Refunds and returns in a vertically differentiated industry

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A R T I C L E   I N F O
Article history:
Received 14 January 2014
Received in revised form 20 October 2014
Accepted 10 December 2014
Available online 13 January 2015

Keywords:
Refunds
Cancellation terms
Vertical differentiation

A B S T R A C T
Firms frequently offer refunds, both when physical products are returned and when service contracts are terminated prematurely. We show how refunds act as a “metering device” when consumers learn about their personal valuation while experimenting with the product or service. Our theory predicts that low-quality firms offer inefficiently strict terms for refunds, while high-quality firms offer inefficiently generous terms. This may help to explain the observed variety in contractual terms.

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1. Introduction

Refunds and termination clauses are ubiquitous. For instance, the annual turnover of product return in the U.S. retail industry exceeds 100 billion U.S. dollars, of which 70% are due to reasons of taste and fit (see Posselt et al., 2008; Anderson et al., 2009). Likewise, contracts for services, including insurances, utilities, or subscriptions to health clubs, frequently involve cancelation clauses allowing customers to terminate prematurely. As we document below, however, there is wide variety in the use that firms make of such contracts. We present a theory based on firms’ vertical differentiation that generates such heterogeneity. In our model, firms use refund and return policies to extract a higher share of the information rent of those consumers who have a stronger preference for the respective product. In equilibrium, high-quality firms offer excessively generous terms, while low-quality firms offer excessively strict terms.

Several studies find that higher-quality retailers, such as up-market stores or internet retailers with a higher customer rating, offer more generous terms.1 When firm characteristics and product quality are unobservable to customers at the time of purchase, this relationship could be explained through signaling, similar to the theory of warranties put forward by Grossman (1981).2 However, when the reported measures of quality, such as customer ratings, are readily observable by customers, signaling alone cannot explain the observed heterogeneity. In our model, high-quality firms extract more surplus from consumers by offering an excessively high refund, while the opposite holds for competing low-quality firms. These distortions “at both ends” also distinguish our theory from models that explain contract heterogeneity by an efficiency rationale, e.g., as goods differ in their salvage value to firms after they are returned.3 Below we relate our findings to the predictions offered by other recent contributions to the literature on refunds and restocking fees.

In our model, consumers hold only privately observed prior beliefs about their valuation and they learn from experimenting with the product or service. With competition, two firms with a known high or low quality are in the market. Following the approach in Shaked and Sutton (1982), consumers who ultimately derive a higher utility from the product have also a higher marginal valuation. Prior to experimenting with a product or service, consumers have only imprecise knowledge of their utility (their “true type”). We characterize an equilibrium where the market is segmented as follows (albeit our key empirical prediction holds more generally, as we show as well). Customers who, ex-ante, have a lower expected utility turn to the low-quality firm. Consequently, for the low-quality firm its “marginal” consumer has the highest ex-ante valuation among all its customers and, therefore, the lowest marginal valuation for a higher refund, given that he is less likely to return the product (or to terminate a contract prematurely). The opposite holds for

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1. The authors thank Pascal Courty, Florian Hoffmann, and Martin Peitz for helpful comments. The paper replaces an earlier working paper entitled “Refunds as a Metering Device”.
2. Corresponding author.
3. Davis et al. (1995) document a positive correlation between the salvage value and the refund.
the high-quality firm. There, the “marginal” customer has the lowest ex-ante valuation and, therefore, the highest marginal valuation for a higher refund.

The optimal distortion of the refund away from the efficient level is now orthogonal for both firms, albeit explained by the same mechanism. By reducing the refund below the efficient level, which is equal to the salvage value or to the cost of continuing service, the low-quality firm can extract more of the consumer surplus of “inframarginal” customers, who have low ex-ante valuation. For the high-quality firm the opposite picture emerges. To extract relatively more consumer surplus from its “inframarginal” customers, who have a higher ex-ante valuation, the high-quality firm optimally offers a refund that is excessively generous.

In both cases, the results can be understood in terms of “metering” (cf. Schmalensee, 1981), namely when we interpret the ex-ante likelihood of a return as “metering” the extent of the usage that different customers will make of the refund option. Among the customers of the high-quality firm, it is the marginal customer for whom – from an ex-ante perspective – it will be most likely that the product is returned. Among the customers of the low-quality firm, the marginal customer is instead least likely to return the product. By increasing both the refund and the price so that the marginal consumer remains indifferent, the high-quality firm reduces the consumer surplus of infra-marginal customers, as the latter are less likely to return the product. The symmetric picture applies to the low-quality firm, where a less generous refund, accompanied by a price reduction that makes the marginal consumer still indifferent, reduces the consumer surplus for the respective infra-marginal customers, as these are ex-ante more likely to return the product. In both cases, the optimal choice trades off information rent extraction with total surplus maximization, as a distortion of the refund away from the first-best choice strictly reduces the latter.

To summarize, what is key in our setting is the combination of ex-ante private information by consumers, the fact that this is correlated with the likely usage that they will make of the refund option, and vertical competition. We also only consider single-product firms. The role of refunds to extract (more) consumer surplus when consumers have ex-ante private information follows the sequential screening literature (cf. Courty and Li, 2000), albeit – as we discuss below in much detail – we restrict consideration to a single contract offer rather than a menu. Our key contribution to this literature is the consideration of vertical competition and the thereby obtained different implications for low- and high-quality firms.

Notably in the marketing literature, recent contributions have explored other aspects and determinants of optimal refund policies on which this paper must remain silent. Shulman et al. (2009) consider a firm with two products, which can thus still capture sales when one product is returned, and they consider as well the option of pre-purchase information provision. The latter option is particularly relevant in their setting as ex-ante consumers may differ not only in their expected valuation but also in the knowledge about their valuation. Further, while in our paper consumers can learn only about a firm specific utility component, while experimenting with one product a consumer may also learn about his valuation for a competing product. Shulman et al. (2011) explore both types of learning in a setting with horizontal differentiation. Notably they contrast the findings when two differentiated products are offered by a monopolist with those when they are offered by competing firms and find that as the perceived differentiation increases, the refunds become less generous with competition and more generous with a monopolist.7 Finally, these as well as our paper typically consider variations in the refund terms, while Che (1996) considers risk averse consumers, and Davis et al. (1995) examine instead the use of full money-back return policies. Notably, these may also give rise to extreme consumer opportunism, as analyzed for instance in Hess et al. (1996), where consumers buy and return a product for the strict purpose of free renting.

The rest of this paper is organized as follows. Section 2 introduces the baseline model. In Sections 3 and 4 we derive the results under monopoly and competition, respectively. Section 5 extends the model to the case where consumers vary in the quality of information they possess ex-ante. Section 6 offers some concluding remarks.

2. The model

2.1. Utility

We model a market for differentiated goods. For a given consumer in this market, utility depends both on a common quality measure $y$ that differs between firms and an intrinsic fit $t$ that differs between consumers: $u(t, y) = yt$. Importantly, we postulate that $t$, which is not observed by the firms, is also only partially observed by consumers before they purchase. Specifically, we stipulate that $t = \theta + \epsilon$, where $\theta$ is observed before purchase and $\epsilon$ only after purchase. Here, $\theta \in \Theta$, $\Theta$ is distributed according to $G(\theta)$ with density $g(\theta) > 0$, while $\epsilon \in \tilde{\epsilon}$, $\tilde{\epsilon}$ is distributed according to $F(\epsilon)$ with density $f(\epsilon) > 0$. We assume that these are drawn independently, both for a given consumer and across consumers, but we will also comment below on how our results generalize.8 There is a mass one of consumers in the market.

2.2. Firms and contracts

We consider a model of vertical differentiation. Precisely, at most two firms operate in the market, which we denote by $i = 1, h$. Firm $h$’s intrinsic quality is given by $y_h > 0$ and firm $l$’s is given by $y_l$ where $0 < y_l < y_h$. That is, firm $h$’s intrinsic quality is better than that of firm $l$.

Firms have constant production costs $c > 0$ and offer the following contracts. A contract specifies a sales price $p$ together with a refund $r$. When a good is returned, it has the salvage value $s$ with $0 < s < c$. Note that the salvage value is independent of the firm’s quality $y$. For instance, we may suppose that after early return the good is no longer salvable. Then, $c - s$ is the cost of initiating a contract, $s$ is the cost of continuing to service a customer who has not terminated earlier, $p - r$ is the price for initiating the contract, and $r$ is the additional payment required to continue the service.

Firms offer a single contract $(p, r)$. Such a restriction may be particularly realistic with physical products. Otherwise, a firm would have to ascertain that a customer who bought under a less generous refund policy does not claim a higher refund by returning a product that was bought by another customer under a more generous refund policy. That is, the firm must ensure that product–customer matches remain

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4. We do not consider the possibility of costly pre-purchase information acquisition, as in Matthews and Persico (2007).

5. Somewhat related, we also do not consider at all vertical issues, which would arise when the manufacturer interacts with a (possibly also multi-product) retailer. Such a channel structure approach is taken notably in Shulman et al. (2010), which allows to combine problems of forward channel management (i.e., wholesale pricing) and reverse channel structures (i.e., accepting and salvaging returns).

6. See also Inderst and Pettit (2012) for a model with such two-dimensional ex-ante heterogeneity, albeit there the focus is on two-dimensional screening with nonlinear (service) contracts, so that there is no relationship to the issue of a refund.

7. Kuskov and Lin (2010) consider costly information provision by firms. e.g., through free sampling that resembles a full refund policy, in a vertically differentiated setting. However, the key difference is that consumers obtain this information “for free”, i.e., before making any payment to the respective seller, while in our model, as well as typically also in other models of refunds and returns, a consumer must first pay an initial price before learning about the product. In this sense, the results of Kuskov and Lin (2010) are thus more closely related to those in the literature on pre-contractual (pre-sale) information provision, e.g., Lewis and Sappington (1994); Johnson and Myatt (2006).

8. It should be noted that the additive structure of $t$ is by itself not restrictive. In fact, the part of $r$ that is unknown to a consumer ex-ante (the “error term”) can always be defined as $\epsilon = t - \theta$. 

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uniquely identified as, otherwise, a “gray market” for second-hand products could allow returning customers to always use the most generous refund policy available.\footnote{While it is common in retailing to make product return contingent on holding a valid receipt, such a “plain receipt policy” would not be sufficient for this purpose.} Letting customers choose between different contracts, specifying different prices and refunds, may also be unprofitable when it consumes too much valuable assistance time at the point of sale or is generally too costly to administer. Finally, customers may shy away from the additional complexity that this decision involves, preferring instead a simple, transparent choice.

2.3. Timing

We consider the following market game. At \( \tau = 0 \), each firm chooses a contract \((p, r)\). At \( \tau = 1 \), each consumer learns his ex-ante type \( \theta \) and chooses whether to purchase and, if so, from which firm. At \( \tau = 2 \), provided a consumer purchased, he learns the full fit \( \tau = \theta + \varepsilon \) and thus the respective utility \( u(t, y) \). He can then choose whether to return the product, in which case he realizes the refund \( r \). Otherwise, he keeps the good and realizes the utility \( u(t, y) \) in \( \tau = 3 \). All parties are risk neutral, and we abstract from discounting.

Note that, according to this specification, the customer only derives utility when consuming the service over the time interval between \( \tau = 2 \) and \( \tau = 3 \), but not over the “experimentation” phase between \( \tau = 1 \) and \( \tau = 2 \). Our qualitative results all hold, however, when a fraction of \( u(t, y) \) is enjoyed over the first interval and the residual fraction over the second interval.

Finally, we make the following parameter restrictions that ensure that we can safely rule out some corner solutions. From

\[
y_h (\bar{\theta} + \varepsilon) < s, \tag{1}
\]

returning the product is sometimes efficient also for the highest-type consumer and even when purchasing from firm \( h \). (Put differently, a return is always efficient when \( \varepsilon \) is realized.) From

\[
y_h (\bar{\theta} + \varepsilon) > c, \tag{2}
\]

purchasing and consuming the product – even that of firm \( l \) – is sometimes efficient also for the lowest-type consumer. (Put differently, purchasing and consuming is always efficient for the highest realization \( \varepsilon \).)

3. Monopoly benchmark

Suppose for now that only a single firm is in the market. Since only a single firm operates, presently we drop the subscript \( i = \{l, h\} \) for clarity. A customer returns a product when \( y(\theta + \varepsilon) < r \), while he continues to consume the good when \( y(\theta + \varepsilon) \geq r \).\footnote{As this is a zero-probability event, we stipulate without loss of generality that the consumer does not return the product when he is indifferent.} His expected utility from purchasing is given by

\[
U(p, r, \theta) := V(r, \theta) - p, \tag{3}
\]

where

\[
V(r, \theta) = r F(r/y - \theta) + \int_{r(y - \theta)}^{\varepsilon} y(\theta + \varepsilon) dF(\varepsilon).
\]

Note further that \( dV/d\theta > 0 \), which holds strictly whenever the good is consumed with positive probability. As is immediate, when \( r > s \) holds, the refund is too generous, and the product will sometimes be returned even though the consumer’s valuation exceeds the salvage value. Instead, when \( r < s \) holds, the refund is inefficiently low, and the product will sometimes be consumed even though the respective valuation is lower than the salvage value. In what follows, we will be interested in when either case arises, or alternatively when \( r = s \).

The firm’s expected profit with a consumer of type \( \theta \) consists of two parts: The up-front margin, \( p - c \), and the additional profit or loss when the product is returned, which together becomes

\[
n(p, r; \theta) := p - c + (s-r) F(r/y - \theta). \tag{4}
\]

It is also useful to define total surplus with a type-\( \theta \) customer:

\[
\omega(r; \theta) = \int_{r(y - \theta)}^{\varepsilon} [y(\theta + \varepsilon) - s] dF(\varepsilon) + s - c.
\]

As the consumer’s expected utility \( V(r, \theta) \) is increasing in \( \theta \), as long as there is a sale with positive probability, at \( \tau = 1 \) there is a critical type \( \theta^* \) such that all consumers \( \theta \geq \theta^* \) purchase, while consumers \( \theta < \theta^* \) do not purchase.\footnote{Again, resolving the indiffernce of the ex-ante type \( \theta \) in this way is without loss of generality, as the realization \( \theta = \hat{\theta} \) is a zero-probability event.} From inspection of Eq. (3) we can immediately conclude that, as is intuitive, \( \theta^* \) increases with \( p \) and decreases with \( r \). Hence, the firm chooses \((p, r)\) so as to maximize expected profits

\[
\Pi(p, r; \theta^*) = \int_0^\varepsilon \omega(p, r; \theta^*) dG(\theta) \tag{5}
\]

subject to the participation constraint of the lowest type: \( U(p, r; \theta^*) = 0 \).\footnote{Strictly speaking, when \( \theta^* < \hat{\theta} \) holds, this already uses that, by optimality for the firm, the price \( p \) is set so as to make \( \hat{\theta} \) just indifferent between purchasing and not purchasing.}  

**Proposition 1.** Suppose there is a single firm in the market. As long as there is an ex-ante difference in consumers’ types, \( \theta > \hat{\theta} \), the monopolist chooses a refund that is inefficiently generous, \( r > s \).

**Proof.** See Appendix.

This result is best understood as follows in terms of “metering” (cf. also the introduction). Recall that high-\( \theta \) consumers \( \theta > \theta^* \) receive a strictly positive consumer rent: \( U(p, r; \theta) > 0 \). Recall also that consumers with a higher ex-ante type \( \theta \) are less likely to make use of the refund option. In fact, the type that is most likely to return the product is the marginal type \( \theta^* \). When the firm increases the refund \( r \) and the price \( p \) simultaneously, so as to keep the marginal consumer just indifferent, this makes \( U(p, r, \theta) \), as a function of the type \( \theta \), flatter. It allows us to extract more consumer surplus from higher types, though at the cost of inefficiently reducing available surplus with all consumer types.

This trade-off between rent extraction for high-\( \theta \) consumers and maximization of total surplus is formally evident when we write the first-order condition for \( r \) (cf. also expression Eq. (20) in the proof of Proposition 1) as follows:

\[
(r-s) \varepsilon \int_0^\varepsilon F(r/y - \theta) dG(\theta) = \int_0^\varepsilon [F(r/y - \theta^*) - F(r/y - \theta)] dG(\theta). \tag{6}
\]

There, the rent-extraction rationale is captured by the term on the right-hand side and the rationale to maximize ex-ante surplus by the term on the left-hand side.\footnote{Incidentally, note that as consumers make different use of the refund option, the cost that this imposes on the seller \((r-s \varepsilon) \) is also type-dependent. This is different, for instance, in the seminal contribution by Spence [1975], where a change in quality may affect the valuation of the marginal consumer differently from that of “inframarginal” consumers, but where the cost of servicing a customer is the same.} The latter disappears when \( \hat{\theta} = \theta^* \) so that there is no ex-ante private information of consumers.

It is convenient to illustrate this further with the help of a comparative analysis. For this we stipulate for brevity’s sake that the seller’s...
problem is strictly quasiconcave. Further, we invoke the standard hazard rate assumption that for $G(\theta)$
\[
d\left[ \frac{g(\theta)}{1-G(\theta)} \right] > 0.
\]

(7)

The following comparative analysis is now conducted for the “marginal” type $\theta'$. We notice, though, that this is clearly determined optimally in equilibrium (and thus endogenous; cf. below). Still, Corollary 1 helps to shed additional light on the economic forces that determine the equilibrium refund policy of a monopolist.

**Corollary 1.** When Eq. (7) holds, the monopolist’s optimal choice of $r^* > s$ becomes less distorted (lower $r^*$ and thus lower difference $r^* - s > 0$) when his coverage of the market decreases (higher $\theta'$).

**Proof.** See Appendix.

For the “metering” result it is clearly important that, for the given $r$, the ex-ante private information $\theta$ is correlated with the likelihood with which the product is subsequently returned. For our chosen specification this is immediate from the respective probability $F(\theta | y = \theta)$. Formally, this is again immediately evident from the first-order condition in expression (6), precisely the right-hand side. As we already noted above, the particular specification of the utility function and the additive structure $t = \theta + \varepsilon$ is not necessary for this result to hold.15

To conclude this section, we ask how the marginal ex-ante type $\theta'$ is pinned down under a monopoly. To keep our exposition brief, suppose that the firm’s program to choose $r$ is strictly quasiconcave for a given $\theta'$, so that there is always a unique value $r^*$ that solves the respective first-order condition (20). Then, differentiating the firm’s profits in Eq. (19) and making use of the envelope theorem with respect to $r^*$, we have that
\[
d\Pi_i = \int_{\theta_i} \pi(p_i, r^*; \theta) dG(\theta).
\]

From consumer optimality, it must hold that $U_\theta(\theta) \geq U_\theta(\theta)$ for all $\theta \in \Theta$ and $U_\theta(\theta) \geq U_\theta(\theta)$ for all $\theta \in \Theta$. Note that the offer made by the other firm $j$ generates for each consumer who purchases at firm $i \neq j$ a type-dependent reservation value.

Our analysis proceeds now as follows. Our first characterization is for the case where the market segments into exactly two intervals. We then also derive sufficient conditions for this to be the case. Subsequently, we derive our key result also for the case where the market may be split up differently. With a simple segmentation into two intervals, we next solve first a relaxed program for each firm, where we assume that the “participation constraint”, i.e., that $U_\theta(\theta) \geq U_\theta(\theta)$ or, respectively, $U_\theta(\theta) \geq U_\theta(\theta)$, hold only at a single customer type: There is a critical type $\theta = \theta_\theta$, so that from $U_\theta(\theta) = U_\theta(\theta)$, together with $U_\theta(\theta) > U_\theta(\theta)$ for all $\theta > \theta'$ and $U_\theta(\theta) < U_\theta(\theta)$ for all $\theta < \theta'$, the participation constraint binds only at $\theta'$.

**4.1. Optimal refunds with simple segmentation**

When the relaxed program applies, the contract design problems for the two firms simplify as follows. As in our preceding analysis with a monopoly, we first take $\theta'$ as given, now together with the respective reservation value $U' \geq 0$, so that $U(\theta') = U(\theta') = U'$. After substitution for the respective prices $p_i$ and $p_j$ from the participation constraints, in analogy to the procedure in the proof of Proposition 1, firm profits are given by
\[
\Pi_i = \Pi_i \left(p_i, r_i; \theta_i \right) = \int_{\theta_i} \left[ V(\theta_i, y_i; \theta_i) - c - (r_i - s) F(\theta_i/y_i - \theta_i) - U' \right] dG(\theta).
\]

Note that, to avoid confusion, we have made explicit the dependency of $V(\cdot)$ on the quality of the consumed product, $y_i$ or $y_j$.

**Proposition 2.** Consider the relaxed programs of the two competing firms, so that the participation constraint for each firm binds only at the single marginal type $\theta'$. Then, the high-quality firm $h$ chooses a refund that is inefficiently generous, $r_h > s$, while the low-quality firm $l$ chooses a refund that is inefficiently strict, $r_l < s$.

**Proof.** See Appendix.

The intuition for the competitive result under market segmentation is immediate from our previous discussion of how a monopolistic firm can use the refund for metering, thereby extracting a higher surplus from “inframarginal” consumer types. For the low-quality firm, the marginal type $\theta'$ is now, however, the highest type that it serves, while for all lower types $\theta < \theta'$ we have $U(\theta') > U(\theta)$. Their utility from purchasing the low-quality product is strictly higher than their respective (type-dependent) reservation value, which they would realize when purchasing, instead, the high-quality product. To extract more of the lower types’ consumer surplus, the low-quality firm finds it

\footnote{15 In fact, write the conditional distribution of $r$ as $F(\theta | \theta)$, so that the likelihood of returning the product is $F(\theta | \theta)$. Then, the right-hand side of expression (6) contains now the (integral over) the difference $F(\theta' | \theta) - F(\theta | \theta)$, which for our argument to hold needs to be strictly decreasing in $\theta$ in the interior of the respective supports. This is the case if and only if the family of distribution functions $F(\theta | \theta)$, parametrized by $\theta$, satisfies strict First-Order Stochastic Dominance.

16 The “true” surplus is then clearly strictly positive: $\alpha(r^*; \theta') > 0$.

17 This presumes that both sets of types are measurable.}
optimal to reduce the refund below the efficient level, given that lower types have a strictly higher ex-ante likelihood of making use of the refund, compared to the marginal consumer \( \theta' \). Put differently, by reducing \( r_l \) and adjusting the price \( p_l \) accordingly, \( U_l(\theta) \) becomes flatter, which reduces the expected utility for all lower types. Recall, instead, that for the high-quality firm, which serves the upper segment of the market, it is optimal to make \( U_h(\theta) \) flatter, which is achieved by setting \( r_h^* > s \). This discussion also makes clear that what is needed for our results to hold is that firms are vertically, rather than only horizontally, differentiated. In the latter case it would instead typically hold that for each firm the marginal consumer is the one with the highest likelihood of subsequently returning the product, so that the outcome for each firm would resemble the monopoly case, instead.

Again, it is illustrative how contracts change when the marginal type varies. For this illustration we continue to maintain the hazard rate condition (Eq. (7)) while adding its standard complementary condition, namely, that

\[
\frac{d}{d\theta} \left( \frac{g(\theta)}{G(\theta)} \right) < 0.
\]

(10)

With this we can extend the previous monotonicity result from the monopoly case, albeit now the distortions in the two firms’ contracts change inversely: While one contract becomes more distorted, the other contract becomes less distorted. Note again, however, that the comparative analysis in Corollary 2 is simply for illustrative purposes as clearly \( \theta' \) will be derived in equilibrium (cf. below).

**Corollary 2.** When Eqs. (7) and (10) hold, then as the low-quality firm’s share of the market increases (higher \( \theta' \)), the low-quality firm’s refund policy becomes (inefficiently) less generous and that of the high-quality firm (efficiently) less generous.

**Proof.** See Appendix.

Note that

\[
\frac{dU_l(\theta')}{d\theta} > \frac{dU_l(\theta')}{d\theta}
\]

(11)

is necessary to ensure that the participation constraint for each firm is indeed slack around the marginal type. Generally, for \( y_h > y_l \), we have from

\[
\frac{dU_l(\theta)}{d\theta} = y_l[1 - F(r_l^*/y_l - \theta)]
\]

(12)

that a sufficient condition for the assumed segmentation is given by

\[
\frac{r_h^*}{y_h} < \frac{r_l^*}{y_l^*}.
\]

(13)

This can also be expressed in terms of primitives when we consider a specific functional form. We show this next before completing the characterization of the equilibrium. We note also that, as shown below, the key comparative result holds even when the considered market segmentation does not apply. When \( F(x) \) is uniformly distributed with support \([0, T]\) and \( G(\theta) \) is uniformly distributed with support \([\theta_l, \theta_h]\), we obtain

\[
r_h^* = s + \frac{1}{2} y_h (\theta_{\text{opt}} - \theta')
\]

and

\[
r_l^* = s - \frac{1}{2} y_l (\theta_{\text{opt}} - \theta').
\]

This intuitively illustrates the respective distortions, i.e., of \( \frac{1}{2} y_h (\theta_{\text{opt}} - \theta') \) above the salvage value for the high-quality firm’s refund and of \( \frac{1}{2} y_l (\theta_{\text{opt}} - \theta') \) below the salvage value for the low-quality firm’s refund.

After substituting also for the optimal \( \theta' \) (cf. below), condition (13) becomes

\[
\frac{1}{2} (\theta_{\text{opt}} - \theta) \leq s \left( \frac{1}{y_h} \right) - \frac{1}{y_h}
\]

(14)

Note also that condition (13), respectively condition (14), is only sufficient but not necessary.

As used also in the uniform example, the determination of the marginal type \( \theta' \) is again standard. We obtain from differentiation of the two profit functions, similar to the procedure in the monopoly case, that

\[
o_{y_h}(\theta') - \frac{1 - G(\theta')}{G(\theta')} [y_h_1 - F(r_l^*/y_h - \theta')] - y_l [1 - F(r_l^*/y_l - \theta')] = 0
\]

(15)

and, likewise, that

\[
o_{y_l}(\theta') - \frac{1 - G(\theta')}{G(\theta')} [y_h_1 - F(r_l^*/y_h - \theta')] - y_l [1 - F(r_l^*/y_l - \theta')] = 0.
\]

(16)

Prices are obtained from \( U_l(\theta') = U_l(\theta') \), so that \( p_l = V(r_h, y_h; \theta') - U_l(\theta') \) and \( p_l' = V(r_l', y_l'; \theta') - U_h(\theta') \).

4.2. No simple segmentation

When there is no such simple segmentation of the market into two intervals, each firm possibly serves a set of disjoint intervals. A simple characterization is then no longer obtained. However, what is key for our overall conclusions is that still our main qualitative insights survive, namely how refunds change in quality across firms.

**Proposition 3.** When both firms are active in the market and when one firm has higher quality, \( y_h > y_l \), then in a pure-strategy equilibrium it always holds that \( r_l^* < r_h^* \).

**Proof.** See Appendix.

The result in Proposition 3 is reassuring with respect to the (empirical) predictions of our model. We can thus robustly claim that when refund policies are shaped by vertical competition together with a screening or “metering” motive, then higher-quality firms will ceteris paribus offer more generous refunds. It should again be noted that for this comparison the salvage value has been kept constant, so that the variation in refunds is not driven simply by differences in salvage value across qualities.

5. Heterogeneity in the value of information

In the following section, we extend the analysis to the case where, ex-ante, consumers do not differ in their expected valuation, but rather in the expected value from experimenting with the product, i.e., in the quality of information that they expect to thereby obtain (cf. Courty and Li, 2000). We thus postulate that \( t \), the fit value, is now given by

\[
t = \theta c.
\]

(17)

Also, it holds that \( \int c dF(x) \equiv 0 \) and \( \theta > \theta \equiv 0 \). Thus, \( \theta \) orders the conditional distribution of \( t \) in the sense of a Mean-Preserving Spread. To rule out corner solutions we assume in analogy to the parameter restriction (Eq. (2)) that \( y_h T > c \). A consumer returns firm \( f \)’s product whenever \( y_h \theta c < r_h \) while keeping it otherwise. His gross expected utility is thus given by

\[
V(r_f, y_f; \theta) = r_f F(r_f/y_f, \theta) + \int_{r_f/y_f, \theta}^T y_f \theta dF(x).
\]

(18)
This is strictly increasing in the quality, \( y_i \), provided that the product is not always returned. Expected utility is also increasing in the customer’s type

\[
\frac{dV(r_i, y_i; \theta)}{d\theta} = \int_{r_i/(y_i\theta)}^{\theta} y_i \cdot c \cdot dF(c) \geq 0,
\]

which holds strictly when the product is not returned for sure. From this we have also that

\[
\frac{d^2V(r_i, y_i; \theta)}{d\theta^2} = -f(r_i/(y_i\theta)) \frac{1}{y_i\theta} \leq 0,
\]

which holds strictly when the threshold \( r_i/(y_i\theta) \) is in the interior of the support of \( \varepsilon \). Thus, as long as a customer both returns and consumes the product with positive probability, the marginal valuation for a higher refund is strictly decreasing in \( \theta \). This is again the key characteristic that we will use in what follows.

For generality, we also want to account for the case where the fit value turns out to be negative. To avoid “forcing” the buyer to then consume the product, we stipulate that there is free disposal.18 Similar to the procedure above, we first assume again that the respective participation constraints \( U_i(\theta) \geq U_j(\theta) \) with \( i \neq j \) bind only at some interior type \( \theta_i^* \), so that we can focus on the thereby relaxed program. A firm’s profit with consumer \( \theta \) is now given by

\[
\Pi(p_i, r_i; \theta) = p_i - c + (s-r_i) F(r_i/(\theta y_i)).
\]

In analogy to Proposition 1, substitution for the respective prices \( p_i \) and \( p_h \) yields expected firm profits

\[
\Pi_h = \int_{\theta}^{\theta'} [V(r_h, y_h; \theta') - c - (r_h - s) F(r_h/(\theta y_h)) - U'][dG(\theta)],
\]

\[
\Pi_l = \int_{\theta}^{\theta'} [V(r_l, y_l; \theta') - c - (r_l - s) F(r_l/(\theta y_l)) - U'][dG(\theta)],
\]

where \( U' \) is the utility that is obtained by the marginal type.

**Proposition 4.** Take now the utility function \( u = ty \), with type \( t = \theta \varepsilon \) (cf. Eq. (17)). Suppose the market is fully covered and that it is sufficient to consider only the participation constraint of some marginal type \( \theta' \) that segments the market. Then, as in Proposition 2, firm \( h \) sets an inefficiently generous refund, \( r_h^* > s \), and firm \( l \) sets an inefficiently strict refund, \( r_l^* < s \).

**Proposition 4** mirrors the characterization from Proposition 2. We have thus established another channel through which customer heterogeneity together with vertical differentiation of products can lead to a wide variety of refund policies — and again, in particular, to a positive correlation between quality and refund levels. Also, we obtain again that refunds are chosen inefficiently high or low, respectively.

Note finally that, as previously, we have focused on the case where the market is segmented in two type sets. Again, condition (11) is necessary for this to hold, which now transforms to

\[
\frac{dU_i(\theta')}{d\theta} - \frac{dU_j(\theta')}{d\theta} = \int_{y_i/(\theta y_j)}^{\theta} y_i \cdot c \cdot dF(c) + \int_{y_j/(\theta y_i)}^{\theta} (y_h - y_i) \cdot c \cdot dF(c) > 0
\]

and which holds for any \( \theta' \) whenever \( r_h/y_h \leq r_l/y_l \) (cf. condition (13)). Again, while this is not in terms of the model’s primitives, it can be readily verified once a solution has been calculated. For instance, when both \( \theta \) and \( \varepsilon \) are distributed uniformly, in analogy to condition (14), we obtain the condition

\[
y_i \left( 2 - \frac{s - \theta}{\Delta - \theta} \right) \leq y_h \left( 2 - \frac{s - \theta}{\Delta - \theta} \right),
\]

where \( \Delta = \ln(\overline{\theta}) - \ln(\overline{\theta}) \).

6. Concluding remarks

Firms frequently offer refunds, both when physical products are returned and when service contracts are terminated prematurely. We show how refunds can be used by firms as a “metering device” in case consumers, while having different expectations about their utility, still learn when experimenting with the product or service.

In our benchmark monopoly case, the refund is inefficiently high, as this allows the firm to extract more of the consumer rent of customers with a high ex-ante valuation and thus a lower marginal valuation for the refund. Our main contribution lies, however, in the analysis of the competitive model. There, two vertically differentiated firms, as in Shaked and Sutton (1982), compete through offering prices and refund terms. Our main positive prediction is that the low-quality firm offers a lower refund, though the salvage value is the same across products and even though product quality is observable to consumers ("no signaling"). We showed that this result is robust to a different source of consumer heterogeneity, where consumers differ in the precision of information that they obtain from experimenting with the product or service. Our results may thus offer an explanation for the wide variety of contractual terms that have been observed in empirical work (cf. the introduction). This complements the predictions of notably recent contributions to the marketing literature. As discussed in the introduction, combining the various aspects and determinants that these contributions focus on and that are neglected in the present analysis with our focus on vertical differentiation may prove fruitful for future analysis.

From a normative perspective, refunds are inefficient at both firms, at least when the equilibrium is characterized by a simple segmentation of the market, so that consumers with a lower preference for quality indeed purchase the respective product and vice versa. In particular, the low-quality firm then offers an inefficiently strict refund policy. In non-reported calculations we have explored the impact of stipulating a binding, mandatory minimum refund, similar to a consumer protection policy. This restricts the low-quality firm’s scope to extract consumer surplus. The impact that this has on welfare and expected consumer surplus is, however, generally ambiguous, notably as it makes the pricing decision of the firm less aggressive. In terms of consumer protection policy, authorities should thus be aware that what seem to be excessively unfavorable terms of refund or cancelation can arise also in an environment with rational consumers, instead of being merely instruments to exploit naive consumers, which would warrant the imposition of a minimum mandatory refund or cancelation period (cf. Loewenstein et al., 2003 or Inderst and Ottaviani, 2013).

7. Appendix: Omitted proofs

**Proof of Proposition 1.** For the proof we can take some \( \theta^* \) as given, which for a given \( r \) pins down \( p \) from the requirement that \( U(p, r; \theta^*) = 0 \). After substitution we have

\[
\Pi[p, r; \theta^*] = \int_{\theta^*}^{\theta} [V(r; \theta') - c + (s-r) F(r_l/y - \theta')] dG(\theta).
\]

18 Note that, in principle, this also imposes a restriction on the lowest feasible refund, \( r \geq 0 \). However, this restriction will not bind in equilibrium.
We now differentiate with respect to \( r \) to obtain the first-order condition
\[
d dI(p, r; \theta') \frac{dr}{dr} = 0,
\]
which yields
\[
\int_{\theta'}^{\theta} [F(r/y - \theta') - F(r/y - \theta)] dG(\theta) - (r - s) \int_0^{\theta'} f(r/y - \theta) dG(\theta) = 0. \tag{20}
\]

The first term in Eq. (20) is strictly positive whenever at least the lowest participating type \( \theta' \) returns with positive probability,
\[
r' - y - \theta' > \varepsilon, \tag{21}
\]
and when at least the highest participating type keeps the product with positive probability,
\[
r' - y - \theta < \varepsilon. \tag{22}
\]

In this case, i.e., when Eqs. (21) and (22) hold, we have immediately that \( r - s > 0 \).

In what follows, we show that Eqs. (21) and (22) must hold. Take first Eq. (22). If this did not hold, profits would be negative from \( s < c \). Take next Eq. (21). We argue to the contrary and suppose that there are no returns in equilibrium. Note that this requires that \( r < s \) (cf. condition (1)). The firm then makes profits of \((p - c)(1 - G(\theta'))\). Profits clearly remain unchanged as we increase \( r \) until \( r/y - \theta' - \varepsilon \) holds with equality. As we then increase \( r < s \) further, however, we have from inspection of Eq. (20) that \( dI(p, r; \theta')/dr > 0 \), which contradicts the optimality of the initial choice \( r \). Thus, also Eq. (21) must hold at an optimal value \( r \). Q.E.D.

**Proof of Corollary 1.** Note first that as \( \theta' \to \overline{\theta} \), we have from rewriting the first-order condition (6)
\[
r' - s = \int_{\theta'}^{\overline{\theta}} \frac{F(r'/y - \theta') - F(r'/y - \theta)}{f(r'/y - \theta) dG(\theta)}
\]
and by applying l'Hopital's rule that \( r' - s \) converges to
\[
y \left[ 1 - G(\theta') \right] \frac{d}{d\theta} r'/y - \theta \bigg|_{\theta' = \overline{\theta}} = 0.
\]

Next, from implicit differentiation of Eq. (20), together with the stipulated strict quasiconcavity of the seller's program, we have that the sign of the continuous function \( dr'/d\theta' \) is determined by the expression
\[
d^2I(p, r; \theta') \frac{dr'\theta' - \overline{\theta})}{d\theta'} = f(r'/y - \theta') [1 - 1 - G(\theta')] \left( r' - s \frac{1}{y} \frac{g(\theta')}{1 - G(\theta')} - 1 \right). \tag{23}
\]

To sign Eq. (23), note first that \( r' > s \) holds whenever \( \theta' < \overline{\theta} \) (cf. Proposition 1) and that \( r' \to s \) as \( \theta' \to \overline{\theta} \), which implies that \( r' \) must be decreasing somewhere. Arguing to a contradiction, suppose thus that \( dr'/d\theta' > 0 \) were to hold for some values \( \theta' \). Then, by continuity of \( r' \), there must be some value(s) \( \theta' < \overline{\theta} \) where the term Eq. (23) is zero and where, in addition, it cuts zero from above. To see that this cannot be the case, note that the derivative of Eq. (23), when evaluated at such a value \( \theta' \), equals:
\[
d (r'/y - \theta') [1 - G(\theta')] \left( r' - s \frac{1}{y} \frac{g(\theta')}{1 - G(\theta')} - 1 \right) + f(r'/y - \theta') [1 - G(\theta')] \times \frac{dr'}{d\theta'} \frac{1}{y} \frac{g(\theta')}{1 - G(\theta')} + (r' - s) \frac{1}{y} \frac{d}{d\theta'} \frac{g(\theta')}{1 - G(\theta')} = f(r'/y - \theta') [1 - G(\theta')].
\]

Here, the first equality follows as at the considered value \( \theta' \), both \( dr'/d\theta' = 0 \) and
\[
(r' - s) \frac{1}{y} \frac{g(\theta')}{1 - G(\theta')} - 1 = 0.
\]

The second inequality, in turn, follows from \( r' > s \) and from the hazard rate assumption (Eq. (7)). Thus, the term (23) is indeed strictly positive in the immediate right-side neighborhood of the considered value \( \theta' \), and we obtain a contradiction. Q.E.D.

**Proof of Proposition 2.** When the refund for either firm is characterized by the respective first-order condition, we have in analogy to the proof of Proposition 1 (cf. condition (20)) that
\[
(r' - s) \frac{1}{y} \frac{g(\theta')}{1 - G(\theta')} = \int_{\theta'}^{\overline{\theta}} [F(r'/y - \theta') - F(r'/y - \theta)] dG(\theta)
\]
and
\[
(r' - s) \frac{1}{y} \frac{g(\theta')}{1 - G(\theta')} \theta' \bigg|_{\theta' = \overline{\theta}} = 0.
\]

When these first-order conditions apply, the assertions that \( r' > s \) and \( r' < s \) follow immediately. By the same arguments as in the proof of Proposition 1, we can rule out for either firm the cases where the good is either returned with probability one or never returned with probability one. Q.E.D.

**Proof of Corollary 2.** The proof that \( dr'/d\theta' < 0 \) follows directly from Corollary 1. The proof for \( dr'/d\theta' > 0 \) proceeds now analogously, making use of Eq. (10). As \( \theta' \to \overline{\theta} \), we have from
\[
r' - s = \int_{r'}^{\overline{\theta}} \frac{F(r'/y - \theta') - F(r'/y - \theta)}{f(r'/y - \theta) dG(\theta)}
\]
and by applying l'Hopital's rule that \( r' - s \) converges to
\[
y \left[ 1 - G(\theta') \right] \frac{d}{d\theta} r'/y - \theta \bigg|_{\theta' = \overline{\theta}} = 0.
\]

Next, from implicit differentiation of Eq. (25), together with the stipulated strict quasiconcavity of the seller's program, the sign of the continuous function \( dr'/d\theta' \) is determined by the expression
\[
d^2I(p, r; \theta') \frac{dr'\theta' - \overline{\theta})}{d\theta'} = f(r'/y - \theta') [1 - G(\theta')] \left( s - r' \frac{1}{y} \frac{g(\theta')}{1 - G(\theta')} - 1 \right). \tag{26}
\]

We know that \( r' < s \) for all \( \theta' < \overline{\theta} \) and that \( r' \to s \) as \( \theta' \to \overline{\theta} \) implying that \( r' \) must be decreasing somewhere. Arguing to a contradiction, suppose thus that \( dr'/d\theta' > 0 \) were to hold for some values \( \theta' \). Then, by continuity of \( r' \), there must be some value(s) \( \theta' > \overline{\theta} \) where the term Eq. (26) is zero and where, in addition, it cuts zero from below. To see that this can, however, not be the case, note that the derivative of Eq. (26) evaluated
at such a point $\theta'$ equals:
\[
\begin{align*}
\frac{d}{d\theta}[(s-r_i')^2 - 1]_y G(\theta') + f'(r_i'/y_i') G(\theta')
\times \left[ \frac{1}{y_i' G(\theta')} \frac{d}{d\theta} G'(\theta') \right] + \left[ \frac{1}{y_i' G(\theta')} \cdot \frac{1}{y_i' G(\theta')} \right] \left( \frac{g'(\theta')}{G(\theta')} \right) &= \frac{d}{d\theta} G(\theta') \times \left[ \frac{1}{y_i' G(\theta')} \cdot \frac{1}{y_i' G(\theta')} \right] \left( \frac{g'(\theta')}{G(\theta')} \right) < 0,
\end{align*}
\]
where the equality is due to the fact that at the considered value $\theta'$, both $d\theta'/d\theta = 0$ and $\int \left[ s-r_i' \right] \theta G(\theta') = 0$. The inequality, in turn, follows from $r_i' < s$ and from the hazard rate assumption (Eq. (10)). This completes the contradiction. Q.E.D.

Proof of Proposition 3. We argue to a contradiction. Suppose that in equilibrium $r_i' > r_i$. Given $y_i > y_i$, condition (13) holds and the market is separated with firm $h$ operating on $[\theta - \theta]$ and firm $l$ on $[\theta - \theta']$. Fix a cutoff point $\theta'$. When both firms are active in the market, $\theta'$ is interior. We need to analyze three cases: (i) $r_i' \geq r_i, s \leq r_i', s > r_i$, and (iii) $r_i' \geq r_i, s > r_i'$.

Take first case (i). From inspection of $d\Pi_l(\theta')/d\theta$, using the first-order condition in Eq. (25), note first that independent of $r_i$, it holds that
\[
\frac{d}{d\theta} [F(r_i/y_i' - \theta') - F(r_i/y_i - \theta)] G(\theta) \leq 0.
\]

Thus, since $F(s) > 0$, $d\Pi_l(\theta')/d\theta$ is strictly negative for all $\theta \in (s, r_i')$. This implies that neither $r_i' \geq r_i > s$ nor $r_i' \geq r_i > s$ can hold in equilibrium for firm $l$. Still staying with case (i), suppose next that $r_i' = r_i = s$. Since $y_i(\theta + \xi) > s \forall \theta \in (\theta, \theta')$, cf. Eqs. (1) and (2), it must hold that
\[
\frac{d}{d\theta} [F(r_i/y_i' - \theta') - F(r_i/y_i - \theta)] G(\theta) \leq 0
\]
and hence $d\Pi_l(\theta')/d\theta_{r_i'=s}<0$, so that with $r_i' = r_i = s$ firm $l$ would still want to deviate.

The argument proving that $s \geq r_i' \geq r_i$ (case (ii)) cannot arise in equilibrium is analogous, with the only difference that this time one must consider firm $h$'s unilateral deviation. Finally, with regards to case (iii), observe that we have already ruled out that $r_i' = r_i = s$ can arise in equilibrium. When $r_i' > s \geq r_i$, we can argue, as in case (i), that firm $l$ has an incentive to deviate, as $d\Pi_l(\theta')/d\theta$ is strictly negative for all $\theta \in (s, r_i')$; while when $r_i' < s < r_i$, we can argue likewise for firm $h$. Taken together, we can thus conclude that $r_i' \geq r_i$ cannot arise in equilibrium. Q.E.D.

Proof of Proposition 4. When the refund for either firm is characterized by the respective first-order condition, we have in analogy to the proof of Proposition 2 (respectively, Proposition 1; cf. condition (20)) that
\[
(r_i-s) \int \frac{1}{y_i} \frac{d}{d\theta} f(r_i/y_i) G(\theta) = \int \frac{d}{d\theta} \left[ F(r_i/y_i) - F(r_i/y_i') \right] G(\theta)
\]
and
\[
(r_i-s) \int \frac{1}{y_i} \frac{d}{d\theta} f(r_i/y_i') G(\theta) = \int \frac{d}{d\theta} \left[ F(r_i/y_i') - F(r_i/y_i) \right] G(\theta).
\]

When these hold, the assertions that $r_i' > s$ and $r_i' < s$ follow immediately from the fact that the probability of return decreases with the consumer's type, as noted above. Note also that $r_i > 0$.

Finally, by the same arguments as in the proof of Proposition 1, we can rule out for either firm the cases where the good is either returned with probability one or never returned with probability one (i.e., the cases where $r_i$ and $r_i'$ would be determined by the respective corner solutions, rather than the respective first-order conditions). Q.E.D.

References


