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Abstract

A product exhibits personal fit uncertainty when its consumers have idiosyncratic and uncertain values for it. Often a consumer can learn her long-run value quickly by obtaining the good for a trial period. Money back guarantees of satisfaction are commonly used to lower the cost to consumers of learning their values this way. Increasingly, however, consumers can instead learn about their values before they purchase by, e.g., reading product reviews or consulting experts. We study the effect on a firm's optimal price and refund of this competing source of information. An efficient outcome would be achieved by setting the refund for a return equal to its salvage value. But a monopoly will, for some parameters, induce consumers to stay uninformed by promising a refund that is greater than the salvage value. This generates an inefficiently large number of returns, which the firm finds worthwhile in order to eliminate the information rents that consumers would obtain by becoming informed. This finding is consistent with the observation that for many products, money back guarantees are generous, as they commonly refund the entire, or almost the entire, purchase price of a product.

Keywords: information acquisition, refunds, money back guarantees, personal fit uncertainty

JEL numbers: L1

1. Introduction

A product market exhibits "personal fit uncertainty" if the consumers of the product have idiosyncratic and uncertain values for it. For example, a purchaser of a lamp may be unsure it will match the home decor; a purchaser of a present for a friend may be unsure of the friend's tastes; a purchaser of clothing from a catalog or online store may be unsure of its true cut or color; a purchaser of a textbook may be unsure about whether she will drop the course; a purchaser of a camera may be unsure if its controls will suit her hands. In each case the customer is uncertain of her value for the good, and different ones are likely to have different values. In each case it is not the common-value quality of the product, privately known to the seller or otherwise, that is uncertain, but rather the fit of the product to the specific customer who purchased it.

A consumer can often evaluate the fit of a product quickly once it is in her possession, without fully consuming it. This learning opportunity is socially beneficial if the product is returned to the seller when the consumer's subsequent value for it is less than that of the seller. It may also be a source of additional profit, since the seller can increase demand for trial usage by offering a money back guarantee of satisfaction. We interpret such a guarantee broadly as a promise to refund a specified amount of the purchase price if the product is returned within a certain period of time. The refund is paid with "no questions asked," since subjective satisfaction is unverifiable. Money back guarantees are ubiquitous in consumer markets, especially in the United States. Indeed, the return option they create is often used: approximately six percent of all retail goods are returned in the United States,[1] and far more in internet and catalog retailing.[2]

Our point of departure is the observation that consumers increasingly have ways of learning about their values for products *before* they purchase them. For example, in order to better estimate personal fit, a consumer can read descriptions and reviews on the internet and in magazines. She can consult experts and friends who purchased the good in the past, and she can devote time to studying her own needs. Our purpose in this paper is to identify the effects of such ex ante research options on a seller's choice of refund and purchase price.

An inital question, however, is whether it is more efficient for a consumer to learn

[1] Rogers and Tibben-Lembke (1999), p. 7-9.

[2] A NFO Interactive survey shows that in 2000, twenty percent of internet shoppers who purchased a product online in the first six months of the year returned it within six months. According to Forrester Research, the value of internet returns after the 2000 Christmas season was nearly 600 million dollars. According to Hammond and Kohler (2002), 12-35% of clothing purchased from catalogs is returned.

ex ante about her fit to a good, or to instead use the good on a trial basis. The answer depends on the relative costs and accuracies of the two information channels. A consumer's cost of ex ante research is likely to be greater than her cost of trying the good – the latter cost could even be negative if the good yields a benefit during the trial period. On the other hand, the cost of producing the good is saved if the consumer forgoes purchasing when she learns ex ante that she has a low value for it.

A profit-maximizing seller has an additional reason to want the consumers to stay uninformed. For, if they privately learn their values ex ante, the consumers who decide to purchase will receive an information rent that cuts into the seller's share of the surplus. Consequently, if the seller could simply choose whether its customers are ex ante informed of their values, it would sometimes choose to have them uninformed when efficiency would prescribe that they become informed.

The seller can induce the consumes to stay uninformed by promising a generous refund for returns. However, a refund is an imperfect instrument for this purpose, for two reasons. First, refunds that are too large decrease the total surplus by generating too many returns. Second, in order to keep consumers from wanting to become informed, they may have to be charged a low purchase price and hence be given a sizable share of the surplus anyway. These forces lower the seller's incentive to keep consumers uninformed. They may even cause the seller to prefer to induce its customers to become informed, by not offering a guarantee, despite the resultant loss of information rent.

We study a simple model that delineates these forces and their effects. A firm produces a discrete product for a mass of risk neutral consumers with unit demands. Each consumer's value for the good is initially unknown, but she can learn it either before purchasing at some cost, or during a trial period after purchasing. For various parameter configurations, we determine the firm's optimal price and refund, whether the consumers become informed, and the nature of the resulting inefficiency.

The firm's optimal scheme depends upon the *information cost* to the consumers of becoming ex ante informed of their values. When the information cost is relatively low, the firm offers no refund and the consumers become informed. However, the seller may still need to charge a price lower than the usual monopoly price for informed consumers. The latter price can be so high that if it were to be charged, the consumers would prefer not to purchase. The firm then charges a lower price that just makes the consumers willing to become informed.

When the information cost is in an intermediate range, the firm induces the consumers to stay uninformed. It does this by offering a refund that is larger than the salvage value of a return. The excessive refund generates an inefficiently large number of returns. This result is in accordance with the generous refunds and large numbers of returns seen in some markets.

At the end we briefly consider two kinds of extension. The first allows consumers to receive a benefit from using the product during the trial period, as when a television set is purchased the day before the Super Bowl game. Including this benefit does not affect the magnitude of optimal refunds, but it does expand the set of situations in which refunds are offered. The second kind of extension is to a more competitive environment.

1.1. Related Literature

A small literature studies monopoly selling schemes for goods with personal fit uncertainty resolved by post-purchase consumer learning. In such a setting, Davis et al. (1995, 1998) consider the use of full money-back refunds to increase demand, and of "hassle" costs to limit the number of returns. Che (1996) shows that a monopoly may offer a full refund as a way of providing insurance to risk averse consumers. Fruchter and Gerstner (1999) show that "satisfaction-guaranteed" refunds, which are equal to the purchase price plus the hassle costs of making a return, are sometimes more profitable than full money back refunds or zero refunds. Chu et al. (1998) show that optimal refunds may be partial if consumers benefit from the product during the trial period.[3]

The details of our model differ from those of these papers, and we address some different issues (e.g., efficiency). The main difference, however, is our introduction of ex ante research by consumers, which provides an entirely different rationale for refunds. The only paper we know that considers a second way for consumers to learn their values is Heiman et al. (2001), a marketing paper which compares the profitability of pre-purchase product demonstrations to those of money back guarantees.

Our model can be viewed broadly as a contribution to the literature on mechanisms that prevent, encourage, or determine information acquisition, such as Cremer and Khalil (1992), Lewis and Sappington (1997), Cremer et al. (1998a,b), and Bergemann and Välimäki (2002). It also relates to studies of how much information a seller should directly provide buyers about their personal values, such as Lewis and Sappington (1994), Bergemann and Pesendorfer (2002), and Eso and Szentes (2004).

[3]Further afield is Courty and Li (2000), in which a menu of refund contracts is used to screen imperfectly privately informed consumers who subsequently learn their values for the good. In this paper consumers are ex ante identical, and screening is not possible. Our working paper, "Information Acquisition and the Excess Refund Puzzle," contains a related screening model.

More narrowly, the model can be viewed as developing a suggestion by Barzel (1982) that sellers may sometimes want to prevent buyers from acquiring information. This suggestion is also pursued in Barzel et al. (2004) in a model of IPO policies. An underwriter "stabilizes" an IPO by promising to agree to buy back a certain fraction of the shares from the buying investors at the IPO price. This is analogous to a stochastic contract in our framework that randomizes between a zero and a full refund. Barzel et al. (2004) show that if the underwriter wants to deter buyers from acquiring information, its optimal stabilization policy pays the full refund with positive probability.

Lastly, we warn the reader of two literatures that may appear more related than they are. The first is about how aggregate uncertainty in consumer demand can cause a manufacturer to offer a refund to retailers for ordered but unsold inventory, as in Marvel and Peck (1995), Kandel (1996), and Padmanabhan and Png (1997). Although we briefly interpret our model (in Section 7) as one in which a manufacturer wholesaler sells to a competitive retail sector, it has no aggregate uncertainty.

The other seemingly related literature is on warranties, which focuses on product quality rather than personal fit uncertainty. This literature generally considers situations in which evidence of low quality, such as product breakdown, is verifiable. Although the distinction is not sharp and not always followed, warranties have been distinguished from guarantees in so far as they specify replacement, repair, or refunds for products that verifiable non-performance, not refunds for subjective dissatisfaction (e.g., Davis et al., 1995, 1998). The vast literature on warranties has viewed them as devices that, e.g., provide insurance against product failure (Heal, 1977); signal a seller's private information about product quality (Grossman, 1981; Lutz, 1989; Moorthy and Srinivasan, 1995; Shieh, 1996); screen heterogenous consumers (Matthews and Moore, 1986; Mann and Wissank, 1989); and deal with moral hazard (Cooper and Ross, 1985). In contrast, we focus on markets in which dissatisfaction is subjective, consumers are risk neutral, sellers have no informational advantage, and consumers are not heterogenous in a way that allows a screening menu to be used.

1.2. Structure of the Paper

The environment is described in Section 2, and the efficient benchmark in Section 3. The firm's optimal choice of price and refund are derived in Sections 4 and 5. Welfare and comparative statics are discussed in Section 6. Extensions to allow for trial-period benefits and for competition are considered in Section 7. 8 concludes. Appendix A contains some proofs, and Appendix B an example.

2. Environment

The set of agents is a unit mass (continuum) of potential buyers, and a firm that sells them a discrete good. For now, we have in mind a retailer and its customers.

2.1. Consumers

Each consumer wants at most one unit of the good. Her use value for it, v, is drawn from a distribution F that has a positive and differentiable density, f, on $[0,1]$, with mean $\bar{v}$. An *informed consumer* knows her value for the good when she decides whether to purchase it, and an *uninformed consumer* does not. No consumer's value is observed by another party.

An uninformed consumer who purchases the good learns her value for it during an initial trial period. For now, a consumer is assumed to receive no benefit from the good during the trial period. She bears a return cost of $t \geq 0$ if she tries the good and then returns it to the seller.

A consumer with value v who purchases the good for price p receives utility $v - p$ if she keeps it, gross of any cost she might have borne to become informed. If she instead returns the good for a refund $\hat{r}$, her utility is $\hat{r} - t - p$.

All consumers are ex ante identical and uninformed. Once a consumer knows the set of contracts available in the market, she chooses whether to pay an *information cost,* $c \geq 0$, in order to become informed ("acquire information").

2.2. Firm

The firm has a constant unit cost of procuring the good, $k > 0$. It is either the cost of directly producing the good, or of obtaining it from a wholesaler.

The firm has a *gross salvage value,* $\hat{s}$, for a returned good. It is the maximum amount the firm is willing to pay for a return, and so it cannot exceed the firm's cost of producing a new unit. In general $\hat{s}$ should be less than k : if a return is resold, $\hat{s}$ is equal to the cost k that is saved when a returned rather than a new unit is used to make a sale, less the necessary refurbishing, restocking, and storing costs. We assume $\hat{s} \leq k$.

We also assume $t < \hat{s}$, so that the gross salvage value of a return exceeds a consumer's cost of making a return after trying the good out.

Most of the results depend on the *(net) salvage value* of a return, $s \equiv \hat{s} - t$. In terms of it, the parameter assumptions $0 \leq t < \hat{s} \leq k$ become the following:

Assumption 1. $k - s \geq t \geq 0$ and $s > 0$.

2.3. Contracts

The *gross refund* paid by the firm for a return is $\hat{r}$. The *(net) refund* the consumer receives is the gross benefit less the cost of trying and returning, $r \equiv \hat{r} - t$. We assume the gross refund cannot be negative, which is equivalent to $r \geq -t$. A *refund contract* is a pair (p, r) consisting of the purchase price p and the net refund r.

We assume the firm will lose money if it offers a gross refund greater than the purchase price. Unlike the cost t of returning the good after trying it, a consumer's cost of returning the good immediately after purchasing it is presumably negligible. Hence, offering a gross refund greater than the price would create a money pump in which consumers purchase and return large numbers of the good, creating a loss for the firm. Such consumer arbitrage is prevented if and only if $\hat{r} \leq p$.[4] Combining this *no-arbitrage constraint* with nonnegativity yields a feasibility constraint on the net refund:

(FE) $0 \leq r + t \leq p$.

Three specific kinds of contracts are worth naming.

(a) A *no-refund contract* is any (p, r) with $r \leq 0$. It generates no returns, and is equivalent to selling the good without a guarantee, i.e., to the contract $(p, -t)$ that has a gross refund $\hat{r} = r + t = 0$.

(b) A *full-refund contract* is one in which the gross refund is equal to the purchase price. It takes the form, $(p, r) = (p, p - t)$, so that $\hat{r} = p$. A full-refund contract is optimal when the no-arbitrage part of (FE) binds.

(c) A *(full) satisfaction-guaranteed contract* has the form (p, p), so that the gross refund is $\hat{r} = p + t$. Such a contract entirely eliminates the downside risk of a purchase, and satisfies (FE) if and only if $t = 0$.

2.4. Payoffs

An uninformed consumer returns the good if and only if she learns during the trial period that her value for it is less than the net refund offered for a return. The most she is willing to pay for the good, when it is bundled with a promised refund r, is thus

$$V_u(r) \equiv \int_0^1 \max(v, r) dF(v).$$

[4] In Subsection 6.2 below we consider a weaker no-arbitrage condition.

Integrating by parts yields

$$V_u(r) = \bar{v} + \int_0^r F(v)dv. \tag{1}$$

The first term in (1) is the consumer's expected (use) value for the good, and the second is her value for the return option generated by the guarantee. Her marginal value for an increase in the refund is $V_u'(r) = F(r)$, the probability that she returns the good.

When offered a contract (p, r), an uninformed consumer purchases only if $p \le V_u(r)$. The firm's expected profit is then

$$\pi_u(p, r) \equiv p - k - (r - s)F(r). \tag{2}$$

An informed consumer, on the other hand, does not care about the refund guarantee. She purchases the good only if she knows she will keep it, and only if her value exceeds the price. Given that she pays c to become informed, her ex ante expected utility is $V_i(p) - c$ when the price of the good is p, where $V_i(p)$ is her information rent:

$$V_i(p) \equiv \int_p^1 (v - p)dF(v). \tag{3}$$

Integrating this by parts and comparing to (1) establishes that

$$V_i(p) = V_u(p) - p. \tag{4}$$

Becoming informed when the price is p is payoff equivalent to staying uninformed when offered the satisfaction-guaranteed contract (p, p).

Offering the good for price p to an informed consumer yields expected profit

$$\pi_i(p) \equiv (p - k)(1 - F(p)). \tag{5}$$

We assume the following for convenience.

Assumption 2. $\pi_i(\cdot)$ has a unique maximizer, p_I, and $\pi_i'(p) \gtreqless 0$ as $p \lesseqgtr p_I$.

3. Efficient Contracts and Outcomes

In order to establish the efficient benchmark, we start at the two possible interim stages following an information acquisition decision, and then turn to that decision itself.

3.1. Informed Consumers

Suppose the consumers have become informed. Then efficiency requires the good to be delivered to precisely those whose values exceed the production cost, i.e., to each consumer with value $v \geq k$. This outcome is achieved by offering any contract that specifies $p = k$. Given that the consumers have become informed, the amount of the promised refund is irrelevant because they do not return the good.

The maximal expected surplus that can be generated when the consumers have become informed, net of the cost of becoming informed, is

$$S_i^*(c) \equiv \int_k^1 (v-k)dF(v) - c = V_i(k) - c. \tag{6}$$

3.2. Uninformed Consumers

Suppose now that the consumers have stayed uninformed. A consumer who then obtains the good and learns her value is v generates a surplus of s or v, depending on whether she returns the good. Efficiency requires it to be returned if $s > v$. The resulting surplus is $\max(v, s) - k$. The maximal expected surplus generated by giving the good to an uninformed consumer is hence

$$S_u^* \equiv V_u(s) - k. \tag{7}$$

We take this to be positive, so that it is efficient to produce for the uninformed.

Assumption 3. $k < V_u(s)$.

The efficient outcome conditional on the consumers being uninformed is achieved by offering a contract that specifies the refund $r = s$, so that precisely those consumers with values less than s will return the good, and a price $p \leq V_u(s)$, so that they purchase the good. Among the efficient contracts for an uninformed consumer that yield nonnegative payoffs, (k, s) is the best for the consumers, giving the firm zero profit, and $(V_u(s), s)$ is the best for the firm, giving it a profit equal to the entire surplus S_u^*.

3.3. Efficient Information Acquisition

It is efficient for the consumers to become informed if $S_i^*(c)$ exceeds S_u^*. Equating the two and solving for c yields the social value of ex ante information:

$$c^* \equiv V_i(k) - S_u^* = \int_s^k F(v)dv. \tag{8}$$

The consumer should become informed if $c < c^*$, and stay uninformed if $c > c^*$.

The formula for the value of information c^* can be derived in a more intuitive way. Learning a consumer's value for the good ex ante allows the mistake of producing the good for her when her value is less than the production cost to be avoided. When her value is v, the net cost of this mistake is $k - \max(v, s)$. The most that should be paid for the information is the expected cost of this mistake,

$$\int_0^k [k - \max(v, s)]\, dF(v) = \int_s^k F(v)dv = c^*.$$

3.4. Achieving Efficiency

We have seen that the contract (k, s) achieves an efficient outcome conditional on either information acquisition decision. It also gives the consumers the entire surplus that can be generated by that decision: $S_i^*(c)$ if they become informed, and S_u^* if they stay uninformed. They therefore acquire information efficiently when offered (k, s), and the resulting outcome is fully efficient.

Other contracts also achieve efficiency. If $c \leq c^*$, any contract with $p = k$ and $r \leq s$ does so, since lowering the refund from s will only strengthen the consumers incentive to become informed. If $c > c^*$, efficiency is achieved by any contract with $r = s$ and a price low enough that the consumers will stay uninformed and purchase.

Efficiency would be achieved if there were multiple firms competing in Bertrand fashion. Specifically, suppose the firms simultaneously and publicly offer contracts, and then each consumer decides whether to become informed, and then whether to purchase and from which firm. The subgame perfect equilibria of this game are efficient and give the firms zero profit, by the usual undercutting argument. Hence, (k, s) is the unique equilibrium contract if $c > c^*$. It is also an equilibrium contract if $c \leq c^*$, although then the return option is unused because the consumers become informed. A no-refund contract with price $p = k$ is also an equilibrium contract in this case.

4. Constrained Profit Maximizing

We now consider two constrained profit-maximizing programs for the monopoly firm. One restricts the set of allowed contracts to those that induce consumers to stay uninformed, and the other to contracts that induce them to become informed. The firm's optimal policy is later determined by comparing the values of the two programs.

4.1. Inducing Consumers to Stay Uninformed

A consumer who is offered a contract (p, r) and has stayed uninformed is willing to purchase if and only if the contract satisfies an individual rationality constraint:

$$(\mathrm{IR}_u) \quad V_u(r) - p \geq 0.$$

She will stay uninformed only if $V_u(r) - p \geq V_i(p) - c$, which rearranges to

$$c \geq \int_r^p F(v)dv. \tag{9}$$

In words, (9) requires the consumer's cost of becoming informed to exceed the maximum amount she would be willing to pay to become informed. It is convenient to rewrite (9) as a bound on the price,

$$(\mathrm{IA}_u) \quad p \leq P(r, c),$$

where $P(r, c)$ is defined for any (r, c) by the following expression:[5]

$$\int_r^{P(r,c)} F(v)dv \equiv c. \tag{10}$$

Inequality (IA_u) is the information acquisition constraint for inducing consumers to stay uninformed. Since P is an increasing function, this constraint loosens if r or c increases, so that a larger price can be charged without triggering information acquisition.

The maximal profit that can be achieved by inducing consumers to stay uninformed is the value of the following program:

$$(\mathrm{P}_u) \quad \Pi_u(c) \equiv \max_{p,r} \; p - k - (r - s)F(r)$$
$$\text{subject to } (\mathrm{IR}_u),\ (\mathrm{IA}_u), \text{ and (FE)}.$$

Note that at least one of the two upper bound constraints on the price, (IR_u) and (IA_u), must bind. That is, (p^*, r^*) is a solution only if p^* is the smaller of $V_u(r^*)$ and $P(r^*, c)$.

Proposition 1 (i) below characterizes the solution of (P_u) when the information acquisition constraint can be ignored. Observe that if (IA_u) is deleted, the solution is $(p, r) = (V_u(s), s)$, since this contract achieves, and gives to the firm, the maximal surplus $S_u^* = V_u(s) - k$ that can be obtained when the consumers stay uninformed. It satisfies (IA_u) when $V_u(s) \leq P(s, c)$. The value of c for which this is an equality is

$$\bar{c} \equiv \int_s^{V_u(s)} F(v)dv. \tag{11}$$

[5] Let $P(r, 0) = 0$ for $r < 0$. Then P is well-defined and continuous on $\mathbb{R} \times \mathbb{R}_+$.

This proves that $(V_u(s), s)$ is the solution when $c \geq \bar{c}$.

Proposition 1 (*ii*), proved in Appendix A, concerns the case $c < \bar{c}$. It states that if c is still high enough that the firm can make profit by inducing consumers to stay uninformed, then (IA_u) binds, and the optimal refund exceeds the salvage value.

Proposition 1.

(*i*) *If* $c \geq \bar{c}$, *then* $(V_u(s), s)$ *is the unique solution of* (P_u). *That is, if the consumers' cost of becoming informed is equal to or greater than the threshold* $\bar{c}$, *then the maximal profit that can be achieved by inducing consumers to stay uninformed is uniquely achieved by the contract* $(V_u(s), s)$.

(*ii*) *If* $c < \bar{c}$ *and* $\Pi_u(c) > 0$, *then any solution* (p^*, r^*) *of* (P_u) *satisfies* $p^* = P(r^*, c)$ *and* $r^* > s$. *That is, if the consumers' cost of becoming informed is below the threshold* $\bar{c}$, *and the maximal profit that can be achieved by inducing consumers to stay uninformed is positive, then any contract that achieves that profit and induces the consumers to stay uninformed makes the consumers indifferent about becoming informed, and specifies a refund greater than the salvage value.*

We give here a heuristic argument for why $r^* > s$ in part (*ii*). Suppose the firm must, in order to deter information acquisition, charge the price $P(r, c)$ when it wants to promise a refund r. Increasing the refund then generates a marginal benefit equal to the amount that the increase in the refund allows the price to be raised:

$$MB^L \equiv P_r(r, c) = \frac{F(r)}{F(P(r, c))}.$$

The 'L' denotes "low", as this is the low cost case of Proposition 1 (*ii*). On the other hand, when c is high as in Proposition 1 (*i*), the firm can charge the maximal price $V_u(r)$ without triggering information acquisition. It's marginal benefit from raising the refund is the amount this price can then be raised:

$$MB^H \equiv V_u'(r) = F(r).$$

Observe that for any $r > 0$, $MB^L > MB^H$: needing to actively deter information acquisition increases the firm's marginal benefit from raising the refund. The marginal cost of raising the refund is the same in the two cases, $MC \equiv \partial(r - s)F(r)/\partial r$, and so $MB^L - MC > MB^H - MC$ for all $r > 0$. The optimal refund is s in the high c case, and so satisfies $MB^H - MC = 0$ (since $s > 0$). Therefore, $MB^L - MC > 0$ at $r = s$. This shows that in the low c case, raising the refund above s increases profit.

4.2. Inducing Consumers to Become Informed

Turning to the problem of maximizing profit while inducing consumers to become informed, the first constraint is that they should prefer becoming informed to not purchasing: $V_i(p) - c \geq 0$. Letting $P_i \equiv V_i^{-1}$, this constraint is

$$(\mathrm{IR}_i) \quad p \leq P_i(c).$$

The second constraint insures that consumers prefer to become informed rather than to stay uninformed and purchase. A no-refund contract maximizes a consumer's incentive to become informed. Thus, since a refund is also not paid when consumers become informed, we can restrict attention to no-refund contracts. By the arguments in the previous subsection, when they are offered a no-refund contract with a price p, the consumers are willing to become informed, rather than to stay uninformed and purchase, only if the following information acquisition constraint holds:

$$(\mathrm{IA}_i) \quad p \geq P(0, c).$$

The consumers are willing to become informed if and only if both (IR_i) and (IA_u) are satisfied. The maximal profit that can then be obtained is thus

$$(\mathrm{P}_i) \quad \Pi_i(c) \equiv \max_p \pi_i(p)$$
$$\text{subject to } P(0, c) \leq p \leq P_i(c).$$

The constraint set of this program is the area between the two curves in Figure 1, and to the left of $c = V_i(\bar{v})$. To verify the figure, note that $P(0, 0) = 0$ and $P_i(0) = 1$; $P(0, c)$ increases and $P_i(c)$ decreases in c; and $P(0, c) = P_i(c) = \bar{v}$ at $c = V_i(\bar{v})$.[6] The constraint set is nonempty if and only if $c \leq V_i(\bar{v})$: the consumers cannot be induced to become informed if doing so costs them more than $V_i(\bar{v})$.[7]

The solution is p_I, the unconstrained maximizer of π_i, when c is small enough that $P(0, c) \leq p_I \leq P_i(c)$. One of the two constraints binds when c is higher. If $p_I > \bar{v}$, the constraint that can bind is (IR_i), and it does so when $c > V_i(p_I)$. In this case p_I is so high that if it were to be charged, the consumers would prefer not to purchase than to become informed, but lowering the price would induce them to become informed. The "single-peaked" property of π_i required by Assumption 2 implies that when $p_I > P_i(c)$, the solution of (P_i) is $P_i(c)$, the price in the constraint set that is closest to p_I.

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[6] These claims are obvious except perhaps for $P(0, V_i(\bar{v})) = \bar{v}$. This identity comes from the definition (10), together with the expression $V_i(\bar{v}) = \int_0^{\bar{v}} F(v)dv$ implied by (1) and (4).

[7] Let $\Pi_i(c) \equiv -\infty$ for $c > V_i(\bar{v})$.

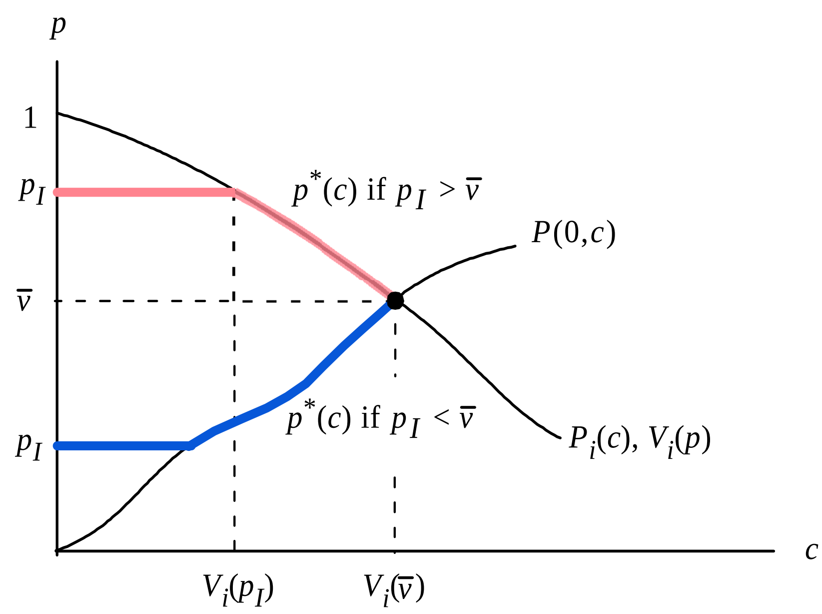

Figure 1: The two possible forms of a solution to (P_i).

A similar argument shows that if $p_I < \bar{v}$, then only (IA_i) can bind. We therefore have the following proposition.

Proposition 2. *Consumers can be induced to acquire information only if* c, *their cost of becoming informed, satisfies* $0 \leq c \leq V_i(\bar{v})$. *In this case the maximal profit that can be obtained while inducing consumers to become informed is uniquely achieved by a no-refund contract with price*

$$p^*(c) \equiv \begin{cases} \min\left(p_I, P_i(c)\right) & \text{if } p_I \geq \bar{v} \\ \max\left(p_I, P(0,c)\right) & \text{if } p_I \leq \bar{v}. \end{cases}$$

5. The Optimal Contract

We now characterize the firm's optimal contract. We do so by determining which of the constrained profit functions, $\Pi_u(c)$ or $\Pi_i(c)$, is greater for each value of c.

We first dispense with the case of high information costs. Recall that if $c > c^*$, maximal surplus is largest when consumers stay uninformed: $S_u^* > S_i^*(c)$. Proposition 1 (i) implies that $\Pi_u(c) = S_u^*$ for $c \geq \bar{c}$. Therefore, since individual rationality implies $S_i^*(c)$ is an upper bound on the profit that can be obtained by inducing consumers to become informed, $\Pi_u(c) > \Pi_i(c)$ if $c > c^*$ and $c \geq \bar{c}$. We have $\bar{c} > c^*$, by Assumption 3. This proves the following lemma.

Lemma 1. $\Pi_u(c) > \Pi_i(c)$ *for all* $c \geq \bar{c}$.

Thus, for high costs $c \geq \bar{c}$, the firm prefers to induce consumers to stay uninformed. By continuity this should be true for somewhat lower costs as well. But if c is quite low, the consumers will want to become informed unless the offered price is quite low and/or the refund quite high. This will make the constrained profit $\Pi_u(c)$ small. We should thus expect that if c is sufficiently low, the firm will prefer to induce the consumers to become informed. This is true, so long as $s < k$. But if $s = k$, there is no net cost of producing a good for a consumer who will return it – the social cost of learning one's value by trying the good is zero, and hence less than the cost of becoming ex ante informed for any $c > 0$. This causes the firm to always prefer, when $s = k$, to induce the consumers to stay uninformed. The following lemma confirms these intuitions.

Lemma 2. $\underline{c} \in [0, \bar{c})$ *exists such that for all* $c \geq 0$,

$$\Pi_u(c) \lesseqqgtr \Pi_i(c) \text{ as } c \lesseqqgtr \underline{c}.$$

Furthermore, $\underline{c} = 0$ *if and only if* $s = k$.

Proof. We apply the intermediate value theorem to $\Delta(c) \equiv \Pi_u(c) - \Pi_i(c)$. We know $\Delta(\bar{c}) > 0$, by Lemma 1. Hence, we need to prove that (i) Δ is continuous on $[0, \bar{c}]$; (ii) Δ is strictly increasing on $[0, \bar{c}]$; and (iii) $\Delta(0) < 0$ ($\Delta(0) = 0$) when $s < k$ ($s = k$).

(i) The maximum theorem implies Π_u is continuous on $\mathbb{R}_+$. Proposition 2 implies Π_i is continuous at any $c \leq V_i(\bar{v})$. So Δ is continuous on $[0, \bar{c}]$ if $\bar{c} \leq V_i(\bar{v})$. When $c = \bar{c}$, the contract $(V_u(s), s)$ satisfies (IA_i) and (IR_i) with equality, and (FE). The constraint set of (P_i) is therefore nonempty when $c = \bar{c}$. This proves $\bar{c} \leq V_i(\bar{v})$.

(ii) Let $0 \leq c_1 < c_2 < \bar{c}$, and let (p_i, r_i) solve (P_u) when $c = c_i$. Since $P(r, c_1) < P(r, c_2)$ for all r, (p_1, r_1) is in the constraint set when $c = c_2$. This implies $\Pi_u(c_1) \leq \Pi_u(c_2)$. If this were an equality, (p_1, r_1) would be a solution for c_2 as well as c_1, in which case Proposition 1 (ii) would imply $p_1 = P(r_1, c_i)$ for both $i = 1, 2$. This contradiction of $P(\cdot, c_1) < P(\cdot, c_2)$ proves that $\Pi_u(\cdot)$ strictly increases on $[0, \bar{c}]$.

(iii) By Proposition 2, $\Pi_i(0) = \pi_i(p_I) > 0$. We have three cases to consider: $s = k$, which implies $t = 0$; $s < k$ and $t = 0$; and $s < k$ and $t > 0$. The last case is easiest: if $t > 0$, the only contract in the constraint set of (P_u) when $c = 0$ is the zero-price no-refund contract $(0, -t)$. It yields profit $-k \leq 0$, proving that $\Delta(0) < 0$ in this case. Turning now to the first two cases, suppose $t = 0$. Then the constraint set of (P_u) when $c = 0$ consists of all satisfaction-guaranteed contracts with $p \geq 0$. From (2) and (5), we obtain the identity $\pi_u(p,p) = \pi_i(p) - (k-s)F(p)$. Thus,

$$\Pi_u(0) = \max_{p\geq 0} \{\pi_i(p) - (k-s)F(p)\}. \tag{12}$$

Hence, if $s = k$, then $\Pi_u(0) = \pi_i(p_I) = \Pi_i(0)$. In the remaining case, $s < k$ and $t = 0$, the objective function in (12) is strictly less than $\pi_i(p)$ for all $p > 0$. This implies, since p_I, the unique maximizer π_i, is positive, that $\Pi_u(0) < \pi_i(p_I) = \Pi_i(0)$. ■

We now put these two lemmas together with Propositions 1 and 2. For the case of high information costs, Lemma 1 and Proposition 1 (i) yield the following.

Theorem 1. *If the consumer's cost of becoming informed satisfies $c \geq \bar{c}$, then the firm's unique optimal policy is to induce the consumers to stay uninformed by offering the contract $(V_u(s), s)$.*

For the case $c < \bar{c}$, we use Proposition 1 (ii) to characterize the optimal contract when $\Pi_u(c) \geq \Pi_i(c)$. But that proposition only applies when $\Pi_u(c) > 0$. The following lemma shows that the firm can always make positive profit, and so $\Pi_u(c) > 0$ is indeed true whenever $\Pi_u(c) \geq \Pi_i(c)$.

Lemma 3. *For any $c \geq 0$, $\max(\Pi_u(c), \Pi_i(c)) > 0$.*

Proof. Suppose the firm offers a contract (p, s), with $k < p < V_u(s)$. If the consumers' best reply is to stay uninformed, they purchase because $p < V_u(s)$, and the firm's profit is $p - k > 0$. The only alternative consumer best reply is to become informed, in which case profit is $(p-k)(1-F(p)) > 0$. This contract is thus feasible for at least one of the programs (P_u) or (P_i), and generates positive profit for it. ■

Most of the following theorem now follows from Lemma 2 and Propositions 1 (ii) and 2. The exception is the statement that when $c < \underline{c}$, the price specified by the optimal no-refund contract is the smaller of p_I and $P_i(c)$. This seems to contradict Proposition 2 when $p_I \leq \bar{v}$, as then the price should be $\max(p_I, P(0,c))$. The proof resolves the contradiction by showing that if the price $P(0,c)$ were to solve (P_i), then it would be more profitable to induce the consumers to stay uninformed, contrary to $c < \underline{c}$.

Theorem 2. *Suppose the consumer's cost of becoming informed satisfies $c < \bar{c}$, and let let $\underline{c} \in [0, \bar{c})$ be the threshold cost given in Lemma 2. Then:*

(i) *If $c > \underline{c}$, the firm's unique optimal policy is to induce consumers to stay uninformed, and an optimal contract (p^*, r^*) satisfies $p^* = P(r^*, c)$ and $r^* > s$.*

(*ii*) *If $c < \underline{c}$, the firm's unique optimal policy is to induce consumers to become informed, and it does so by offering a no-refund contract with price* $p^* = \min(p_I, P_i(c))$.

Proof. It remains only to show that if $c < \underline{c}$ and p is the optimal price, then $p = \min(p_I, P_i(c))$. Since p solves (P_i), this is true by Proposition 2 if $p_I \geq \bar{v}$. So suppose $p_I < \bar{v}$. Then $p = \max(p_I, P(0, c))$. Assume $p = P(0, c)$. By definition, the no-refund contract with price $P(0, c)$ makes the consumers indifferent between becoming informed, and staying uninformed and purchasing. So the constraint set of (P_u) contains $(p, 0)$. This implies $p - k \leq \Pi_u(c)$. But then $\Pi_i(c) = (p - k)(1 - F(p)) \leq \Pi_u(c)$, which contradicts Lemma 2. This proves $p = p_I$. Hence, because $p_I < \bar{v}$ and $\bar{v} < P_i(c)$, we have $p = \min(p_I, P_i(c))$. ■

6. Welfare and Comparative Statics

In this section we draw out some of the welfare and comparative static implications of Theorems 1 and 2. We discuss separately the cases of information costs that are high, medium, and low: $c > \bar{c}$, $c \in (\underline{c}, \bar{c})$, and $c \in (0, \underline{c})$, respectively.

6.1. High Information Costs

When $c > \bar{c}$, the firm achieves an efficient outcome by offering the contract $(V_u(s), s)$. Consumers stay uninformed and purchase, which is optimal since $\bar{c} > c^*$. The efficient number of returns are obtained because the refund is equal to the salvage value of a return. The purchase price increases in the net salvage value, $s = \hat{s} - t$, and is independent of the other parameters except F.

6.2. Medium Information Costs

When $c \in (\underline{c}, \bar{c})$, the firm induces the consumers to stay uninformed, and it does so by promising a refund that exceeds the salvage value of a return. This generates an inefficiently large number of returns.

The firm offers a full-refund contract only if the no-arbitrage constraint, $r + t \leq p$, binds in (P_u). As this is impossible when $t < c$,[8] in this case a partial refund is optimal. (This bound is not tight – partial refunds are optimal if $t - c$ is positive but not too large.)

[8] By Theorem 2 and (10), $p^* = P(r^*, c) \geq r^* + c$. Hence, $p^* > r^* + t$ when $c > t$.

Turning to comparative statics, recall that in the present case the optimal contract solves (P_u), and that (IA_u) binds. So $P(r,c)$ can be substituted for p to eliminate a constraint and variable. We can also dispense with the nonbinding constraint $r \geq -t$. Hence, (p^*, r^*) is optimal if and only if $p^* = P(r^*, c)$, and r^* solves the following program:

$$
\begin{aligned}
(\mathrm{P}_u^*) \quad & \max_r P(r,c) - k - (r-s)F(r) \\
& \text{subject to } (\mathrm{IR}_u^*) \quad P(r,c) \leq V_u(r), \\
& \qquad\qquad (\mathrm{FE}^*) \quad r + t \leq P(r,c).
\end{aligned}
$$

When the constraints do not bind, the first-order condition (using $P_r = F(r)/F(P)$) is

$$\frac{1}{F(p)} = 1 + (r-s)\frac{f(r)}{F(r)}, \tag{13}$$

where $p = P(r,c)$. We can view (13) as defining p as a function of (r,s), say $\hat{p}(r,s)$, for $s \in [0,1]$ and $r \in [s,1]$. If the constraints in (P_u^*) do not bind, an optimal contract (p^*, r^*) satisfies the two-equation system,

$$p^* = \hat{p}(r^*, s) \text{ and } p^* = P(r^*, c). \tag{14}$$

It is convenient now to assume a relatively weak regularity condition,[9]

$$(\mathrm{R}) \quad \frac{d}{dr}\left[\frac{(r-s)f(r)}{F(r)}\right] > 0 \text{ for } r \in (s,1).$$

This condition insures that (14) has a unique solution,[10] as it implies that $\hat{p}(r,s)$ decreases in r. Hence, since $\hat{p}(s,s) = 1 > P(s,c)$ and $\hat{p}(1,s) < 1 \leq P(1,c)$, and $P(r,c)$ is increasing in r, the system (14) has a unique solution, $(p^*, r^*) \in (0,1) \times (s,1)$. Figure 2 illustrates.

When (FE^*) does not bind, Figure 2 reveals the comparative statics properties with respect to the information cost. Given the c shown in the figure, the optimal contract is the point at which the curves $\hat{p}(\cdot, s)$ and $P(\cdot, c)$ cross, yielding the optimal refund $r^* = r^*(c,s)$. It is to the left of the point $r^{vp} = r^{vp}(c)$ at which $P(\cdot, c)$ and V_u cross, and so satisfies (IR_u). In this unconstrained case we have $\partial r^*/\partial c < 0$ and $\partial p^*/\partial c > 0$, since the curve $P(\cdot, c)$ increases in c. However, as c increases the cro ssing point r^{vp} decreases. Once c has risen to c^0, we have $r^* = r^{vp}$, i.e., the constraint (IR_u) just binds.

[9] Condition (R) strengthens Assumption 2. It holds if $d[rf(r)/F(r)] > 0$ on $(0,1)$, and is satisfied, e.g., by $F(r) = r^\theta$ for any $\theta > 0$.

[10] Without (R), (14) may have multiple solutions, and only some would be optimal. But the set of optimal solutions would still exhbit the monotonicities that we show below, as can be verified by the methods of Milgrom and Shannon (1994).

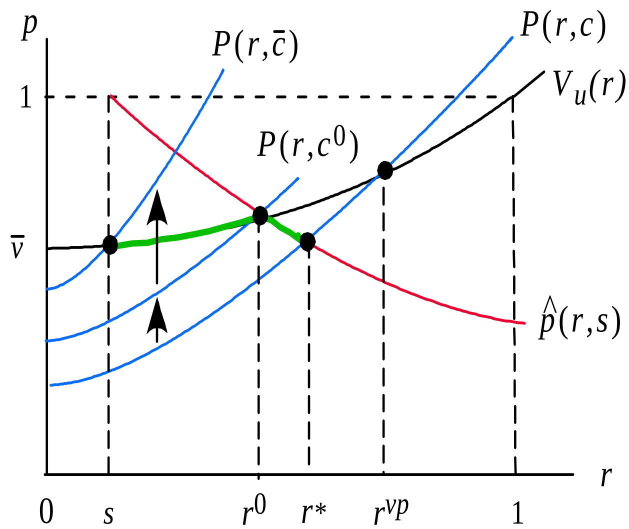

Figure 2: Comparative statics with $t < c < c^0 < \bar{c}$.

It continues to bind at all $c \in (c^0, \bar{c})$, and on this interval $\partial r^*/\partial c < 0$ and $\partial p^*/\partial c < 0$. In the limit, $(p^*, r^*) \to (V_u(s), s)$ as $c \to \bar{c}$. The heavy curve is the path of the optimal contract as the information cost increases from c to $\bar{c}$.

Similarly, when (FE*) does not bind, Figure 2 reveals the comparative statics with respect to the salvage value. As s increases, the curve $\hat{p}(\cdot, s)$ shifts up. Hence, at the indicated c and s in which (IR_u) does not bind, $\partial r^*/\partial s$ and $\partial p^*/\partial s$ are both positive. Once s has risen to point where $r^* = r^{vp}$, further increases yield $\partial r^*/\partial s = \partial p^*/\partial s = 0$.

Finally, we can now see what happens if (FE*) binds. Envision the line $p = r + t$ in Figure 2. It is steeper at any r than are the curves $P(\cdot, c)$ and V_u (see Lemma 4 in Appendix A). This line passes through the indicated (p^*, r^*) when $t = p^* - r^*$. Then (FE*) binds, and the optimal contract is a full-refund contract. As t increases the optimal contract remains a full-refund contract, sliding leftward down the $P(\cdot, c)$ curve. Thus, in this region, the optimal price p^*, and so the gross refund $\hat{r}^* = p^*$, as well as the net refund r^*, all decrease in t. Shifting curves in the figure also reveals that when (FE*) binds, $\partial r^*/\partial c > 0$ and $\partial p^*/\partial c > 0$,[11] and $\partial r^*/\partial s = \partial p^*/\partial s = 0$.

The following table summarizes the predicted changes in the optimal contract for each increase in a parameter, given $c \in (\underline{c}, \bar{c})$.

[11] Note that (FE*) does not bind when c is close to $\bar{c}$, since then r^* is close to s, and we have $P(s, \bar{c}) = V_u(s) > k$ (by Assumption 2) and $k \geq s + t$ (Assumption 1).

	Unconstrained			(IR_u^*) Binds			(FE_u^*) Binds		
	c	s	t	c	s	t	c	s	t
r^*	$-$	$+$	0	$-$	0	0	$+$	0	$-$
$\hat{r}^*$	$-$	$+$	$+$	$-$	0	$+$	$+$	0	$-$
p^*	$+$	$+$	0	$-$	0	0	$+$	0	$-$

We make two comments about these comparative statics predictions. First, without the underlying model of information acquisition deterrence, it would be surprising to see the price and refund move in opposite directions, as is predicted in Table 1 in the unconstrained case when c changes. One would have instead expected the refund and price to be co-monotone, reasoning that when a smaller refund is promised, demand decreases and so a lower price should be charged. Here, however, the information acquisition constraint prevents the firm from charging as high a price and promising as low a refund as it would otherwise do. An increase in c loosens this constraint, allowing the firm to move both variables as desired, the price up and the refund down.

Second, the predictions when (FE_u^*) bind have special import because they apply to the many markets in which full refunds are prevalent. And they too are somewhat surprising. For example, consider the result that the refund increases in c. One might have expected that when consumers find it more costly to become informed, the firm should lower the refund because it can now do so without triggering information acquisition. Here, however, a contract is optimal only because the information acquisition constraint prevents the price from being raised, and the no-arbitrage constraint prevents the refund from being raised. An increase in c weakens the information acquisition constraint, thereby allowing the firm to raise the price without triggering information acquisition, and the higher price weakens the no-arbitrage constraint, thereby allowing the refund to be raised as well. A similar explanation applies to the result that when (FE_u^*) binds, the gross refund, $\hat{r}^* = r^* + t$, decreases in t.

Remark. The result that full refunds are optimal for a range of parameters – those for which (FE_u^*) binds – depends on the form of the no-arbitrage constraint we have assumed, $\hat{r} \leq p$. In some cases this constraint may take other forms. Suppose, for example, that a consumer must pay t whenever she returns the product, even if she has not tried it.[12] The no-arbitrage constraint should then be $\hat{r} - t \leq p$, and so (FE_u^*)

[12] As a referee has observed, this may occur if the firm is somehow able to costlessly prevent consumers from immediately returning the product after purchasing.

becomes $r \leq P(r, c)$. This weaker constraint never binds in (P_u^*) (by the logic of footnote 8, with $t = 0$). Hence, full refunds are now optimal only in knife-edge cases, and an optimal refund can be more than full, $\hat{r}^* > p^*$. The optimal contract now always satisfies the comparative statics results obtained above for when (FE_u^*) is nonbinding.

6.3. Low Information Costs

When $c \in [0, \underline{c})$, the firm induces consumers to become informed. No refunds are paid, no goods are returned, and too few goods are sold because $p^* > k$ (else profit would not be positive).

The comparative statics in this case are simple. The optimal price depends only on c and k. It is either the unconstrained monopoly price p_I for informed consumers, which is constant in c and increasing in k, or it is $P_i(c)$, which is constant in k and decreases in c. The price is never greater than p_I, since it is equal to $P_i(c)$ if and only if this amount is less than p_I. When $P_i(c)$ is the optimal price, a lowering of their cost of becoming informed does not benefit the consumers, since the firm just raises the price enough to keep them indifferent about purchasing.

6.4. Comparative Statics of $\underline{c}$ and $\bar{c}$

We now determine how the interval of medium information costs, $(\underline{c}, \bar{c})$, varies with the parameters. This allows one to determine how an economy-wide change affects the number of product markets in which consumers are induced to stay uninformed by excessive refunds.

The upper endpoint $\bar{c}$ of this interval is explicitly defined by (11). It depends only on F and s, and it decreases in s.[13]

The lower endpoint $\underline{c}$ is more interesting. Note that program (P_u) depends on (k, s, t), and (P_i) depends on k. So in general $\underline{c}$ depends on all these parameters, since it is determined by the equation

$$\Pi_u(\underline{c}; k, s, t) = \Pi_i(\underline{c}; k). \tag{15}$$

At $\underline{c}$, both functions are continuous, Π_u is strictly increasing in c, and Π_i is nonincreasing in c (see Lemma 2 and its proof). Thus, any change in (s, t) that raises (lowers) Π_u will lower (raise) $\underline{c}$.

We therefore see that $\underline{c} = \underline{c}(k, s, t)$ decreases in s, since Π_u increases in s. We also see that $\underline{c}$ does not locally depend on t when (FE^*) does not bind in (P_u^*) in a neighborhood

[13] $>$From (11) we obtain $\bar{c}'(s) = F(V_u(s))V_u'(s) \square F(s) = \square [1 \square F(V_u(s))] F(s) < 0$.

of $\underline{c}$, i.e., when at $\underline{c}$ the optimal refund that induces consumers to stay uninformed is a partial one. If it is instead a full refund, then raising t tightens the binding constraint (FE*), and so lowers Π_u and increases $\underline{c}$.

To derive the sign of $\partial\underline{c}/\partial k$, note first that $\partial\Pi_u/\partial k = -1$, since the objective function of (P_u) is $p - k - (r - s)F(r)$, and the constraints do not depend on k. The constraints of (P_i) also do not depend on k, and it's objective function is $(p - k)(1 - F(p))$. The envelope theorem yields $\partial\Pi_i/\partial k = -(1 - F(p^*))$. Now (15) implies

$$\frac{\partial\underline{c}}{\partial k} = \frac{F(p^*)}{\partial\Pi_u/\partial c - \partial\Pi_i/\partial c},$$

which is positive because $\partial\Pi_u/\partial c > 0$ and $\partial\Pi_i/\partial c \leq 0$.[14]

The following table summarizes how $\underline{c}$ and $\bar{c}$ change when the parameters increase.

	k	s	t
$\bar{c}$	0	$-$	0
$\underline{c}$	$+$	$-$	$0, +$

Observe that the interval of information costs $(\underline{c}, \infty)$ for which refunds are offered expands if k decreases, or if t decreases and optimal refunds at $\underline{c}$ are full refunds, or if s increases. Thus, if economy-wide efficiency gains lower production costs, lower the transaction costs of returning products, or lower the cost of processing returns for salvage, refunds should be offered for more products.

6.5. Inefficient Information Acquisition

Recall that the efficient information acquisition decision depends on whether c exceeds c^*. Thus, when $\underline{c} < c < c^*$, the firm induces consumers to stay uninformed, but they would become informed in the efficient outcome. The optimal refund is not only too large given that the consumers have stayed uninformed ($r^* > s$), but it is also too large relative to the zero refund that would be first-best efficient.

The opposite is true when $c^* < c < \underline{c}$. The firm then induces consumers to become informed, but they would stay uninformed in the efficient outcome. It is more profitable in this case to induce information acquisition, because the recovery of the cost of producing the good for low-valued consumers outweighs the loss of giving the purchasing

[14] A slightly more involved argument is required if Π_u or Π_i is not differentiable at $\underline{c}$, but it amounts to the same thing, given the monotonicities and continuities of Π_u and Π_i.

informed consumers an information rent. Observe that in this case, the firm offers a refund that is too small (zero) relative to the efficient refund, $r = s$.

Both types of inefficiency can occur. Examples are given in Appendix B which show that c^* can lie to either side of $\underline{c}$.

7. Extensions

We sketch here two extensions of the model. The first is to allow consumers to receive a benefit from the good in the trial period – the case of prom dresses the day before the senior prom, or television sets the day before the Super Bowl. The second is to settings with competing firms.

7.1. Trial Period Benefits

We incorporate trial period benefits by simply assuming each consumer receives an expected benefit of $b > 0$ from using the good during the trial period. While it may be random ex ante, this benefit is uncorrelated with the consumer's value v that she will obtain in the post-trial period if she keeps the good. A more general pre and post-trial period benefit structure is beyond our scope here.[15]

The expected benefit b appears in the model as a constant added to a consumer's payoff when she purchases. It does not affect her return decision, which remains based on a comparison of the refund r to the post-trail period value v. Consequently, the inclusion of these trial period benefits does not alter the level of optimal refunds. It does, however, expand the set of situations in which a refund is offered. We sketch here the arguments for these results.

Consider program (P_u). An uninformed consumer offered a contract (p, r) will purchase only if $p \leq V_u(r) + b$, so that this is the new (IR_u) constraint. Her payoff if she were to become informed is $V_i(p - b) - c$, since an informed consumer now purchases when $v \geq p - b$. It is easy to show that she prefers staying uninformed if and only if $p \leq P(r, c) + b$, and so this is the new (IA_u) constraint. Since one of these two constraints must bind, the only change to the solution of (P_u) is that the optimal price increases by b. The optimal refund is unchanged, as is the upper bound $\bar{c}$ on the interval of medium information costs. The new profit function Π_u shifts up by b.

Turning to program (P_i), its objective function is now $(p - k)(1 - F(p - b))$. Its

[15] Another special case is studied in Chu et. al. (1998), that in which trial period benefits are perfectly and negatively correlated with post-trial benefits.

constraints (IR_i) and (IA_i) are now $p \leq P_i(c) + b$ and $p \geq P(0, c) + b$, respectively. If neither binds, the new optimal price is larger than before, but the increase in profit Π_u is is less than b.[16] Even if one of the constraints binds, so that the inclusion of b does cause the optimal price to increase by b, Π_u still increases by less than b because not all consumers purchase.

We thus see that the increasing function $\Pi_u(c)$ increases by b, and the nondecreasing function $\Pi_i(c)$ increases by less than b. Hence, the point $\underline{c}$ at which the two are equal decreases in b. The addition of trial period benefits therefore expands both the interval of information costs $(\underline{c}, \infty)$ at which a refund is offered, and the interval $(\underline{c}, \bar{c})$ at which an excessive refund is offered. The magnitude of the refunds that were offered in the absence of the trial period benefits are unaffected.

7.2. Competition

We have assumed the firm is a monopoly, which may be inappropriate for situations in which close substitutes for the firm's product are produced by other firms. However, as is commonly true of monopoly results, we view ours as suggestive of those that should obtain in more complicated models of monopolistic competition. This makes sense even if we interpret the firm in the model as a consumer retailer, since the size and dominance of retailers like K-Mart or Circuit City certainly indicate that they have market power. The argument of Diamond (1961) seems particularly compelling for retailing; when it applies, a seller has monopoly power because consumers do not know the price and refund it offers until they arrive at the store, and their cost of conducting another search at a competing seller is positive.

Another way of introducing retail competition is to assume the firm is a wholesaler, selling the good to competing retailers that then sell it to the consumers. The firm uses a variant of consignment selling: it sells the good to the retailers together with the promise to pay a refund for the goods that the consumers return to them. The retailers then compete in a Bertrand fashion, each one publicly offering a refund contract to attract consumers. As noted in Section 3, this kind of competition yields the retailers zero profits, and the retail outcome is efficient. However, the procurement cost of the retailers is the price they are charged by the wholesaler for product, and their salvage value for a consumer return is the refund the wholesaler subsequently pays when the good is returned to it. The equilibrium retail price is thus equal to the price the

[16] Letting $p_I(b)$ be the unconstrained maximizer, when the constraints do not bind the envelope theorem yields $\partial\Pi_i/\partial b = (p_I(b) - k)f(p_I(b) - b)$, which by the first-order condition is $1 - F(p_I(b) - b) < 1$.

wholesaler charges the retailers, and the equilibrium refund is equal to the refund the wholesaler pays to retailers. The wholesaler consequently acts as though it were selling directly to consumers, and the results of the model apply immediately. (The details of this argument are in Matthews and Persico, 2005).

8. Concluding Remarks

To summarize quickly, we have presented a model in which, if the cost to consumers of learning ex ante their personal fit to a product lies in an intermediate range, the seller will induce them to remain uninformed by offering a guarantee of satisfaction that specifies an excessive refund. The refund is then larger than the seller's salvage value for a return, and it therefore generates an inefficiently large number of returns.

The extent to which refunds and returns are excessive awaits careful empirical study. In our view, it is very plausible that they are excessive for many products. Refunds are often patently generous,[17] and retailers view returns as costly.[18] Logically, those commonly-seen refunds that offer full money back must exceed the seller's salvage value for a return: positive profit implies that a product's purchase price should exceed its procurement cost, and the latter should exceed the salvage value because the seller should be unwilling to pay more for a return than the cost of procuring a new unit. For the model of this paper to have force, excessive refunds should be found for products about which consumers could learn their values by exerting ex ante effort, but they choose instead to stay largely uninformed.

We do not claim, however, that the suppression of information acquisition is the only rationale for excessive refunds. Refunds may be excessive for different reasons in different settings. For example, if there are two types of consumer, one that is exogenously informed and one that is exogenously uninformed, the seller may want to offer a large refund to the uninformed in order to charge them a price large enough to

[17] In a survey of 133 Sacramento area retail stores, Davis et al. (1998) found that sixty percent of the department chain stores, and nineteen percent of the single outlet specialty stores, offered full money back with no restrictions. In the data that Chu et al. (1998) present for computer mail-order stores, forty percent of the stores offered full money back (not including shipping), while the rest deducted 10-20% of the purchase price as a restocking fee.

[18] "Returns have been regarded by online retailers as an unwanted headache, and all too frequently, an expensive one. Gartner Inc.'s Gartner G2 Retail Services Group estimates that returns are costing retailers anywhere from 0.2% to as much as 25% of sales. Forrester Research has estimated that next year, retailers will spend $9 billion to process some $11.5 billion in returned goods purchased online." ("Dealing with Returns," *Internet Retailer,* August 2002, http://www.internetretailer.com/article.asp?id=7419.)

deter the informed consumers from selecting their contract.[19] Alternatively, if consumers are risk averse as in Che (1996), an insurance rationale can be shown to cause efficient refunds to exceed salvage values. (But are consumers really so risk averse in many product markets?) Agency provides another reason: a liberal return policy may deter salespeople from using high-pressure sales tactics, since misleading a customer into purchasing is then likely to generate a return rather than an increase in monthly sales.[20] Behavioral economics provides yet another reason: sellers might offer large refunds in order to induce purchases, at little cost because the endowment effect causes consumers to rarely return a good once purchased.[21] (But then, what accounts for the large numbers of returns?) Lastly, when product quality rather than personal fit is the issue, the warranties literature gives rationales for excessive warranties ranging from screening heterogeneous consumers to signaling a seller's private information (see Subsection 1.1). For each rationale there is probably a setting in which it has merit.

In our view the most interesting and robust result of the model is that sometimes firms want to induce consumers to stay uninformed, and they do so by promising large refunds. We do not, however, wish to emphasize the ancillary result that a firm offers a no-refund contract generating no returns when it wants to induce consumers to become informed. This no-refund no-return result obtains in the model because its informed consumers do not return the good when they purchase it. But if a consumer could only become imperfectly informed ex ante, and then learn more during the trial period, she might sometimes return the good if promised a refund. The seller might then offer a refund that generates returns, even when it induces information acquisition. These refunds, we conjecture, would be small and generate too few returns. We leave this generalization to future work.

[19] This screening idea is explored in Model SC of the working paper, Matthews and Persico (2005).

[20] We thank an anonymous referee for this suggestion.

[21] The endowment effect is studied, e.g., by Kahneman et al. (1990), and by Plott and Zeiler (2005).

Appendix A. Analysis of Program (P_u)

Results concerning program (P_u) are derived here, and Proposition 1 (*ii*) proved.

Define $p^m(r,c) \equiv \min(V_u(r), P(r,c))$. Since ($\mathrm{IR}_u$) or ($\mathrm{IA}_u$) must bind in ($\mathrm{P}_u$), we see that (p^*, r^*) solves it if and only if $p^* = p^m(r^*, c)$ and r^* solves

$$(\mathrm{P}_u^m) \quad \Pi_u(c) \equiv \max_r \; p^m(r,c) - k - (r-s)F(r)$$
$$\text{subject to } 0 \le r + t \le p^m(r,c).$$

The constraint set of this program contains $-t$, and so is nonempty. Since $p^m(r,c) = \min(r, r+c) = r$ for $r \ge 1$, every such r yields the same profit, $r - k - (r-s)(1) = s - k$. Thus, since all its functions are continuous, standard arguments show that (P_u^m) has a solution for each $c \ge 0$, and Π_u is continuous.

Figure 3 may be helpful. It is drawn for $c < \bar{c}$, so that $P(s,c) < V_u(s)$, and with a fairly small t so that the crossing points satisfy $r^{vp} < r^v < r^p$. (At larger t, $r^p = r^v = r^{vp}$ and $r^p < r^v < r^{vp}$ occur.) The following lemma characterizes these crossing points.

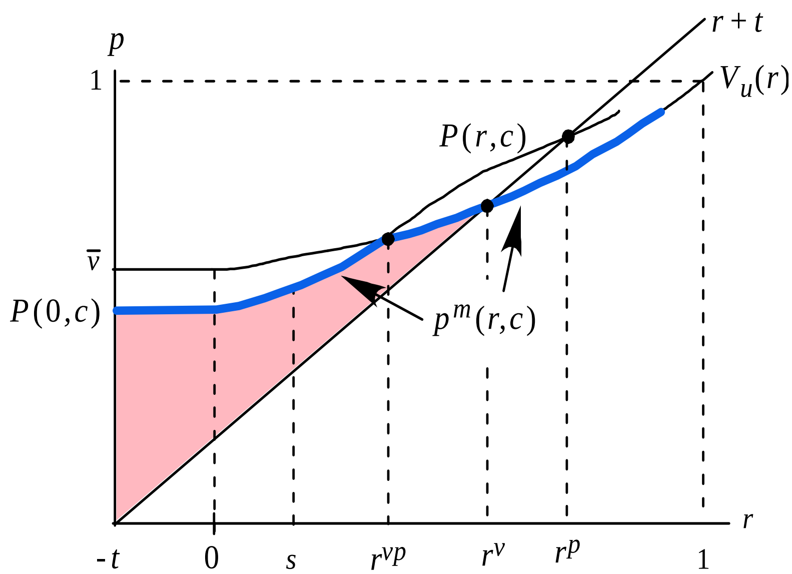

Figure 3: The constraint set of program (P_u).

Lemma 4. *Suppose $c < \bar{c}$ and $\hat{r} \ge -t$. Then r^{vp}, r^v, and r^p exist such that*

(*i*) $s < r^{vp} \le \infty$, *and $V_u(\hat{r}) \ge P(\hat{r}, c)$ if and only if $\hat{r} \le r^{vp}$;*

(*ii*) $s < r^v \le \infty$, *and $V_u(\hat{r}) \ge \hat{r} + t$ if and only if $\hat{r} \le r^v$;*

(*iii*) $-t \le r^p \le \infty$, *and $P(\hat{r}, c) \ge \hat{r} + t$ if and only if $\hat{r} \le r^p$.*

Proof. The facts that each pair of functions of r can cross only once, and in the ways indicated, follows from a comparison of their slopes: since $V_u'(r) = F(r)$, $P_r(r,c) = F(r)/F(P(r,c))$, and $(r+t)' = 1$, and since $P(r,c) \geq r$, we have

$$V_u'(r) \leq P_r(r,c) \leq (r+t)'.$$

The desired crossing points are

$$\begin{aligned} r^{vp} &\equiv \sup\{r \geq -t : V_u(r) \geq P(r,c)\}, \\ r^{v} &\equiv \sup\{r \geq -t : V_u(r) \geq r+t\}, \text{ and} \\ r^{p} &\equiv \sup\{r \geq -t : P(r,c) \geq r+t\}. \end{aligned}$$

We know r^{vp} is well-defined and greater than s because $c < \bar{c}$ implies $V_u(s) = P(s,\bar{c}) > P(s,c)$; r^v is well-defined and greater than s because Assumptions 1 and 3 imply $V_u(s) > k \geq s+t$; r^p is well-defined because $P(-t,c) = P(0,c) \geq 0$. ■

The constraint $p^m(r,c) \geq r+t$ is equivalent to the conjunction of $V_u(r) \geq r+t$ and $P(r,c) \geq r+t$. Hence, by Lemma 4, (P_u^m) can be rewritten as

$$(\mathrm{P}_u^m) \quad \Pi_u(c) \equiv \max_r \; p^m(r,c) - k - (r-s)F(r)$$
$$\text{subject to } -t \leq r \leq \min(r^v, r^p).$$

Proof of Proposition 1 *(ii)***.** Let $c < \bar{c}$, and suppose $\Pi_u(c) > 0$. Let r^* be a solution of (P_u^m), and set $p^* = p^m(r^*,c)$. We must prove $p^* = P(r^*,c)$ and $r^* > s$.

Proof that $p^* = P(r^*,c)$. The definition of p^m implies $p^* \leq P(r^*,c)$. Assume this inequality is strict. Then $p^m(r^*,c) = V_u(r^*) < P(r^*,c)$, and Lemma 4 *(i)* implies $s < r^{vp} < r^*$. By continuity, $\hat{r} \in (s, r^*)$ exists such that $p^m(r,c) = V_u(r)$ for all $r \in [\hat{r}, r^*]$. Thus, on $[\hat{r}, r^*]$ the derivative of the objective function of (P_u^m) is

$$\frac{\partial}{\partial r}\left[V_u(r) - (r-s)F(r)\right] = (s-r)f(r) < 0.$$

So $\hat{r}$ yields greater profit than does r^*. And $\hat{r}$ is feasible for (P_u^m), since $-t \leq s < \hat{r}$ and $\hat{r} < r^* \leq \min(r^v, r^p)$. This contradiction of the optimality of r^* proves $p^* = P(r^*,c)$. ■

Proof that $r^* > s$. Since $p^m(r^*,c) = P(r^*,c)$, we have $V_u(r^*) \geq P(r^*,c)$. This and Lemma 4 imply $r^* \leq r^{vp}$. Hence, letting $\hat{r} = \min(r^v, r^p, r^{vp})$, r^* solves the program

$$\max_{-t \leq r \leq \hat{r}} P(r,c) - k - (r-s)F(r), \tag{16}$$

and the value of this program is $\Pi_u(c)$. Let $A(r)$ denote its objective function, and note that it is continuous. It is constant on $[-t, 0]$. On $(0, 1)$ it has the derivative

$$A'(r) = \left(\frac{1}{F(P(r,c))} - 1\right) F(r) + (s - r)f(r). \tag{17}$$

The first term in (17) is positive for $r \in (0, s]$, since $r \leq s$ and $c < \bar{c}$ imply that $P(r, c) < P(s, \bar{c}) = V_u(s) < 1$. The second term in (17) is nonnegative for $r \in (0, s]$. Hence, $A'(r) > 0$ on $(0, s]$. Since $s > 0$, the interval $(0, s]$ contains s, and so $A'(s) > 0$. We conclude that $\bar{r} > s$ exists such that $A(r_2) > A(r_1)$ for any $r_2 \in (0, \bar{r}]$ and $r_1 < r_2$.

Now assume $r^* \leq s$. Then, by the argument just given, any $r > s$ must be infeasible for (16), so that $\hat{r} \leq s$. Furthermore, $\hat{r}$ itself must solve (16). Because we know $s < \min(r^v, r^{vp})$ from Lemma 4, the fact that $\hat{r} \leq s$ implies $\hat{r} = r^p$. Lemma 4 (*iii*) and the continuity of $P(\cdot, c)$ yield $P(r^p, c) = r^p + t$. Thus,

$$\begin{aligned}
\Pi_u(c) &= P(r^p, c) - k + (s - r^p)F(r^p) \\
&= r^p + t - k + (s - r^p)F(r^p) \\
&\leq r^p + t - k + (s - r^p) \\
&= s + t - k.
\end{aligned}$$

Assumption 1 now implies the contradiction $\Pi_u(c) \leq 0$. This proves $r^* > s$. ■

Appendix B. The Uniform Model

In this appendix we illustrate the model under the assumption that F is the uniform distribution. Along the way we show that both $c^* < \underline{c}$ and $\underline{c} < c^*$ are possible, and that sometimes it is optimal for the firm to offer a full-refund contract.

Given $F(v) \equiv v$, easy calculations yield the following, for $r \geq 0$:

$$\begin{array}{ll}
V_u(r) = \frac{1}{2}\left(1 + r^2\right) & P\left(r, c\right) = \sqrt{r^2 + 2c} \\
p_I = \frac{1}{2}(k + 1) & P_i(c) = 1 - \sqrt{2c} \\
c^* = \frac{1}{2}(k^2 - s^2) & \bar{c} = \frac{1}{8}(1 - s^2)^2.
\end{array}$$

Note that $P(r, c) \leq V_u(r)$ if and only if $r \leq r^{vp} \equiv \sqrt{1 - 2\sqrt{2c}}$. Recalling that (FE*) does not bind in (P_u^*) when $t < c$, we see that

$$t < c \quad \Rightarrow \quad \Pi_u(c) = \max_{r \leq r^{vp}} P(r, c) - k - (r - s)F(r). \tag{18}$$

Case $s = 0$ **and** $t < c$.

(In the text we assumed $s > 0$. But this was only for simplicity, as it allowed the avoidance of possible corner cases that do not arise when F is uniform. The following expressions are valid for $s = 0$, and they are also the limits of the corresponding expressions for $s > 0$ as $s \to 0$.)

Given $s = 0$, we have $\bar{c} = 1/8$. For $c < 1/8$. the solution of (18) when its constraint is dropped is $r^* = \sqrt{.25 - 2c}$. This is the actual solution in this case (so (IR_u^*) does not bind), since it is less than r^{vp} when $c < 1/8$. The optimal price is thus $p^* = P(r^*, c) = .5$, and the constrained maximal profit is $\Pi_u(c) = 2c - k + .25$. Evaluating this at $c^* = k^2/2$ yields

$$\Pi_u(c^*) = \frac{1}{4}(1 - 2k)^2 .$$

We now derive $\Pi_i(c^*)$. Since $s = 0$ and $V_u(0) = 1/2$, Assumptions 1 and 3 imply that the set of possible values for k is $[t, 1/2)$. For such k, easy algebra shows that $p_I < P_i(c^*)$ if and only if $k < 1/3$. Hence,

$$\Pi_i(c^*) = \pi_i(\min(p_I, P_i(c^*))) = \begin{cases} \frac{1}{4}(1-k)^2 & \text{for } k \leq 1/3 \\ k(1-2k) & \text{for } k > 1/3. \end{cases}$$

We conclude, again on the basis of suppressed algebra, that $\Pi_i(c^*) > \Pi_u(c^*)$ for all $k \in (0, 1/2)$. Therefore, $c^* < \underline{c}$ when $s = 0$ and $t < c$.

Case $(k, s) = (.375,\ .125)$ **and** $t < c$.

We show numerically that $c^* > \underline{c}$ holds in this case. The first computation is $c^* = .063$.

To obtain $\Pi_i(c^*)$, we compute $P_i(c^*) = 1 - \sqrt{2c^*} = .646$ and $p_I = .688$. Thus, $P_i(c^*) < p_I$. So Proposition 2 implies $\Pi_i(c^*) = \pi_i(P_i(c^*))$, which yields $\Pi_i(c^*) = .096$.

To obtain $\Pi_u(c^*)$, we first note that when $c = c^*$, $r^{vp} = .541$. This is sufficiently high that it does not bind in (18), since numerically solving its first-order condition yields $r^* = .392$. So this r^* is the solution, and we have $\Pi_u(c^*) = .115$.

Because $\Pi_u(c^*) > \Pi_i(c^*)$, we conclude that $\underline{c} < c^*$.

Case $(c, k, s) = (.1, .375,\ .125)$ **and** $t \in [.228, .25]$.

We show numerically that the firm's optimal policy in this case is to induce consumers to stay uninformed, and it does so by offering a full refund. Note that Assumptions $1 - 3$ hold for these parameter restrictions.

In this case, constraint (IR_u^*) holds in (P_u^*) if and only if $r \leq r^{vp} = .325$. The other constraint, (FE^*) $r + t \leq P(r, c)$, holds if and only if $r \leq r^p$, where here

$$r^p = \frac{2c - t^2}{2t} = \frac{.2 - t^2}{2t}.$$

A computation verifies that $r^p \leq .325$ because $t \geq .228$. Hence, $r^p \leq r^{vp}$, and we can write (P_u^*) as

$$\Pi_u(c) = \max_{r \leq r^p} \sqrt{r^2 + .2} - .375 - (r - .125)r. \tag{19}$$

The objective function of this program is strictly increasing on $[0, .392]$. Thus, since $r^p \leq .325$, its solution is $r^* = r^p$. The corresponding profit is

$$\Pi_u(c) = \sqrt{\left(\frac{.2 - t^2}{2t}\right)^2 + .2} - .375 - \left[\left(\frac{.2 - t^2}{2t}\right) - .125\right]\left(\frac{.2 - t^2}{2t}\right).$$

We now compare this to $\Pi_i(c)$. Since

$$p_I = \arg\max_p \,(p - k)\,(1 - p) = \frac{1}{2}\,(k + 1) = .688,$$

and this exceeds $\bar{v} = .5$, Proposition 2 implies $\Pi_i(c) = \pi_i(\min(p_I, P_i(c))$. Here we have $P_i(.1) = .553 < p_I$. Hence,

$$\Pi_i(.1) = \pi_i(.553) = .080.$$

A computation now shows that $\Pi_u(c) > \Pi_i(c)$ for $t \in [.228, .25]$. We conclude that for each t in this interval, the optimal contract is the full refund contract $(P(r^p, c), r^p)$.

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