Contrived Depreciation in the Presence of Resale Markets[1]

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Abstract

We consider a model of heterogeneous consumers where a monopolist engages in price discrimination by inducing lavish consumers to repeat purchase of a good that depreciates over time. Depreciation here is contrived in the sense that the monopolist chooses both the price and the point in time when the good will lose value. Conditions under which such a discriminating monopolist will earn higher profits are identified. We then analyze the impact of a secondary market for this good on the monopolist. Welfare considerations under alternative scenarios are also dicussed.

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1 Introduction

Does contrived depreciation necessarily enhance monopoly profits? The origins of this durability debate can be traced back to Chamberlain (1957), who argued that by reducing the frequency of purchase, higher durability reduces overall profits, making contrived depreciation a useful tool for the monopolist. However, Swan (1970) established what is known in the literature as the "independence result"*:* namely there is no link between durability and market structure. These results are limited by the fact that they rely on homogeneous consumers. Mussa and Rosen (1978) extend the scope of this analysis by examining quality choice under different market structures after allowing for heterogeneous consumer preferences.

In an interesting paper Basu (1988), formulates the same problem in the context of durability choice under monopoly and competition. In his paper *durability is a distinct aspect of product quality and price discrimination relies on repeated consumer purchase.* Fastidiousness now gets explicitly modelled as a characteristic over which consumer preferences can differ. This makes the problem different from the one analyzed by Mussa and Rosen as market segmentation is no longer dependent only on the number of brands offered for sale. The firm is allowed to treat both product durability and the number of brands as different choice variables.[1] Further, Avinger (1981) reports four different types of products − electric lamps, stainless steel razor blades, phonograph styli and electronic vacuum tubes−, where such monopoly considerations inhibited the introduction of more durable product variants.

Our paper provides a complete solution to the model developed by Basu (1988) in the context of a monopolist using a mechanism-design framework. We consider two types of consumers who get different utility from a good that depreciates over time. Unlike Basu (1988), we use incentive compatibility and participation constraints to endogenize the behavior of these agents. This approach enables us to provide a complete characterization of the set of equilibria of which includes Basu's example as an equilibrium as well. We identify conditions which enable the monopolist to earn higher profits by deliberately reducing durability and making the durability-conscious con-

[1] The following statement from Scherer and Ross (1990, pg 609) perhaps clarifies the difference between them: "In an unpublished speech, an AT&T official observed that one of the most difficult lessons the company had to learn following deregulation was how to make a telephone that lasted only three years".

sumers purchase more often. Second, the model is developed further by incorporating a second hand market and allowing for resale between the two consumer types. We find that the existence of a secondary market is not necessarily detrimental to the monopolist. Under certain conditions the resale market serves as a conduit for extracting the surplus of the low type consumers. This issue has been explored among others by Rust (1986), Kim (1985), and Ireland (1989). Both Kim (1985) and Ireland (1989) treat prices in the primary market as exogenous while Rust considers homogeneous consumers only. In a more recent paper Anderson and Ginsburgh (1994) examine the problem using a model similar to the one developed by Mussa and Rosen. However, they do not investigate what happens in the absence of a resale market and their results focus on the impact of transaction costs on the secondary market. Our paper ignores such costs to emphasize the interactions between these markets in isolation. Also, the emphasis of our paper unlike Anderson and Ginsburgh (1994) is on the durability issue.

Examples of the situation described above can be found in many countries in a variety of markets. Some common examples from the United States are the markets for computers, furniture and cars. Computer leases which are becoming increasingly popular allow consumers to lease a computer for a couple of years, with the option of buying it at the end of the lease period. Thrifty consumers may opt to buy their old computer while the more fastidious ones will purchase a new one. Similarly, consumers can lease a car or furniture which may be purchased at the end of the lease period or lease anew. It also sheds some light on a recent phenomenon in the Indian auto industry (*Indian Express*, Oct. 2, 1998). Car dealers are offering zero percent financing to owners who turn in their old cars to buy a new car even if it is of the same make.[2] The old cars are then refurbished and sold on the second hand market by the dealers themselves. The scheme is being pursued despite the fact that sales of refurbished cars are pretty low. The report argues that this is being done to stem the excess supply of cars and plummeting prices in the resale market. Also it allows the dealers to appropriate the surplus from the secondary market. One way to interpret this would be argue that the auto makers misjudged how often the lavish consumers want to replace their cars. As a result their is excess supply in the used car market. Consequently the auto makers are unable to sell to

[2]It is worth pointing that such schemes did not exist in the Indian auto industry till the entry of a large number of foreign car companieslike Ford, Daewood, etc. in recent years.

thrifty consumers. By intervening in the market the auto industry hopes to stop the excess supply. While these examples may serve to illustrate our point note that they are not perfect examples since other considerations like changing technology, liquidity constraints, etc. may influence the decision to lease or buy a commodity.

Section 2 of the paper develops the basic model and characterizes the range of possible solutions with their welfare implications. The following section introduces a secondary market and examines its consequences for the monopolist. Section 4 is the concluding section of the paper and summarizes the results.

2 The Model

We consider a monopolist who produces a good that lasts for only one period. It remains new for a fraction q of the period, $0 < q \leq 1$, and is of depreciated quality for the remaining $(1 - q)$ of the time. The good also has the "sudden death" property so that at the end of the period it does not have any value. Alternatively, the good becomes so obsolete that at the end of the period there is no demand for it. For simplicity, we assume that at each point in time the consumers wish to possess at most one unit of the good. Consumer heterogeneity takes the form of two types of consumers - the high type and the low type consumer of measure 1 and μ_l respectively.[3] A high type consumer replaces the good as soon as its quality depreciates, but a low type consumer will hold on to a good of depreciated quality. The type i consumer attaches a value of V_n^i to the new product and $V_d^i,\ i = h, l$ to the depreciated product respectively. The loss of utility to consumer i when the good depreciates in quality is given by $\Delta^i = V_n^i - V_d^i$.

Assumption 1: $\Delta^i \geq 0$ *for* $i = h, l$ *and* $\Delta^h > 0$.

This assumption ensures that the high type consumers suffers a positive utility loss when the good depreciates and hence would like to replace it. Note also that since we will look at the steady state and study behavior of consumers as an average over time, this eliminates integer problems.

[3] The proportion of consmers has been normalized by dividing throughout by μ_h.

The consumer's per period utility from purchasing n units of the good for a price durability pair (p, q) is given by

$$U^i(n, p, q) = nqV_n^i + \min[n(1-q), (1-nq)]V_d^i - np \quad (1)$$

This utility function is continuous in n and piecewise linear over $[0, 1]$ and $(1, 1/q]$. So we have:

$$\begin{aligned} \frac{\partial U^i}{\partial n} &= qV_n^i + (1-q)V_d^i - p \quad \text{for} \quad n \in [0,1] \\ &= q(V_n^i - V_d^i) - p \quad \text{for} \quad n \in (1, 1/q] \end{aligned}$$

Consequently, the consumer's optimal choice correspondence $n_i^*(p, q)$ always includes one of $\{0, 1, 1/q\}$.

Assumption 2: *The consumer always chooses the maximal element in* $n_i^*(p, q)$.

This assumption serves the same function as tie-breaking assumption in Basu (1988).

To solve the monopolist's problem we will now express the consumer's problem using standard mechanism design tools. The monopolist must choose (p, q) such that the high type acts lavishly, i.e., repeats purchase while the low type acts thriftily, i.e., purchases only once. Then, for each consumer type i, the incentive compatibility (IC^i) and the participation constraints (IR^i) must hold simultaneously.

Assumption 3:

$$\begin{aligned} IC^h &: V_n^h - p/q \geq qV_n^h + (1-q)V_d^h - p \Rightarrow \Delta^h \geq p/q \quad (2) \\ IR^l &: qV_n^l + (1-q)V_d^l - p \geq 0 \end{aligned}$$

The above assumption shows the two effective constraints for this problem. The other two constraints – (IC^l) and (IR^h) are redundant (see Fudenberg and Tirole, 1991). The monopolist's problem can now be clearly stated as $\max \pi(p, q) = (p - c)\{1/q + \mu_l\}$ subject to IC^h, IR^l, $p \geq 0$, and $q \in (0, 1]$. The parameter c which denotes the cost of production is assumed to be independent of durability and set equal to zero.[4] This enables us to rewrite the profit function as

[4] The assumption of zero production costs is fairly common in this literature and allows us to focus solely on the price discrimination problem.

$$\pi(p,q) = p[1/q + \mu_l] \tag{3}$$

We also define the monopolist profit function from setting $q = 1$ as $\widehat{\pi}(p,1) = \max\ [(1+\mu_l)V_n^l, V_n^h]$. So if the monopolist does not sell to both types the maximum she can get is V_n^h.

Given our assumptions about the behavior of consumers, the profit function is always upper semi-continuous. This ensures that an equilibrium exists in all cases (see Basu (1988) for a proof). The above profit function allows for two distinct possibilities depending on whether Δ^h is at most equal to V_n^l or exceeds V_n^l. This is easily verified by drawing the relevant constraints as rectangular hyperbolas in the $(p, 1/q)$ space. The first case is shown in Figure 1 where $\Delta^h \leq V_n^l$.

Insert Figure 1 about here

The darker line which represents IC^h is always flatter than IR^l and is the effective constraint in this case. Also note that Δ^h and V_n^l are the intercepts on the price axis of IC^h and IR^l respectively and in this figure equality holds at V_n^l.

Consider Figure 2 now. It is easy to check that the two constraints will intersect in the $(p, 1/q)$ space if and only if $1/q > 1$. This represents a high type consumer who is extremely quality conscious as $\Delta^h > V_n^l$.

Insert Figure 2 about here

Let $(\bar{p}, \bar{q})$ be the price durability pair at which IC^h and IR^l intersect. Clearly the darker line represents the binding constraints and profits are maximized accordingly. This is summarized in the following proposition.

Proposition 1 *Assume $V_d^l > 0$. The monopolist will select*

(a) $q = 1$ if the high type consumer is not very quality conscious or $\Delta^h \leq V_n^l$,

(b) $q = \bar{q}$ if the high type consumer is quality conscious or $\Delta^h > V_n^l$ and the proportion of low type consumers in the total population is less than the ratio of the depreciated to the new good for the low type consumers,

(c) $q = 1$ if the high type consumer is quality conscious but $\mu_l > \frac{(\Delta^h - \Delta^l)^2}{\Delta^l V_d^l}$.

Proof. To prove part (a) consider Figure 1 which shows that for $q < 1$, IC^h is binding. So the monopolist maximizes $\pi(p, q) = (1/q + \mu_l)p$ subject to $p/q \leq \Delta^h$. Hence the monopolist will always choose the highest value of q, i.e., set $q = 1$.

To prove the next two parts consider Figure 2 now. We have

$$\begin{aligned} \pi(p, q) &= (1/q + \mu_l)p + \lambda_1(qV_n^l + (1-q)V_d^l - p) \ \text{ if } q \geq \bar{q} \\ &= (1/q + \mu_l)p + \lambda_2(V_n^h - V_d^h - p/q) \ \text{ if } \ q \leq \bar{q} \end{aligned}$$

Note that λ_1 and λ_2 are the usual Lagrange multipliers. When $q \geq \bar{q}$, IR^l is the effective constraint and when $q \leq \bar{q}$, IC^h is binding. Since profits are decreasing along IC^h, following the previous argument the monopolist will never choose $q < \bar{q}$. However it is important to check what happens with the first profit function. Taking the derivative with respect to q we get $\frac{\partial \pi}{\partial q} = -(p/q^2) + \lambda_1 \Delta^l$. By substituting for p and λ_1 and with some manipulation it can be shown that $\frac{\partial \pi}{\partial q} = \Delta^l \mu_l - V_d^l/q^2$.

If $\partial \pi / \partial q \leq 0$ at $q = 1$, then $\bar{q}$ will be optimal. In order for this to be true we need:

$$\frac{\partial \pi}{\partial q} \mid_{q=1} = \Delta^l \mu_l - V_d^l < 0 \Rightarrow V_n^l \mu_l - (1 + \mu_l)V_d^l < 0 \Rightarrow \frac{\mu_l}{1 + \mu_l} < \frac{V_d^l}{V_n^l}$$

If $\partial \pi / \partial q$ is ≥ 0 in q along IR^l i.e., it is positive at $\bar{q}$, $q = 1$ will be optimal. To do this we first solve IR^l and IC^h as an equality to get $\bar{q} = \frac{V_d^l}{\Delta^h - \Delta^l}$. For $q = 1$ to be optimal we need:

$$\frac{\partial \pi}{\partial q} \mid_{\bar{q}} = \Delta^l \mu_l - \frac{(\Delta^h - \Delta^l)^2}{V_d^l} > 0 \Rightarrow \Delta^l \mu_l > \frac{(\Delta^h - \Delta^l)^2}{V_d^l}$$

If $\frac{\partial \pi}{\partial q} |_{\bar{q}} \leq 0$ and $\frac{\partial \pi}{\partial q} |_{q=1} \geq 0$, then the monopolist's profit function has two local maxima and one needs to make a global comparison of the profits to check which one is optimal. ■

This proposition allows us to compare the monopolist's optimal choice from the parameters of the problem itself. Consider an example where $V_n^h = 5$, $V_d^h = 1$, $V_n^l = 2$, and $V_d^l = 1$. This implies $\Delta^h = 4$ and $\Delta^l = 1$. Also assume that $\mu_l = 1$. Using (**??**) we have $\max \pi(p, 1) = 5 = \widehat{\pi}$. Also, we have $(\bar{p}, \bar{q}) = (4/3, 1/3)$ and $\pi(\bar{p}, \bar{q}) = 16/3$. We can now vary the parameters of the problem and see how the monopolist's optimal choice of q is affected. If we increase V_d^h, in Figure 2, IC^h shifts inwards as Δ^h falls. Consequently, both $(\bar{p}, \bar{q})$ increase and profits fall. Note that $q < 1$ as long as $\Delta^h > 2$, i.e., $V_d^h < 3$. It is also possible to check that at $V_d^h = \frac{1}{2}(5 + \sqrt{5})$, profits are less than 5 and it is better to shift to $q = 1$ and $p = 5$. Suppose we now reduce V_d^l. Then in Figure 2, IR^l swivels around V_n^l and becomes flatter. Profits decline as both $(\bar{p}, \bar{q})$ fall. For this case too, it is possible to check that at a certain point $q = 1$ once again becomes the optimal choice. Note also that if we reduce μ_l, then $\pi(\bar{p}, \bar{q}) = 4 + (4/3)\mu_l$. As μ_l falls, profits decrease and for $\mu_l < 3/4$, $\widehat{\pi}$ becomes the optimal choice once again.

The monopolist's optimal decision depends on the parameters of the problem. The monopolist can choose either to sell to both types or only to the high type consumers. Even if the monopolist chooses to sell to both types we can have two possible cases as shown in *Proposition 1.*
At $q = 1$, we have that $p = V_n^l$ and hence $\pi(p, 1) = (1/q + \mu_l)p = (1 + \mu_l)V_n^l$.
At $q = \bar{q}$, we have $\bar{p} = \bar{q}\Delta^h = \frac{\Delta^h V_d^l}{\Delta^h - \Delta^l}$ and hence

$$\pi(\bar{p}, \bar{q}) = (1/\bar{q} + \mu_l)\bar{p} = \frac{\bar{q}\Delta^h}{\bar{q}} + \frac{\Delta^h V_d^l}{\Delta^h - \Delta^l}\mu_l = \Delta^h(1 + \frac{V_d^l}{\Delta^h - \Delta^l}\mu_l)$$

All of this of course needs to be compared with V_n^h. Optimum profits will therefore be given by the following comparision:

$$\pi^*(p, q) = \max[V_n^h,\ (1 + \mu_l)V_n^l,\ \Delta^h(1 + \frac{V_d^l}{\Delta^h - \Delta^l}\mu_l)].$$

2.1 Welfare Analysis

The relationship between contrived depreciation and efficiency is more ambiguous than might generally be perceived. At one level, contrived depreciation is inefficient just as any monopoly outcome is inefficient compared to the competitive outcome. However, a monopolist who resorts to contrived depreciation is not always more efficient than a traditional monopolist. In our simple model, since marginal cost is zero, and durability is costless, full efficiency requires that all consumers buy the product and $q = 1$. When the monopolist is constrained to choosing $q = 1$, then the profit function has two local maxima, i.e., $p = V_n^h$ or $p = V_n^l$. If the global maximum occurs at V_n^l, then it is efficient, while $p = V_n^h$ is inefficient as the monopolist sells only to a particular segment of the market. If the former case is accompanied by contrived depreciation, an inefficiency arises as the low type consumer has V_n^l for a fraction $\bar{q}$ of the time and V_d^l for a fraction $(1 - \bar{q})$ of the time. However, it is more efficient than the latter case where $p = V_n^h$ by making it feasible for the monopolist to sell to the low type consumers as well, instead of leaving them out of the market completely.

3 The Model with Resale

This section analyzes the resale market for a partly depreciated good. The lavish consumer who purchases repeatedly has no use for the depreciated item. Given that the good still has a life of $(1 - q)$, it can be sold to the thrifty consumer. One might assume that the existence of such a resale market would act as a countervailing force to monopoly power. While this is indeed true for some cases, we find that there are also situations where the monopolist can use the secondary market to enhance his market power.

Throughout this section we will assume that only the low type consumers buy from the resale market.

Assumption 4: *Effective potential demand in the secondary market is* μ_l.

Consider now the situation where the high type consumer purchases $1/q$ units of the new good each period and therefore can potentially supply $1/q$ units of the depreciated good in each period. Since each unit of the depreciated good has a life of $(1 - q)$, effective supply in the secondary market is $(1 - q)/q$. Let p_r denote the price in the resale market and r_d^l be the reservation value of the low type buyers. The price in the resale market will clearly depend on the monopolist's choice of q.

Assumption 5: *If* $q < \frac{1}{1+\mu_l}$, *there is excess supply in the resale market and* $p_r = 0$.

As the high type consumer does not gain any utility from resale, his incentive compatibility constraint IC^h is unaffected. But the thrifty consumer now has the option of purchasing from the secondary market. The monopolist's offer will only be considered if the (p, q) pair satisfies a new incentive compatibility constraint IC_2^l arising from the resale market, i.e., $n_i^* = 1$ only if

$$IC_2^l : qV_n^l + (1-q)V_d^l - p \geq V_d^l - \frac{p_r}{1-q} \tag{4}$$

For $p_r = 0$, this reduces to $\Delta^l \geq p/q$. Recall from the pervious section that if $\Delta^l \geq p/q$, the low type consumer will prefer to buy lavishly, i.e., purchase $1/q$ units. Hence we can now write the monopolists profits as

$$\begin{aligned} \pi(p,q) &= (1+\mu_l)p/q \text{ if } q < \frac{1}{1+\mu_l} \text{ and } p/q \leq \Delta^l \text{ and } \Delta^l \leq \Delta^h \quad (5) \\ &= p/q \text{ if } q < \frac{1}{1+\mu_l} \text{ and } \Delta^l < p/q \leq \Delta^h \end{aligned}$$

From this we can deduce that if the monopolist chooses $q < \frac{1}{1+\mu_l}$, her maximal profits are clearly less than $\widehat{\pi}$. Since $\widehat{\pi}$ is achievable by choosing $q = 1$, it follows that the monopolist does not benefit from contrived depreciation. Thus, the second hand market constrains the monopolist if he tries to ensure that the low type patronizes him instead of the resale market. The next proposition is based on this.

Proposition 2 *Let* $V_d^l > 0$. *Contrived depreciation that creates excess supply in the resale market or* $\mu_l < (1-q)/q$ *yields lower profits than choosing* $q = 1$.

Proof. The monopolist now effectively faces the following three constraints:

$$(1+\mu_l) < 1/q \tag{6}$$

$$1/q \leq \frac{\Delta^l}{p} \tag{7}$$

$$1/q \leq \frac{\Delta^h}{p} \tag{8}$$

The first constraint just ensures that the monopolist has to choose $q \in (0, \frac{1}{1+\mu_l})$ and for excess supply to exist we assume that it always holds. Here the monopolist does not need to take account of the original IR^l constraint as $V_d^l > 0$ makes IC_2^l the binding constraint. In order for the resale market to exist, we know that IC^h must be always satisfied otherwise the very source of excess supply is cut off.

Suppose $\Delta^h \leq \Delta^l$. In this case we know from the proof of *Proposition 1* that the monopolist will choose $q = 1$ and never create excess supply in the resale market.

Suppose $\Delta^h > \Delta^l$. Then we know that (6) binds along with (7). Also the type of intersection possible in *Proposition 1* is ruled out since the hyperbola corresponding to (7) always lies below the one corresponding to (8). The profits for this case are given by

$$\pi(p, q) = (1 + \mu_l)p/q = (1 + \mu_l)\Delta^l$$

We will now show that for $\Delta^h > \Delta^l$, the options under $\widehat{\pi}$ are always better. Let $\widehat{\pi} = (1 + \mu_l)V_n^l$. Then setting $q = 1$ is optimal since $V_n^l > \Delta^l$ as long as $V_d^l > 0$. Let $\widehat{\pi} = V_n^h$. This means that $V_n^h > (1 + \mu_l)V_n^l > (1 + \mu_l)\Delta^l$. Hence choosing $q = 1$ is always optimal. ■

Let us now examine what happens to the monopolist's problem when there is excess demand in the resale market or when $\mu_l \geq (1 - q)/q$. The resale price p_r, which now will be strictly positive, will affect the incentive compatibility constraint of the high type consumer in the following manner:

$$IC_2^h : \; V_n^h - \frac{1}{q}(p - p_r) \geq qV_n^h + (1 - q)V_d^h - p \tag{9}$$

The second hand market will also affect the incentive compatibility constraint of the low type consumer since he must now prefer to exercise the resale option over buying from the monopolist:

$$IC_3^l : \; (1 - q)V_d^l - p_r \geq qV_n^l + (1 - q)V_d^l - p \tag{10}$$

We will assume that whenever there is excess demand in the resale market the high type consumer can extract all of the surplus of the low type consumer.

Assumption 6: *If* $q \geq \frac{1}{1+\mu_l}$*, there is excess demand in the resale market and* $p_r = (1-q)V_d^l$.

Using this we compute the monopolist's choice of q that ensures maximum profits in the presence excess demand and compare the results with the full durability case.

Proposition 3 *If* $\Delta^h > \Delta^l(1+\mu_l)$*, then the monopolist will always accommodate the secondary market instead of choosing* $q = 1$.

Proof. Substituting for p_r in IC_2^h and IC_3^l the monopolists constraint's are now given by:

$$\frac{1}{q} \leq (1+\mu_l) \tag{11}$$

$$\frac{1}{q} \leq \frac{\Delta^h}{p - V_d^l} \tag{12}$$

respectively. The first constraint requires that $q \in [\frac{1}{1+\mu_l}, 1]$. Note that IC_3^l redundant when $\Delta^h \geq \Delta^l$. When $\Delta^h < \Delta^l$ there is no (p, q) which will satisfy all three constraints. So maximizing p/q with respect to (11) and (12) gives the optimal price and durability as $\widetilde{q} = \frac{1}{1+\mu_l}$ and $\widetilde{p} = V_d^l + \frac{\Delta^h}{1+\mu_l}$. However, this is only a local maximum and we need to verify whether the monopolist will set $q = 1$.

So we compare $\widehat{\pi}$ with $\pi(\widetilde{p}, \widetilde{q}) = \Delta^h + (1+\mu_l)V_d^l$. For this we need (i) when $(1+\mu_l)V_n^l > V_n^h$:

$$\begin{aligned} \pi(\widetilde{p}, \widetilde{q}) &= \Delta^h + (1+\mu_l)V_d^l > \widehat{\pi} = (1+\mu_l)V_n^l \\ &\Rightarrow (1+\mu_l)V_d^l > (1+\mu_l)V_n^l - V_n^h + V_d^h \end{aligned} \tag{13}$$

and, $(ii)$when $V_n^h > (1+\mu_l)V_n^l$:

$$\pi(\widetilde{p}, \widetilde{q}) = \Delta^h + (1+\mu_l)V_d^l > \widehat{\pi} = V_n^h \tag{14}$$

However, when (13) is satisfied (14) is always satisfied since $(1+\mu_l)V_n^l - V_n^h > 0$ in (13). Rearranging terms in (13) concludes the proof. ■

This somewhat counter-intuitive result has a simple intuitive explanation. When *Proposition 3* holds the monopolist allows the secondary market to operate and extracts all the surplus of the low type consumers by inducing the high type consumers to purchase more often. Notice that the monopolist can resort of this even without providing a different good or an upgrade of any sort. This result holds as long as there are consumers in the market who believe in replacing a good as soon its wear and tear reaches a level they consider inappropriate. We are now in a position to compare the results of this section with those of the Section 2. While it was our prior belief that the resale market will constrain the monopolist, this is not an unequivocal possibility. The resale market can both help or hinder the monopolist. To see this we compare the profits of both sections given by

$$\pi(no\ resale) = \max[\widehat{\pi}, \pi(\bar{p}, \bar{q})] \text{ and } \pi(resale) = \max[\widehat{\pi}, \pi(\widetilde{p}, \widetilde{q})]$$

Comparing the profit levels that are significant for the purpose of contrived depreciation we find that the monopolist prefers the resale market option when

$$\frac{\mu_l}{1+\mu_l} < \frac{\Delta^h - \Delta^l}{\Delta^h} \tag{15}$$

Notice however that this can be easily obtained from (13) by some algebraic manipulation.

We can now summarize our results of both sections: *If* $\Delta^h > \Delta^l(1+\mu_l)$, *then the monopolist will allow the resale market to flourish and enjoy greater profits than under any alternative scenario.* However, if (13) does not hold, then the monopolist will not accommodate a resale market and the optimal decision will be based on the analysis of the previous section.

3.1 Welfare Analysis

Welfare analysis in the presence of resale requires comparison with respect to two benchmark cases: the traditional monopoly situation where the seller is restricted to choosing $q = 1$, and contrived depreciation in the presence of no resale. Contrived depreciation in the presence of resale reduces welfare if the no depreciation monopoly is efficient, but raises welfare otherwise, since the low type at least consumes the depreciated commodity. Comparing with the no resale case, we see that contrived in the presence of resale is less efficient. The low type consumer has both V_n^l and V_d^l in the former case but has only V_d^l in the latter. However, it is necessary to qualify this statement. It is possible for efficiency to be greater with resale if $\pi(\widetilde{p}, \widetilde{q}) > \widehat{\pi}(V_n^h, 1) > \pi(\bar{p}, \bar{q})$. Under these conditions, in the absence of resale, the monopolist will not serve the low types at all while resale makes this profitable, thereby increasing efficiency.

4 Conclusion

We demonstrate under what conditions a monopolist can use the frequency of purchase to increase profits. Other quality considerations could also be introduced in the model in two possible ways. The first would the Mussa-Rosen type of vertical product differentiation based on some characteristic other than durability. Second, the framework could also be used to allow for upgrades. Introducing such quality aspects can provide the monopolist additional means of raising profits though there might be trade-offs involved in this. These issues will become especially critical once we allow quality to depend on the costs of production and require further study. Also, the issue of "lemons" (Akerlof, 1970) ignored here is a possible direction of further work. While perfect competition will always lead to full durability, it is also worth investigating the welfare properties under alternative market structures like oligopolies.

The model does however provide an alternative explanation for trade-ins. Instead of relying on the thrifty consumers, the monopolist might be willing to exchange old lamps for new ones by offering a discount which is equivalent to $(1-q)V_d^l$, which is then extracted through inducing frequent purchases.[5] Also, it is clearly demonstrated that for a substantial range of parameter values, a secondary markets can coexist and lead to higher profits for the monopolist.

[5] Thus allowing the monopolist to continue his unbridled quest for the profit genie!

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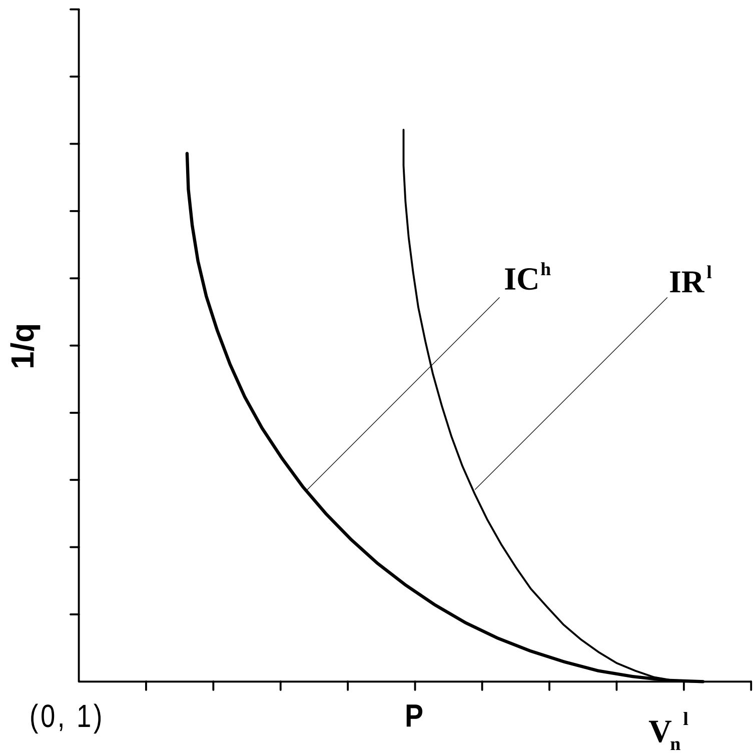

Figure 1

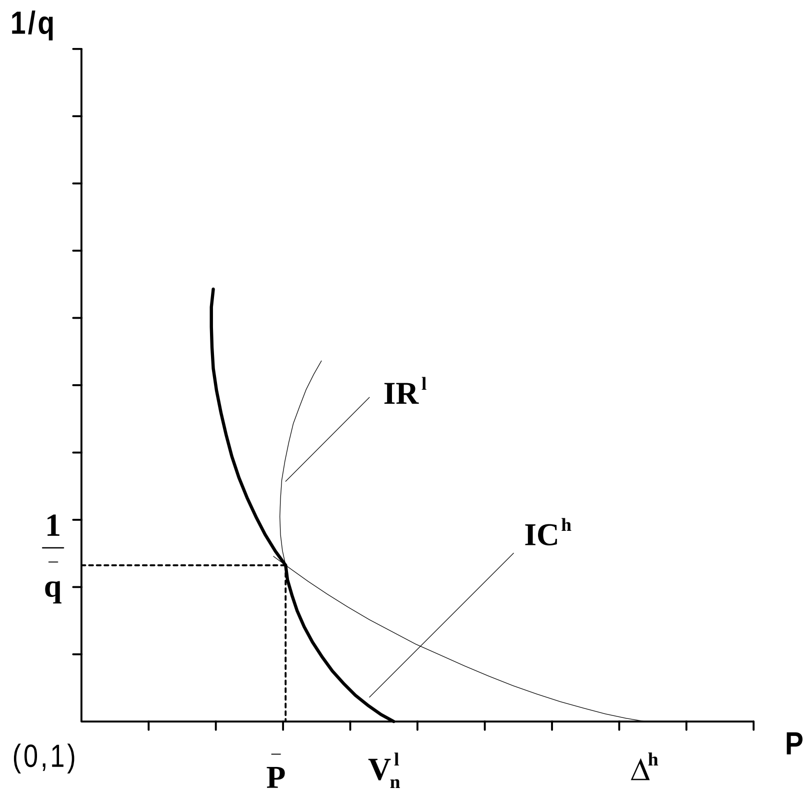

Figure 2