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Returnable Goods: Refunds and Information Acquisition*

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Abstract

TO BE COMPLETED We present two information-based rationales for why sellers of returnable goods tend to offer refunds in excess of the salvage value of the good. Both explanations require at least the potential presence of consumers who can choose to learn their values for the good prior to purchasing.

KEYWORDS: *refunds, information acquisition, warranties, monopoly pricing*

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1. Introduction

Little attention has been paid by economists to the phenomenon of returned goods. Nonetheless, somewhere near six percent of all products sold to the final consumer are returned to the seller for a refund. About twenty-five percent of goods sold by catalog are returned.[1] According to a survey of internet shoppers, two out of ten respondents who purchased a product online in the first six months of 2000 returned the good within six months.[2] The value of returns by internet shoppers after the 2000 Christmas season was nearly 600 million dollars.[3]

We can define a *returnable good* as one that can be given to a possible buyer for a "trial period" to inspect or try out, whereupon it be returned to the seller. To distinguish this from the productive rental of a good, the consumer should obtain virtually no value from the good during the trial period. The trial period serves only an informative purpose, giving the consumer an opportunity to learn how much she would value the good if she were to retain it. The physical features of the good are not in question, and the seller has no private information about product quality. Rather, each consumer has an idiosyncratic private value for the good that is initially unknown to both her and everybody else. Examples of returnable goods abound: music CD's, consumer electronics, cameras, clothing, some books, etc.

Generally such a good is returned not because the consumer finds it defective, but because she finds her own value for it to be less than the refund given for a return. Clothing is returned because it is found not to fit; a textbook is returned because the student learns she is not interested in the corresponding course; a silver-colored DVD player is returned because the consumer's spouse declares it to be too ugly next to the black television. Because these goods are not returned because they are defective, they are not the subject of most of the existing economic literature on warranties. That literature concerns warranties that pay a refund when a product fails. These warranties may, for example, provide insurance against product failure (Heal, 1977), signal product quality (Grossman 1981; Lutz, 1989), screen heterogeneous risk-averse consumers (Matthews and Moore, 1987), or alleviate moral hazard (Spence, 1977; Cooper and

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

[2] The survey was conducted by NFO Interactive, and excerpts can be found on the web at http://www.nfoi.com/nfointeractive/nfoipr082500.asp

[3] According to a study by Forrester Research.

Ross, 1985; Mann and Wissink, 1990; Dybvig and Lutz, 1993).[4] In contrast, product failure is not an issue for the returnable goods we study here.

The primary puzzle to explain is why firms offer refunds for returned goods that are not defective. True, doing so may further allocative efficiency. If the seller's salvage value for the good is greater than the consumer's private value that she learns by trying it out, efficiency requires the good to be returned to the seller. However, paying a refund greater than the salvage value of the good is not efficient, as it induces too many returns. And refunds are typically greater than salvage values; a refund is often equal to the purchase price, which is surely greater than the salvage value once the costs of refurbishing, repackaging, and restocking the good for resale are taken into account.

One possible explanation for this excess-refund puzzle is based on risk aversion. If the consumer is risk averse and the seller is risk neutral, the seller could offer the consumer insurance against the risk of finding out, in the trial period, that her value for the good is low. Optimal insurance would require a payment that depends on the consumer's realized value, which is clearly not the case with real refunds. However, if the consumer's value remains her private information, her total payment can depend only on the observable act of returning the good. Insurance then can be provided by raising the consumer's payment in the good, high value states of the world by increasing the purchase price, and lowering her payment in the bad, low-value states by increasing the refund for a returned good. This brings her average marginal utilities closer together in the bad and good states. It is straightforward to prove that, when the consumer's realized value for the good is not seen by the seller, and when the seller is risk neutral and the consumer is risk averse, then efficiency requires a refund that exceeds the salvage value of the good.

However, it seems hard to attribute many instances of excess refunds to consumer risk aversion. Risk aversion should be minimal when the sums at stake are small relative to personal wealth, as is often the case with clothing, books, and nowadays even electronics.

In this paper we explore two other explanations for excess refunds. Both entail the supposition that at least some consumers can learn their values for the good without trying it out. The first explanation is a pure screening one. There are types of consumers, ones who are exogenously informed of their values, and others who can only

[4] One exception is Courty and Li (2001), which we discuss in the Related Literature.

learn their values by trying the good out. The former type, an *informed consumer,* only cares about the purchase price of the good: she never purchases and returns the good, since her optimal strategy is to not purchase when her value is less than the price.[5] But the latter type, an *uninformed consumer,* does care about the refund, since she will return the good when she learns during the trial period that her value for it is low. By increasing the refund, a firm can also increase the purchase price, which then makes the refund contract (price and refund) meant for an uninformed consumer less attractive to an informed consumer. Thus, a monopoly seller attempting to screen the two types of consumer may want to increase the refund above the salvage value of the good in order to weaken the incentive constraint of the informed types. We indeed show this to be the case, under certain conditions on the parameters.

Our second explanation supposes that consumers can, prior to purchasing the good, acquire information about their value. We assume for simplicity that by paying a cost c, a consumer can perfectly learn her value for the good. The purchase prices and refunds available in the market determine whether a consumer wants to acquire this costly information prior to purchasing, or to remain uninformed and simply purchase the good to learn her value for it (or to not purchase at all). By setting the refund sufficiently high, a firm will induce consumers to remain uninformed. If they remain uninformed they obtain no information rents, and so the firm may be able to extract a greater profit from them. We show that this is indeed the case: if the information acquisition cost c is not too high, a monopoly firm will induce consumers to remain uninformed by setting the refund greater than the good's salvage value.

Note that both of these information-based explanations for excess refunds require the seller to have market power. Indeed, in each of our environments, we show that efficiency requires refunds to equal salvage values, and a competitive market acheives an efficient outcome. Only inefficient monopoly outcomes have refunds greater than salvage values.

1.1. Related Literature

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Courty and Li (2000)

Cremer and Khalil (1992)

[5] We assume that no feasible refund is greater than the purchase price.

Cremer, Khalil, and Rochet (1998)

Heiman, Zilberman, and McWilliams (2001)

Heiman, McWilliams, Zhao, and Zilberman (2002)

Lewis and Sappington (1994, 7),

1.2. Structure of the Paper

The model is set up in Section 2. Efficient outcomes are characterized in Section 3. Refund contracts are introduced in Section 4, and efficient menus of refund contracts are characterized in Section 5. Competitive refund contracts are studied in Section 6. Monopoly refund contracts are characterized in Section 7. More general monopoly selling mechanisms are discussed in Section 8, and Section 9 concludes. The Appendix contains the longer proofs.

2. Model

The market consists of one or more firms selling a discrete, returnable good to a unit mass (continuum) of consumers.

2.1. Consumers

Each consumer wants at most one unit of the good. Her value for the good is denoted v. Initially she does not know v, but she has two ways of discovering it. The first is to pay a cost c before making her purchase decision, in which case she is an *informed consumer* at the time of purchase. Refer to this as *becoming informed.* The second way she can learn v is to purchase the good and use it briefly on a trial basis. In this case she is an *uninformed consumer* at the time of purchase. The trial period is too short for the consumer to obtain any benefit from the good – she obtains the value v only if she does not return the good after the trial period.

The value-cost pair (v, c) is the consumer's *type.* No firm and no other consumer observes a consumer's type. Ex ante, a consumer herself only observes c.

Consumers are risk neutral and care only about the good and money. A consumer of type (v, c), who purchases the good for price p and does not return it, obtains ex post utility $v - p$ if she had remained uninformed prior to purchasing, and $v - p - c$ if she had instead become informed.

A consumer's cost of trying the good and then returning it is $t \geq 0$. If she purchases it for price p and returns it for refund r, her utility gross of the cost she might have incurred to become informed is $r - p - t$.

Values and information costs are distributed independently of each other, and independently across consumers, on the interval $[0, 1]$. The distribution of values is denoted F, and it has a differentiable and positive density, f.

The distribution of information costs is denoted G. We consider three alternative kinds of distribution:

Case EX (*Exogenous Information*). A fixed and exogenous fraction $\bar{G} \in (0, 1)$ of consumers are informed, and the others are are uninformed.[6]

Case ID (*Identical Information Costs*). All consumers have the same information cost, $\bar{c} \in (0, 1)$: the distribution G jumps from 0 to 1 at $c = \bar{c}$.

Case HE (*Heterogeneous Information Costs*). The distribution G has a differentiable and positive density g on $[0, 1]$.

In Case EX the fractions of informed and uninformed consumers are exogenously specified, and so no information acquisition decisions are made. Incentive compatibility is the only issue, as informed and uninformed consumers are free to mimic each other. In Case ID, information acquisition is the only issue. Since all consumers have the same cost of becoming informed, they all make the same information acquisition decision as a function of market prices and refunds. In Case HE both information acquisition and incentive compatibility issues arise. Because different consumers have different information costs, the fraction who become informed depends on the available prices and refunds.

2.2. Firms

A firm can produce a unit of the good at cost $k \in [0, 1)$ (constant unit costs).

A firm's salvage value for a returned good is s. The firm may want to bear the costs of refurbishing, restocking, and storing a returned good in order to resell it in the future. Since this allows the firm to produce in the future one less unit of the good, the future

[6] This can be taken to be the case in which each consumer has either a zero cost of becoming informed and does so, or she has a prohibitively high cost and stays uninformed: $G(0) = \bar{G}$ and $G(1) = 1 - \bar{G}$.

value of a refurbished good is the production cost k. The returned good's salvage value is then the discounted present value of k less the refurbishing, restocking, and storing costs. This argument implies $s \leq k$.

Assuming the firm can always choose to discard a returned good, we have $s \geq 0$. We make the stronger assumption that $s \geq t$: the good's salvage value is not less than the consumer's cost of trying and returning the good. The case $s < t$ is of of less interest for a model of refunds, as then the good would never be returned and a refund would never be paid in an efficient allocation. Nonetheless, a monopoly may still want to induce returns by paying a refund greater than t. In some environments we shall show that a monopoly sets $r > s$, and the reader will note that these results do not need $s \geq t$. We assume $s \geq t$ primarily to eliminate a number of less interesting cases from the analysis.

To summarize, we assume $0 \leq t \leq s \leq k$.

2.3. Outcomes

A *(consumer) outcome* specifies for each type of consumer whether she becomes informed, whether she obtains the good and for what price, and whether she returns it and for what refund. We restrict attention to equal treatment outcomes: all consumers of the same type obtain the same allocation. In addition, two timing and informational constraints must be observed. First, whether a consumer becomes informed prior to purchasing cannot depend on her unknown v. Similarly, whether an uniformed consumer obtains a good, and the price she pays for it, also cannot depend on her v.

3. Efficient Outcomes

In this section we characterize *efficient* outcomes, which we take to be those outcomes that maximize ex ante expected surplus.

A central question is whether a consumer should become informed prior to purchasing. The trade-off is clear. The benefit of becoming informed is that the cost of producing the good will be saved in the event that her value is so low that the good is not produced for her. This benefit must be offset against the cost of becoming informed. An increase in the net salvage value of a returned good, $s - t$, will decrease the net benefit of becoming informed.

Consider first an uninformed consumer who obtains the good. If her value for the good is v, it generates a gross surplus of v if she keeps it and $s - t$ if she returns it. She should return it if she learns that v is less than $s - t$, and she should keep it otherwise. Producing for an uninformed consumer thus yields a maximal expected surplus of

$$S_u^* \equiv \int_0^1 \max(v, s-t) dF(v) - k. \tag{1}$$

In order for refunds to play a role, we assume $S_u^* > 0$.

Consider now an informed consumer.If she has value v, the social value of producing the good for her is still $\max(v, s - t)$. This, however, exceeds the production cost k only if $v > k$, since $s - t \leq k$. So the good should be produced for this consumer only if v exceeds k, and she should not return the good when she gets it. The maximal expected surplus generated by this consumer is

$$S_i^*(c) \equiv \int_k^1 (v - k) dF(v) - c. \tag{2}$$

The maximal surplus generated by a consumer with information cost c is the maximum of $S_i^*(c)$ and S_u^*, and whether she should become informed depends on which is higher. The critical cost at which $S_i^*(c) = S_u^*$ is (integrate by parts)

$$c^* \equiv \int_{s-t}^{k} F(v) dv. \tag{3}$$

Our assumptions imply $c^* \in [0, 1)$. Consumers with $c < c^*$ should become informed, and those with $c > c^*$ should not. The case $c^* = 0$ arises when $s = k$ and $t = 0$; in this case a consumer can learn her value by trying and returning the good at a social cost of $k - s + t = 0$, and so this is the cheapest way of acquiring the information.

Proposition 1. *The following outcome is efficient. Each consumer with $c \geq c^*$ stays uninformed, receives the good, and returns it iff she learns that $v < s-t$. Each consumer with $c < c^*$ becomes informed, receives the good iff she learns that $v \geq k$, and never returns it.*[7]

Remark 1. The social value of pre-production information can be defined as the expected increase in surplus, gross of the information cost, that can be achieved by a consumer becoming informed. In this model it is c^*, as we now show. If $v < s - t$ is

[7] Any other outcome achieves the same surplus iff it differs only by having some consumers with $c = c^*$ become informed; some uninformed consumers returning the good when $v = s - t$; and some informed consumers not receiving the good when $v = k$.

learned by becoming informed, surplus increases by $k+t-s$, since in this case becoming informed saves the production and return costs, but loses the salvage value. If instead $v \in [s-t,k]$, surplus increases by $k-v$, since becoming informed then saves the production cost and loses the consumption value. If $v > k$, becoming informed does not change any actions and so has no effect on gross surplus. Accordingly, the social value of pre-production information is

$$\int_0^{s-t} (k+t-s)dF(v) + \int_{s-t}^{k} (k-v)dF(v).$$

This sum is easily shown to be c^*, and so c^* is indeed the social value of pre-production information. Note that it varies intuitively with the parameters. It increases with k and t, since for some consumers these costs are saved when they become informed. But c^* decreases in s, since the net cost of trying the good decreases in its salvage value.

4. Refund Contracts

A *refund contract* is a pair $(p,r) \in \mathbb{R}^2_+$. A consumer who accepts this contract pays the purchase price p, but obtains the refund r if she returns the good. A contract of the form $(p,0)$ is a *no-refund contract.*[8]

A firm that were to offer a refund greater than the purchase price would be likely to incur an extreme loss. A consumer's cost of returning the good immediately after purchasing it, without trying it out, is presumably very small. Offering a refund greater than the price would thus create a costly money pump in which some consumers would purchase and return large numbers of the good, on each of which the firm would lose $r-p$ dollars. We thus assume a refund contract is feasible only if $r \leq p$.

It follows that an informed consumer does not care about the refund. She has no informational reason to try the good, and she cannot gain monetarily by purchasing and returning it. She purchases the good only if she knows she will keep it, and she does so only if her value exceeds the price. Her expected utility from becoming informed depends only on the purchase price and her information cost:

$$U^i(p,c) \equiv \int_p^1 (v-p)dF(v) - c. \tag{4}$$

[8] We trust that no confusion will be caused by referring to the refund contract $(p,0)$ as a no-refund contract!

A firm's expected profit from offering a contract with price p to a consumer who will become informed before deciding to purchase is therefore

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

If an uninformed consumer purchases the good, she keeps it only if she learns that her value exceeds the refund less her cost of returning the good. Thus, if the refund is r and her value is v, her induced value is $\max(v, r-t)$, and her expected induced value,

$$V(r-t) \equiv \int_0^1 \max(v, r-t)dF(v), \tag{6}$$

is the maximum she is willing to pay for the good as an uninformed consumer,[9] and doing so yields her expected utility

$$U^u(p,r) \equiv V(r-t) - p. \tag{7}$$

This uninformed consumer generates for the firm an expected profit

$$\pi^u(p,r) \equiv p - k + (s-r)F(r-t). \tag{8}$$

5. Efficient Refunds

In this section we characterize the menus of refund contracts that give rise to efficient outcomes.

Let $M \subset \mathbb{R}^2_+$ denote the *menu* of contracts available in the market. An outcome is *achieved* by M if it is generated by information acquisition, purchasing, and returning decisions that are optimal for the consumers given M. Refer to M as an *efficient menu* if it achieves an efficient outcome.

A consumer can always choose not to purchase. Consequently, if her information cost is c and she faces menu M, her optimized utility is

$$U(M,c) \equiv \max_{(p,r)\in M} \left(U^i(p,c), U^u(p,r), 0\right). \tag{9}$$

We restrict attention to menus that only contain contracts that will possibly be chosen by some consumer. These are the menus that only contain contracts (p,r) that solve the maximization problem (9) for some c in the support of G.

[9] Note that $S_u^* = V(s-t) - k$.

Consider first an uninformed consumer. Her choice (p, r) generates surplus

$$S_u(r) \equiv \pi^u(p,r) + U^u(p,r) \tag{10}$$
$$= S_u^* - \int_{r-t}^{s-t} [(s-t) - v]\, dF(v).$$

The integral is the surplus lost when her value is between $r - t$ and $s - t$, since then her return decision is inefficient. This loss is positive if $r < s$ or if $r > s$. So s uniquely maximizes $S_u(\cdot)$ on $[0, 1]$, and $S_u(s) = S_u^*$. Efficiency requires each uninformed consumer to choose a contract with a refund equal to the good's salvage value.

Consider now a consumer with information cost c who becomes informed. If she chooses (p, r) when she decides to purchase, the resulting expected surplus is

$$S^i(p,c) \equiv \pi_i(p) + U^i(p,c) \tag{11}$$
$$= S_i^*(c) - \int_k^p (v-k)\, dF(v).$$

The integral is the surplus lost when the consumer's value is between p and k, since then her purchasing decision is inefficient. This loss is positive unless $p = k$. Hence, $S^i(p, c)$ is maximized at $p = k$ (marginal cost pricing), and we have $S^i(k, c) = S_i^*(c)$. Since $\pi_i(k) = 0$, efficiency precludes a firm from making profit on informed consumers.

So, informed consumers must receive contracts with a purchase price of k, and uninformed consumers must receive contracts with a refund of s. Three considerations remain: (i) uninformed consumers must find it optimal to purchase the good; (ii) the menu must induce efficient information acquisition; and (iii) the menu must be incentive compatible: informed consumers must not prefer the contract meant for uninformed consumers, and vice versa.

Incentive compatibility is automatic if the menu is a singleton, so that there is only one contract available. The obvious candidate is (k, s). This contract gives the firms zero profit, and the consumers get the entire social surplus. An uninformed consumer gets S_u^* if she purchases the good, and she does so because $S_u^* > 0$. An informed consumer with information cost c receives $S_i^*(c)$. Each consumer thus receives the entire social benefit, and bears the entire cost, of her information acquisition decision. She acquires information efficiently, becoming informed if $c < c^*$ and staying uninformed if $c > c^*$. These observations prove the following result.

Proposition 2. *For any distribution G of information costs, the singleton menu $\{(k, s)\}$ is efficient.*

Other menus of contracts are also efficient. An obvious example is $\{(k,s),(k,0)\}$. This menu achieves the same outcome as does $\{(k,s)\}$, with the informed consumers choosing the no-refund contract $(k,0)$, and the uninformed choosing (k,s). This menu also gives the firms zero profit.

Sometimes an efficient menu can give the firms a profit on uninformed consumers, since they may sometimes be charged a price greater than k. Efficiency is maintained so long as their price is not so high that they (*i*) choose not to purchase, or (*ii*) choose to become informed, or (*iii*) choose a contract meant for an informed consumer.

We see from (6) and (7) that an uninformed consumer will choose (p,s) only if

$$p \leq V(s-t). \tag{12}$$

The contract $(V(s-t),s)$ gives the entire surplus $S_u^* = V(s-t)-k$ to the firm. Whether this upper bound can be achieved in an efficient menu depends on the nature of the distribution of information costs.

We start with Case ID, the case in which all consumers have the same information cost $\bar{c}$. If $\bar{c} < c^*$, an efficient menu induces all consumers to become informed and the refunds are irrelevant.[10] The more interesting case is $\bar{c} > c^*$, so that efficiency requires all consumers to remain uninformed and to choose a contract of the form (p,s). They will all choose the available contract of this form that has the lowest price. Any efficient menu is therefore a singleton. Other than the individual rationality constraint (12), p is constrained in this case only by an information acquisition constraint: the consumers must prefer to remain uninformed. This inequality, $U^u(p,s) \geq U^i(p,\bar{c})$, can be written as

$$\int_{s-t}^{p} F(v)\,dv \leq \bar{c}. \tag{13}$$

This information acquisition constraint can be written as another upper bound on the price, $p \leq P(\bar{c},s)$, where $P(c,r)$ is defined for any $(c,r) \in [0,1]^2$ by

$$c \equiv \int_{r-t}^{P(c,r)} F(v)\,dv. \tag{14}$$

This proves most of the following result.

[10] When $\bar{c} < c^*$, any set of contracts of the form (k,r), with each $r \in [0,k]$ sufficiently low that $U^i(k,\bar{c}) \geq U^u(k,r)$, is efficient. (This includes any $r \in [0,s]$.) Since these refunds are never claimed, such a menu acheives the same outcome as the no-refund singleton $\{(k,0)\}$.

Proposition 3. *In Case* ID, *for $\bar{c} > c^*$, a menu is efficient if and only if it contains a single contract, (p, s), and $p \leq \min(V(s-t), P(\bar{c}, s))$. Furthermore, $c^0 \in (c^*, 1)$ exists such that this maximal price is*

$$\min(V(s-t), P(\bar{c}, s)) = \begin{cases} P(\bar{c}, s) & \text{if } \bar{c} \leq c^0 \\ V(s-t) & \text{if } \bar{c} \geq c^0. \end{cases} \tag{15}$$

Proof. In the text we proved that a menu is efficient in this case if and only if it is a singleton $\{(p, s)\}$, with $p \leq \min(V(s-t), P(\bar{c}, s))$. From (14) we have $P_c(c, s) = F(P(c, s))^{-1} > 0$. Since $P(c^*, s) = k$ and $S_u^* > 0$, we have $P(c^*, s) < V(s-t)$. Because $s - t < 1$,

$$V(s-t) = \int_0^1 \max(v, s-t) dF(v) < 1.$$

Hence, since (14) implies $P(1, s) > 1$, we have $P(1, s) > V(s-t)$. This proves the existence of $c^0 \in (c^*, 1)$ satisfying (15). ■

We now turn to Case EX, that in which a fraction $\bar{G} \in (0, 1)$ of consumers are exogenously informed, and $1 - \bar{G}$ are uninformed. Now the profit that can be obtained from uninformed consumers is contrained by incentive compatibility, rather than an information acquisition constraint. Let (k, r) be a contract meant for informed consumers in an efficient menu, and let (p, s) be the contract for the uninformed. The incentive constraint $U^i(k, 0) \geq U^i(p, 0)$ is equivalent to $k \leq p$: the informed always choose the contract with the lowest purchase price, as they do not care about the refund. The incentive constraint of the uninformed, $U^u(p, s) \geq U^u(k, r)$, is satisfied by the largest range of prices p when r is as small as possible, i.e. when the informed types receive the no-refund contract $(k, 0)$. The constraint $U^u(p, s) \geq U^u(k, 0)$ can be written as

$$p \leq V(s-t) - (E(v) - k). \tag{16}$$

Also relevant is the uninformed consumers' individual rationality constraint, (12). We have the following result (note that (17) combines $k \leq p$, (12), and (16)).

Proposition 4. *In Case* EX, *the purchase price p paid by the uninformed consumers in any efficient menu satisfies*

$$k \leq p \leq V(s-t) - \max(0, E(v) - k). \tag{17}$$

Furthermore, $\{(k, 0), (p, s)\}$ is an efficient menu if and only if (17) holds.

We now turn to the Case HE in which the information costs are continuously distributed. Since $c^* \in [0, 1)$, efficiency in this case requires a positive mass of consumers to remain uninformed. Let (p, s) be their contract. They must prefer remaining uninformed and choosing it to becoming informed and then choosing it (when they learn $v > p$). Hence, $U^u(p, s) \geq U^i(p, c)$ for all $c > c^*$. Using (14), this is equivalent to

$$p \leq P(c, s) \text{ for all } c > c^*.$$

This is in turn equivalent to $p \leq P(c^*, s)$, since $P(\cdot, s)$ is increasing. The definition of c^* in (3) implies $P(c^*, s) = k$. We thus conclude that uninformed consumers cannot be charged a price greater than k in any efficient menu. If they are charged a price lower than k, all informed consumers will prefer (p, s) to the contract $(k, \cdot)$ meant for them. The uninformed can thus be charged a price lower than k only if no consumers should remain informed, i.e., only if $c^* = 0$. If $c^* > 0$, then $p = k$ is required. This proves the following result.

Proposition 5. *In Case* HE, *the purchase price* p *paid by the uninformed consumers in any efficient menu satisfies* $p \leq k$. *If* $c^* > 0$, *then* $p = k$ *and every efficient menu achieves the same outcome as does the singleton* $\{(k, s)\}$.

We reiterate the key findings of this section before moving on. First, in every case the only refunds ever paid are equal to the salvage value of the good. Second, efficiency precludes profits on informed consumers and, in Case HE, on uninformed consumers. In Cases EX and ID, an efficient menu can give firms the entire surplus S_u^* on uninformed consumers when the constraints of Propositions 3 and 4 allow the uninformed consumers to be charged $p = V(s - t)$.

6. Competitive Refunds

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Suppose now that there are two or more identical firms, and they compete in a Rothschild-Stiglitz fashion. That is, they first simultaneously offer menus (sets) of refund contracts to the market. Then each consumer decides whether to become informed. Finally, each consumer purchases the good by choosing one of the market contracts, or she chooses not to purchase. Each firm produces an amount of the good equal to the amount demanded. Refer to this as the *competitive game.*

One (subgame perfect) equilibrium of the competitive game consists of each firm offering the efficient contract (k, s). This contract yields zero profit, and it gives a consumer with information cost c the maximal social surplus given her cost, $\max(S_i^*(c), S_u^*)$. There is thus no contract that a deviating firm can offer that will attract this consumer away from (k, s), and at the same time make positive profit. Hence, all firms offering (k, s) is indeed an equilibrium.

The following proposition shows that every equilibrium is efficient.

Proposition 6. *Every equilibrium of the competitive game is efficient. If some consumers remain uninformed, then (k, s) is offered, and the uninformed accept only it. In this case every accepted contract takes the form (k, r) with $r \leq s$, and s is the only refund ever paid.*

7. Monopoly Refunds

We now assume there is only one firm and examine its optimal menu of refund contracts.

The analysis is eased if the price that maximizes the profit obtained from an informed consumer is unique. We accordingly assume $\pi_i(p) = (p - k)(1 - F(p))$ has a unique maximizer, and denote it as p_I. Note that $k < p_I < 1$. We also assume $\pi_i(\cdot)$ strictly increases (decreases) to the left (right) of p_I. Accordingly, we henceforth make the following assumption:[11]

(A1) $\pi_i(\cdot)$ has a unique maximizer p_I, and $\pi_i'(p) \gtrless 0$ as $p \lessgtr p^I$.

7.1. Monopoly Refunds in Case EX

We start with Case EX. No information acquisition decisions are made in this case; only incentive compatibility and individual rationality constrain the monopoly. It will choose a menu containing at most two contracts, one for the informed consumers and one for the uninformed. The uninformed will be given a no-refund contract, since they don't care about refunds, and giving them no refund maximally weakens the incentive constraint that requires the uninformed consumers to prefer their contract to that of the informed consumers. A monopoly menu that induces both the informed and the

[11] Assumption (A1) is equivalent to $p - k - \frac{1-F(p)}{f(p)}$ having a unique zero on $[k, 1]$. This is weaker than the usual assumption that this function be strictly monotonic.

uninformed to purchase can thus be assumed to take the form $\{(p_i, 0), (p_u, r)\}$, where $(p_i, 0)$ attracts the informed and (p_u, r) the uninformed. We now write such a *no-exclusion menu* more simply as a triple, (p_i, p_u, r). Possibly the monopoly will want to exclude the uninformed, in which case the optimal menu is the singleton $\{(p_I, 0)\}$. We consider this possibility at the end.

The monopoly's optimal no-exclusion menu in Case EX solves the program

$$
\begin{aligned}
&(\mathrm{P}_{ex}) \quad \max_{p_i, p_u, r} \bar{G}\pi_i(p_i) + (1-\bar{G})\pi^u(p_u, r) \\
&\text{subject to} \\
&(\mathrm{IC}_i) \quad p_u \geq p_i, \\
&(\mathrm{IC}_u) \quad V(r-t) - p_u \geq E(v) - p_i, \\
&(\mathrm{IR}_u) \quad V(r-t) - p_u \geq 0, \\
&(\mathrm{RP}) \quad r \leq p_u.
\end{aligned}
$$

Constraint (IC_i) is the incentive constraint $U^i(p_i, 0) \geq U^i(p_u, 0)$: an informed consumer will choose contract $(p_i, 0)$ over (p_u, r) only if the former has the lower price. Constraint (IC_u) is the incentive constraint of an uninformed consumer, since $U^u(p_u, r) = V(r-t) - p_u$ and $U^u(p_i, 0) = E(v) - p_i$. Constraint (IR_u) is the individual rationality constraint of an uninformed consumer. The individual rationality constraint for the informed consumers is not required: their equilibrium utility must be nonnegative because they always have the option of not purchasing. The final constraint, (RP), requires the refund in contract (p_u, r) to be no greater than the purchase price, as discussed in Section 5.

To give an intuition for the solution, suppose neither incentive constraint binds. The monopoly can then deal with the informed and uninformed consumers separately. The optimal price for the informed is $p_i = p_I$. The optimal price for the uninformed will be as large as it can be without violating (IR_u), and so $p_u = V(r-t)$. The firm's profit on an uninformed consumer is then equal to the entire surplus generated by the transaction:

$$
\pi^u(p_u, r) = S_u(r) - U^u(p_u, r) = S_u(r),
$$

where $S_u(r)$ is defined in (10). The firm's optimal r is thus the efficient refund, $r = s$, that maximizes $S_u(r)$. The price paid by the uninformed is $p_u = V(s-t)$.

This menu $(p_i, p_u, r) = (p_I, V(s-t), s)$ satisfies (RP).[12] It also satisfies the informed consumers' incentive constraint if $p_I \leq V(s-t)$. It satisfies the uninformed consumers'

[12] Since $V(s-t) - k = S_u^*$, and we have assumed $S_u^* > 0$, we have $s \leq k < V(s-t)$.

incentive constraint if $p_I \geq E(v)$. We have thus derived the monopoly menu for the case $p_I \in [E(v), V(s-t)]$.[13]

This argument suggests that the incentive constraint of the uninformed binds if $p_I < E(v)$. In this case the informed consumers' contract must be made less attractive to the uninformed by raising p_i above p_I, and the uninformed consumers' contract must be made more attractive by lowering p_u below $V(s-t)$, in order to restore (IC$_u$). On the other hand, the informed consumers' incentive constraint binds if $V(s-t) < p_I$. In this case the informed consumers' contract must be made more attractive by lowering p_i below p_I, and the uninformed consumers' contract must be made less attractive by raising p_u above $V(s-t)$. Note that raising p_u above $V(s-t)$ requires the refund to be raised above s, as otherwise (IR$_u$) will be violated. The optimal refund thus exceeds s when $V(s-t) < p_I$. This is all established in the following proposition.

Proposition 7. *In Case* EX, *the monopoly's optimal no-exclusion menu* (p_i, p_u, r) *takes one of three forms, depending on the relationships between* p_I, $E(v)$, *and* $V(s-t)$:

(*i*) *Case* $p_I < E(v)$. *Then (IC$_u$) binds,* $p_i \in (p_I, E(v)]$, $p_u = V(s-t) + p_i - E(v)$, *and* $r = s$.

(*ii*) *Case* $E(v) \leq p_I \leq V(s-t)$. *Then (IC$_i$) and (IC$_u$) do not bind, and* $(p_i, p_u, r) = (p_I, V(s-t), s)$.

(*iii*) *Case* $V(s-t) < p_I$. *Then (IC$_i$) binds,* $p_i = p_u = V(r-t) < p_I$, *and* $r \geq s$; $r > s$ *if* $s > t$ *or*

$$\pi_i'(E(v)) > \frac{1-\bar{G}}{\bar{G}}. \tag{18}$$

Proof. FOR APPENDIX (*i*) Consider the relaxed program obtained by deleting (IC$_i$) and (RP) from (P$_{ex}$). The constraints (IC$_u$) and (IR$_u$) can be written as one:

$$V(r-t) - p_u \geq \max(0, E(v) - p_i) \equiv \bar{U}(p_i).$$

This constraint binds, as otherwise p_u could be profitably raised. It can thus be written as an equality. It and the variable p_u can now be eliminated by substitution, using $\pi^u(p_u, r) = S_u(r) - \bar{U}(p_i)$. The relaxed program is thus written as an unconstrained program,

$$(\mathrm{P}^i_{ex}) \quad \max_{p_i, r} \bar{G}\pi_i(p_i) + (1-\bar{G})[S_u(r) - \bar{U}(p_i)].$$

[13] Note that $E(v) = \int_0^1 v dF(v) \leq \int_0^1 \max(v, s-t) dF(v) = V(s-t)$.

The optimal refund is $r = s$, the maximizer of $S_u(\cdot)$. For every $p_i > E(v)$, we have $\bar{U}(p_i) = 0$, and hence

$$\bar{G}\pi_i'(p_i) - (1-\bar{G})\bar{U}'(p_i) = \bar{G}\pi_i'(p_i).$$

Since $p_I < E(v)$, assumption (A1) implies that $\pi_i'(p_i) < 0$ for $p_i > E(v)$. For $p_i \leq p_I$,

$$\bar{G}\pi_i'(p_i) - (1-\bar{G})\bar{U}'(p_i) = \bar{G}\pi_i'(p_i) + 1 - \bar{G} > 0,$$

again using (A1). Any p_i that maximizes (P^i_{ex}) thus satisfies $p_i \in (p_I, E(v)]$.[14] The corresponding p_u, obtained from $V(s-t) - p_u = \bar{U}(p_i) = E(v) - p_i$, is

$$p_u = V(s-t) + p_i - E(v). \tag{19}$$

It remains to show that a solution of the relaxed program (P^i_{ex}) solves (P_{ex}), which is done by showing that a solution of (P^i_{ex}) satisfies the constraints (IC_i) and (RP). Using $V(s-t) \geq E(v)$ (fn 13), (19) implies $p_u \geq p_i$, and hence (IC_i). Since $p_i > p_I > k \geq s$, we also have $p_u > s$, and so (RP) is satisfied. This proves (*i*).

(*ii*) This part was proved in the text.

(*iii*) Let (P^{iii}_{ex}) denote the program obtained from (P_{ex}) by deleting (IC_u). In this program (IR_u) binds, as otherwise p_u could be raised profitably. So $p_u = V(r-t)$. By substituting this into the program, and using $\pi^u(p_u, r) = S_u(r) - U^u(p_u, r) = S_u(r)$, we obtain

$$\begin{aligned} &\max_{p_i, r} \bar{G}\pi_i(p_i) + (1-\bar{G})S_u(r) \\ &\quad \text{subject to} \\ &\quad (\mathrm{IC}_i') \quad p_i \leq V(r-t), \\ &\quad (\mathrm{RP}') \quad r \leq V(r-t). \end{aligned}$$

If (IC_i') were not to bind in this program, the optimal p_i would be p_I, the maximizer of $\pi_i(\cdot)$. The corresponding optimal r would be s, the maximizer of $S_u(\cdot)$. (Note that s satisfies (RP), since $S_u^* > 0$ implies $V(s-t) > k$, and we have $k \geq s$.) But then (IC_i') would imply $p_I \leq V(s-t)$, contrary to this being case (*iii*). So (IC_i') binds, and hence

[14] The Kuhn-Tucker condition for p_i to maximize (P^i_{ex}) on this half-closed interval is

$$\pi_i'(p_i) \begin{Bmatrix} = \\ \geq \end{Bmatrix} - \frac{1-\bar{G}}{\bar{G}} \text{ for } p_i \begin{Bmatrix} < \\ = \end{Bmatrix} E(v).$$

$p_i = V(r-t)$. We can now write (P_{ex}^{iii}) as

$$\max_r \bar{G}\pi_i(V(r-t)) + (1-\bar{G})S_u(r)$$
$$\text{subject to}$$
$$(\mathrm{RP}') \quad r \leq V(r-t).$$

It is easily shown that a unique $\bar{r} \in [E(v), 1]$ exists such that $V(\bar{r}-t) = \bar{r}$, and that $V(r-t) \geq r$ iff $r \leq \bar{r}$.[15] We can thus rewrite the relaxed program a final time:

$$(\mathrm{M}P_{ex}^{iii}) \quad \max_{r \leq \bar{r}} \bar{G}\pi_i(V(r-t)) + (1-\bar{G})S_u(r).$$

To summarize, (p_i, p_u, r) solves (P_{ex}^{iii}) iff r solves (MP_{ex}^{iii}), and $p_i = p_u = V(r-t)$. Furthermore, $p_i = p_u$ implies that the neglected constraint (IC_u) holds, since $V(r-t) \geq E(v)$ for all r by (6). Hence, (p_i, p_u, r) solves the original program (P_{ex}) iff r solves (MP_{ex}^{iii}), and $p_i = p_u = V(r-t)$.

The objective function of ($\mathrm{M}P_{ex}^{iii}$) is continuous in r; denote it as $M(r)$. It's right derivative on $[0,1)$ is

$$M'(r) \equiv \bar{G}F(r-t)\pi_i'(V(r-t)) + (1-\bar{G})(s-r)f(r-t), \tag{20}$$

using $S_u'(r) = (s-r)f(r-t)$ and $V'(r-t) = F(r-t)$. For $r < t$ we have $f(r-t) = F(r-t) = 0$, and so $M'(r) = 0$. For $r \in [t, s)$ we have $V(r-t) \leq V(s-t) < p_I$ (the last inequality comes from being in case (*iii*)). This and (A1) imply $\pi_i'(V(r-t)) > 0$. Hence, $M'(r) > 0$ for $r \in (t, s)$. A solution of ($\mathrm{M}P_{ex}^{iii}$) thus satisfies $r \geq s$. This cannot be an equality if $s > t$, for then

$$M'(s) = \bar{G}F(s-t)\pi_i'(V(s-t)) > 0.$$

So $s > t$ implies $r > s$. If instead $s = t$, then $M'(s) = 0$ and

$$M''(s) = \left[\bar{G}\pi_i'(E(v)) - (1-\bar{G})\right] f(0),$$

using $V(0) = E(v)$. So $M''(s) > 0$ if (18) holds, which again implies $r > s$.

Now assume a solution of (P_{ex}^{iii}) satisfies $p_u \geq p_I$. Then, as $p_u = V(r-t)$, we have $V(r-t) \geq p_I$. So by (A1), $\pi_i'(V(r-t)) \leq 0$. Furthermore, as $p_I > V(s-t)$ in the present case (*iii*), we have $V(r-t) > V(s-t)$. So $r > s$ and, as $s \geq t$, $(s-r)f(r-t) < 0$.

[15] If $t = 0$, then $\bar{r} = 1$. If $t \geq E(v)$, then $\bar{r} = E(v)$. Otherwise, $\bar{r} \in (E(v), 1)$.

Hence, $M'(r) < 0$. But this is contrary to $M'(r) \geq 0$, the necessary condition for r to solve (MP_{ex}^{iii}). Therefore $p_u < p_I$. ■

The monopoly will not want to exclude the uninformed consumers in cases (*i*) and (*ii*) of Proposition 7. This is obvious. The way to exclude the uninformed is to offer just one contract, a no-refund contract $(p_i, 0)$ with the price p_i no less than $E(v)$ so that the uninformed will not enter. In case (*i*) this would mean $p_i > p_I$, and so lowering the price to p_I would increase the profit obtained on the informed consumers and, as a bonus, profitably attract the uninformed as well, since $p_I < E(v)$. In case (*ii*) the firm's best non-exclusion menu already has $p_i = p_I$, and so it cannot make any more profit on the informed by excluding the uninformed. So in both cases the monopoly menus are the non-exclusive ones given in Proposition 7.

In case (*iii*), however, the firm may want to exclude the uninformed by offering just the contract $(p_I, 0)$ to obtain profit $\bar{G}\pi_i(p_I)$. If it instead offers the optimal no-exclusion contract of Proposition 7 (*iii*), its profit is $\bar{G}\pi_i(V(r-t)) + (1-\bar{G})S_u(r)$, where r is the corresponding optimal refund. The firm will thus exclude the uninformed if

$$S_u(r) < \frac{\bar{G}\left[\pi_i(p_I) - \pi_i(V(r-t))\right]}{1-\bar{G}}. \tag{21}$$

The uninformed are excluded in case (*iii*) if each of them cannot generate much surplus, or if they are relatively few in number.[16]

Case (*iii*) is of particular interest when the uniformed are not excluded, for three reasons. First, the optimal no-exclusion menu (p_i, p_u, r) is equivalent to the singleton menu $\{(p_u, r)\}$, since $p_i = p_u$, and the informed never use the refund. Given this singleton menu, an outside observer might have no reason to suspect the firm of screening different consumer types, even though the binding incentive constraint (IC$_i$) affects the solution. Second, the no-exclusion menu in case (*iii*) has, fairly generally, a refund r that is greater than the salvage value s. Third, assuming the cost t of trying and

[16] The following yields an example in which exclusion occurs in case (*iii*). Start with any F, and some $t > 0$. From them define $V(\cdot)$ and $\bar{r}$ (see the proof of Proposition 7). Then choose k such that $k < \bar{r} < p_I$. Then choose $s < \bar{r}$ so that $V(s-t) > k$. This yields an example satisfying all our assumptions. The left side of (21) is bounded above by $S_u(s)$, and and right side goes to infinity as $\bar{G} \to 1$, since $r \leq \bar{r} < p_I$ and (A1) imply $\pi_i(p_I) - \pi_i(V(r-t)) \geq \pi_i(p_I) - \pi_i(\bar{r}) > 0$. So exclusion occurs for large $\bar{G}$. Although this construction requires $t > 0$ (so that $\bar{r} < 1$), it seems clear that other examples can be found with exclusion when $t = 0$.

returning the good is positive, the optimal refund may be a "full money back" refund: constraint (RP) may bind so that $r = p_u$.[17]

7.2. Monopoly Refunds in Case ID

TO BE COMPLETED

7.3. Monopoly Refunds in Case HE

The monopoly's optimal no-exclusion menu in Case HE solves the program

$$
\begin{aligned}
&(\mathrm{P}_{he}) \quad \max_{p_i, p_u, r} G(\hat{c})\pi_i(p_i) + (1 - G(\hat{c}))\pi^u(p_u, r) \\
&\quad \text{subject to} \\
&\quad (\mathrm{IC}_i) \quad p_u \geq p_i, \\
&\quad (\mathrm{IC}_u) \quad V(r-t) - p_u \geq E(v) - p_i, \\
&\quad (\mathrm{IR}_u) \quad V(r-t) - p_u \geq 0, \\
&\quad (\mathrm{RP}) \quad r \leq p_u, \\
&\quad (\mathrm{IA}) \quad \hat{c} = \hat{c}(p_i, p_u, r) \equiv p_u - p_i + \textstyle\int_{r-t}^{p_i} F(v)dv.
\end{aligned}
$$

This program is similar to (P_{ex}), with the addition of a new variable, $\hat{c}$, and a new "information acquisition" constraint, (IA). The type $\hat{c}$ consumer is indifferent between becoming informed and choosing $(p_i, 0)$, or staying uninformed and choosing (p_u, r). Constraint (IA) is a rearrangement of this indifference requirement, $U^i(p_i, \hat{c}) = U^u(p_u, r)$. All consumers with a lower (higher) information cost choose to become informed (stay uninformed). The fractions who become informed and who stay uninformed are $G(\hat{c})$ and $1 - G(\hat{c})$, respectively.

8. General Monopoly Mechanisms

TO BE COMPLETED

[17] The following should yield an example in which $r = p_u$ in case (iii). As in footnote 16, choose parameters so that $k < \bar{r} < p_I$, $s < \bar{r}$, and $V(s-t) > k$. Then $a \equiv \min_{r\in[s,\bar{r}]} \pi_i'(V(r-t)) > 0$, and $b \equiv \min_{r\in[s,\bar{r}]} f(r-t) > 0$. From (20), on $[s, \bar{r}]$ we have $M'(r) \geq \bar{G}F(s-t)a - (1-\bar{G})(\bar{r}-s)b$, and the right side of this inequality is positive if $\bar{G}$ is close enough to 1. So in this case, $r = \bar{r}$, and so $p_u = V(\bar{r} - t) = \bar{r}$. It remains to show, however, that $\bar{G}$ sufficiently high for this to occur can be found that is not so high that (21) also holds, so that non-exclusion is indeed optimal. Note that $t > 0$ is required so that $\bar{r} < 1$: if $t = 0$ then $\bar{r} = 1$ and obviously $p_u = \bar{r}$ is not optimal.

9. Conclusions

TO BE COMPLETED

A. Proofs Missing from the Text

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