that the firm would allow product returns if and only if $\xi \leq \psi - w$. Furthermore, the expected consumer surplus is always zero.

Proof of Proposition 2

First, to induce the consumer to search and buy only if they find a match, the firm solves the following problem

$$E\pi^*_{(1)} = \max_p \; q(p - \psi)$$

$$\text{s.t. } EU_{\text{s}} \geq EU_{\text{ns}} \text{ and } EU_{\text{prior}} < 0$$

$EU_{\text{prior}} < 0$ implies that $p > q + (1-q)w$, and $EU_{\text{s}} \geq EU_{\text{ns}}$ implies that $p \leq 1 - \frac{c}{q}$. Therefore, for this strategy to work, we need $1 - \frac{c}{q} > q + (1-q)w$, which implies that $c < q(1-q)(1-w)$. Given

$c < q(1-q)(1-w)$, it is easy to see that the optimal price is $p^* = 1 - \frac{c}{q}$ and the optimal profit is $E\pi^* = q(1-\psi) - c$. The consumer surplus is $q(1-p^*) - c$, which is equal to 0.

Next, to induce the consumer to buy without search, the firm solves the following problem.

$$E\pi^*_{(2)} = \max_{p,\theta,\gamma} qp + (1-q)((1-\theta)p + \theta(\gamma - \xi)) - (\theta q + (1-\theta))\psi$$

$$\text{s.t. } EU_{\text{s}} < EU_{\text{ns}} \text{ and } EU_{\text{prior}} \geq 0 \text{ and } 0 \leq \theta\gamma \leq \theta(p-w)$$

$0 \leq \theta\gamma$ and $EU_{\text{prior}} \geq 0$ implies that $0 \leq \theta\gamma \leq \frac{q}{1-q} + (1-\theta)w - (\frac{q}{1-q} + (1-\theta))p$, which further implies that $p \leq \frac{\frac{q}{1-q}+(1-\theta)w}{\frac{q}{1-q}+1-\theta}$. $EU_{\text{s}} < EU_{\text{ns}}$ implies that $0 \leq \theta\gamma < (1-\theta)(w-p) + \frac{c}{(1-q)}$,which further implies $p \leq w + \frac{c}{(1-\theta)(1-q)}$. When the firm allows product return (i.e, $\theta = 1$), it is easy to show that any p^* and γ^* that satisfy $\gamma^* = \frac{q}{1-q}(1-p^*)$ and $p^* > 1 - \frac{c}{q}$ would be the optimal solutions. Similar to the proof of Proposition 1, we can show that if there exists an arbitrarily small size of informed consumers who already know the product match without search, then there exists only one unique solution: $p^* = 1$ and $\gamma^* = 0$. Therefore, for the ease of exposition, we select $p^* = 1$ and $\gamma^* = 0$ as the optimal solutions for further discussion in the paper. The firm obtains the optimal profit $E\pi^*_{(2),\theta=1} = q(1-\psi) - (1-q)\xi$. In this case, the consumer surplus is 0.

When the firm does not allow product return (i.e, $\theta = 0$), then if $c < q(1-q)(1-w)$, the optimal price $p^*_{(2)} = \frac{c}{1-q} + w$ and the firm can obtain profit $E\pi^*_{(2),\theta=0} = \frac{c}{1-q} + w - \psi$, and the consumer surplus is $q(1-w) - \frac{c}{1-q}$, which is higher than 0 (note that $c < q(1-q)(1-w)$); if $c > \delta q(1-q)(1-w)$, then $p^*_{(2)} = q + (1-q)w$ and the firm can obtain profit $E\pi^*_{(2),\theta=0} = q + (1-q)w - \psi$, and the consumer surplus is 0.

Finally, we characterize the conditions for each strategy to be equilibrium. For the first strategy to be optimal for the firm, the parameters should satisfy: $E\pi^*_{(1)} > E\pi^*_{(2)}$. $E\pi^*_{(1)} > E\pi^*_{(2)}$ implies that $q(1-\psi) - c > q(1-\psi) - (1-q)\xi$ and $q(1-\psi) - c > \min\{q + (1-q)w - \psi, \frac{c}{1-q} + w - \psi\}$. These two conditions imply that the return processing cost needs to be high and the search cost needs to be low. For the second strategy, if offering returns (i.e., $\theta = 1$) is optimal, then the parameters should satisfy: $q(1-\psi) - (1-q)\xi \geq q(1-\psi) - c$ and $q(1-\psi) - (1-q)\xi \geq \min\{q + (1-q)w - \psi, \frac{c}{1-q} + w - \psi\}$. These conditions suggest that the return processing cost needs to be not high and the search cost needs to be not too low (and also not too high if $\xi > \psi - w$). If not offering returns (i.e., $\theta = 0$) is optimal, then the parameters should satisfy: $\min\{q + (1-q)w - \psi, \frac{c}{1-q} + w - \psi\} \geq q(1-\psi) - c$ and

$\min\{q+(1-q)w-\psi, \frac{c}{1-q}+w-\psi\} \geq q(1-\psi)-(1-q)\xi$. These conditions suggest that the return processing cost needs to be high and the search cost needs to be high. From the analysis above, we can see that the equilibrium conditions are exhaustive and non-overlapping. Q.E.D.

Proof of Corollary 1

The proof is straightforward.

Proof of Proposition 3 and Corollary 2

First, to induce the consumer to search and buy only if they find a match, the firm solves the following problem

$$E\pi^*_{(1)} = \max_p \delta q(p-\psi)$$

$$\text{s.t. } EU_{\text{s}} \geq EU_{\text{ns}} \text{ and } EU_{\text{prior}} < 0$$

$EU_{\text{prior}} < 0$ implies that $p > q+(1-q)w$, and $EU_{\text{s}} \geq EU_{\text{ns}}$ implies that $p \leq 1-\frac{c}{\delta q}$. Therefore, for this strategy to work, we need $1-\frac{c}{\delta q} > q+(1-q)w$, which implies that $c < \delta q(1-q)(1-w)$. Given $c < \delta q(1-q)(1-w)$, it is easy to see that the optimal price is $p^* = 1-\frac{c}{\delta q}$ and the optimal profit is $E\pi^* = \delta q(1-\psi)-c$. The consumer surplus is $\delta q(1-p^*)-c$, which is equal to 0.

Next, to induce the consumer to search and to purchase the product either if they find a match through search or if the search is unsuccessful, the firm solves the following problem

$$E\pi^*_{(2)} = \max_{p,\theta,\gamma} \; q(p-\psi)+(1-\delta)(1-q)((1-\theta)(p-\psi)+\theta(\gamma-\xi))$$

$$\text{s.t. } EU_{\text{s}} \geq EU_{\text{ns}} \text{ and } EU_{\text{prior}} \geq 0 \text{ and } 0 \leq \theta\gamma \leq \theta(p-w)$$

$0 \leq \theta\gamma$ and $EU_{\text{prior}} \geq 0$ implies that $0 \leq \theta\gamma \leq \frac{q}{1-q}+(1-\theta)w-(\frac{q}{1-q}+(1-\theta))p$, which further implies that $p \leq \frac{\frac{q}{1-q}+(1-\theta)w}{\frac{q}{1-q}+1-\theta}$. $EU_{\text{s}} \geq EU_{\text{ns}}$ implies that $\theta\gamma \geq (1-\theta)(w-p)+\frac{c}{\delta(1-q)}$. Therefore,

$$(1-\theta)(w-p)+\frac{c}{\delta(1-q)} \leq \min\{\theta(p-w), \frac{q}{1-q}+(1-\theta)w-(\frac{q}{1-q}+(1-\theta))p\}$$

This implies $\frac{c}{\delta(1-q)}+w \leq p \leq \min\{1-\frac{c}{\delta q}, \frac{\frac{q}{1-q}+(1-\theta)w}{\frac{q}{1-q}+1-\theta}\}$, which further implies that $c < \delta q(1-q)(1-w)$.

Given $c < \delta q(1-q)(1-w)$, if $\theta = 1$, the optimal price is $p^* = 1 - \frac{c}{\delta q}$ and the optimal return fee is $\gamma^* = \frac{c}{\delta(1-q)}$ and the optimal profit is $E\pi^*_{(2),\theta=1} = q(1-\psi) - c - (1-\delta)(1-q)\xi$. In this case, it is also easy to see that the consumer surplus is 0. If $\theta = 0$, $p^* = q + (1-q)w$ and the optimal profit is $E\pi^*_{(2),\theta=0} = (\delta q + 1 - \delta)(q + (1-q)w - \psi)$. In this case, the consumer surplus is given by $\delta q(1-p^*) + (1-\delta)q(1-p^*) + (1-\delta)(1-q)(w-p^*) - c$, which is equal to $\delta q(1-q)(1-w) - c$. This surplus is higher than zero because $c < \delta q(1-q)(1-w)$.

Now, to induce the consumer to buy without search, the firm solves the same problem as in the main model without inconclusive search. Therefore, if the firm offers returns, $p^* = 1$ and $\gamma^* = 0$. The firm obtains the optimal profit $E\pi^*_{(3),\theta=1} = q(1-\psi) - (1-q)\xi$. If the firm does not offer returns, then $p^*_{(3)} = \min\{\frac{c}{\delta(1-q)} + w, q + (1-q)w\}$ and the firm can obtain profit $E\pi^*_{(3),\theta=0} = \min\{\frac{c}{\delta(1-q)} + w - \psi, q + (1-q)w - \psi\}$. In this case, if $c < \delta q(1-q)(1-w)$, the consumer surplus is $q(1-w) - \frac{c}{\delta(1-q)}$, which is higher than 0.

Finally, to characterize the equilibrium conditions, we compare the profits of different strategies above. For instance, for the first strategy to be optimal, we need $E\pi^*_{(1)} \geq \max\{E\pi^*_{(2),\theta=0}, E\pi^*_{(2),\theta=1}, E\pi^*_{(3),\theta=1}, E\pi^*_{(3),\theta=0}\}$. This further suggests that the return processing cost needs to be high and the search cost needs to be low. Similarly, we can characterize other conditions. Following this, we can see that there would be five parameter regions, with each of them corresponding to each strategy above, and thus the equilibrium conditions are exhaustive and non-overlapping. The proof for Corollary 2 follows by checking the equilibrium conditions for $E\pi_{(2),\theta=1}$ to be optimal. The conditions suggest that the return processing cost needs to be intermediate and the search cost needs to be low. Q.E.D.

Proof of Proposition 4

The prior utility of purchase is $EU_{prior} = q(1-p) + (1-q)((1-\theta)(w-p) + \theta(-\gamma - h))$. The expected utility of not searching is $EU_{\text{ns}} = \max\{EU_{prior}, 0\}$. The expected utility of search is

$$EU_{\text{s}} = \underbrace{\delta(q(1-p) + (1-q)0)}_{\text{successful search}} + \underbrace{(1-\delta)EU_{\text{ns}}}_{\text{unsuccessful search}} - c.$$

The analysis is the same as before when the firm does not offer return policy. When the firm offers returns,

(1) consider the strategy under which consumers are induced to search and buy on a match or on an unsuccesful search, but the consumers can return the mismatched product.

The firm solves the following problem:

$$
\begin{aligned}
E\pi^* = &\max_{p,\theta,\gamma} qp + (1-\delta)(1-q)(\gamma - \xi) \\
s.t. &EU_s \geq EU_{\text{ns}} \\
&EU_{prior} \geq 0 \\
&0 \leq \gamma \leq p - w - h.
\end{aligned}
$$

The optimal solution is: $p^* = \min\{1 - \frac{c}{\delta q}, 1 - \frac{1-q}{q}h\}$, $\gamma^* = \max\{\frac{c}{\delta(1-q)} - h, 0\}$. The optimal profit is $E\pi^* = \max\{q - c + (1-\delta)(1-q)(-\xi - h), q - (1-q)h - (1-\delta)(1-q)\xi\}$. In particular, when $c < \delta q(1-q)(1-w)$ and $h \leq \frac{c}{\delta(1-q)}$, we have $p^* = 1 - \frac{c}{\delta q}, \gamma^* = \frac{c}{\delta(1-q)} - h$, and $EU^* = 0$; and when $h \geq \frac{c}{\delta(1-q)}$ and $h \leq (1-w)q$, we have $p^* = 1 - \frac{1-q}{q}h, \gamma^* = 0$, and the consumer surplus $EU_s = \delta(1-q)h - c > 0$. In this case, the consumer surplus increases in h and decreases in q.

(2) Consider the strategy under which consumers are induced to buy without search, but the consumers can return the mismatched product.

The firm solves the following problem:

$$
\begin{aligned}
E\pi^* = &\max_{p,\theta,\gamma} qp + (1-q)(\gamma - \xi) \\
s.t. &EU_s < EU_{\text{ns}} \\
&EU_{prior} \geq 0 \\
&0 \leq \gamma \leq p - w - h.
\end{aligned}
$$

The optimal solution is: $p^* = 1 - \frac{1-q}{q}h$ and $\gamma^* = 0$. The optimal profit is $E\pi^* = q + (1-q)(-\xi - h)$. The consumer obtains expected surplus $EU^* = 0$.

Following the similar analysis for the main model, we can then characterize the equilibrium conditions by comparing profits of different strategies. Q.E.D.

Proof of Proposition 5

The proof is the similar as before. The difference is that when the firm offers return policy, it may choose a moderately complex return policy. To see this, first consider the firm's strategy to induce the consumer to search and buy if she finds a match or if the search is unsuccessful, and the consumer can return the mismatched product with probability θ. The firm solves the following problem

$$E\pi^*_{(2)} = \max_{p,\theta,\gamma} qp + (1-\delta)(1-q)((1-\theta)p + \theta(\gamma - \xi))$$

$$\text{s.t. } EU_{\text{s}} \geq EU_{\text{ns}} \text{ and } EU_{\text{prior}} \geq 0 \text{ and } 0 \leq \theta\gamma \leq \theta(p-w)$$

As before, the constraints imply that $\theta\gamma \leq \min\{\theta(p-w), \frac{q}{1-q} + (1-\theta)w - (\frac{q}{1-q} + (1-\theta))p\}$ and $\frac{c}{\delta(1-q)} + w \leq p \leq \min\{1 - \frac{c}{\delta q}, \frac{\frac{q}{1-q}+(1-\theta)w}{\frac{q}{1-q}+1-\theta}\}$. So given $c < \delta q(1-q)(1-w)$, it is not hard to see that the optimal γ^* should satisfy $\theta\gamma^* = \frac{q}{1-q} + (1-\theta)w - (\frac{q}{1-q} + (1-\theta))p$ and the optimal price p^* should satisfy $p = \min\{1 - \frac{c}{\delta q}, \frac{\frac{q}{1-q}+(1-\theta)w}{\frac{q}{1-q}+1-\theta}\}$. Therefore, we can transform the above problem into the following problem

$$E\pi^*_{(2)} = \max_{\theta} \delta q \min\{1 - \frac{c}{\delta q}, \frac{\frac{q}{1-q} + (1-\theta)w}{\frac{q}{1-q} + 1 - \theta}\} + (1-\delta)q + (1-\delta)(1-q)((1-\theta)w - \theta\xi)$$

The above problem is convex with θ and thus the optimal profit is achieved at either $\theta^* = 0$ or $\theta^* = 1 - \frac{q}{1-q}\frac{1}{\frac{\delta q(1-w)}{c}-1}$ (such that $EU_{\text{s}} = EU_{\text{ns}}$ and $EU_{\text{prior}} = 0$). Furthermore, if $\theta^* = 1 - \frac{q}{1-q}\frac{1}{\frac{\delta q(1-w)}{c}-1}$, it implies that $\gamma^* = 0$ because $EU_{\text{s}} = EU_{\text{ns}}$ and $EU_{\text{prior}} = 0$. In this case, θ^* decrease in c and increase in δ.

The analysis is similar for the firm's strategy to induce the consumer to buy without search. Also, we can characterize the equilibrium conditions by comparing the profits of different strategies. Q.E.D.

Proof of Proposition 6

From the proof for Proposition 3, we can see that the firm would only have incentive to increase the search informativeness above $\underline{\delta}$ in the following situations: (1) the firm induces the consumer to search and buy only if there is a match. This is optimal when $\underline{\delta} > \frac{c}{q(1-q)(1-w)}$ and $q - (1-q)\xi < 0$ and $c < \min\{\overline{\delta}q - (\underline{\delta}q + (1-\underline{\delta}))(q + (1-q)w), \overline{\delta}q - q + (1-q)\xi, \frac{\overline{\delta}q - w}{1 + \frac{1}{\underline{\delta}(1-q)}}\}$; and (2) the firm uses return policy to induce the consumer to search and buy if there is a match or if the search is unsuccessful. This is optimal when $\underline{\delta} > \frac{c}{q(1-q)(1-w)}$ and $q-(1-q)\xi \geq 0$ and $c < \min\{q-(1-\overline{\delta})(1-q)\xi - (\underline{\delta}q+(1-\underline{\delta}))(q+(1-q)w), \overline{\delta}(1-q)\xi, \frac{q-(1-\overline{\delta})(1-q)\xi-w}{1+\frac{1}{\underline{\delta}(1-q)}}\}$. Therefore, the firm has the incentives to increase the search informativeness if and only if $\underline{\delta} > \frac{c}{q(1-q)(1-w)}$ and c is small. Furthermore, the firm would further allow product returns if $\xi < \frac{q}{1-q}$. Q.E.D.