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On Durability of Consumer Goods

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Abstract : *This paper considers a model of durable consumer good. It is assumed to have a life of new and old. The consumer decides what is the optimal time for enjoying the novelty. The monopolist choice is to select the durability of the good to maximize profits and quote the price of the good. It is pointed out that the optimal durability can not be an interior solution as claimed in some of the recent works on the subjects. The reasons for this and some conjectures are spelt out.*

I. Introduction

The possibility of a relationship between market structure and durability of consumer goods has been considered extensively by economists. See Tirole (1988), Jacuemin (1987) and Carlton and Perloff (1990) for extensive discussions. Early models in this area were developed, among others, by Martin (1962), Klieman and Ophir (1966), Levhari and Srinivasan (1969) and Schmalenesee (1979). These models, in turn based essentially on Wicksell (1934), considered alternative market structures as well as a variety of time profiles of product decay and tried to establish a relationship. The general conclusion seems to be in the long run equilibrium a monopolist tends to produce less durable goods than perfectly competitive firms operating under

identical (constant) cost and demand conditions. This proposition has been challenged by Swan (1970, 1972, 1977) and Sieper and Swan (1973) where it is shown that the correct extension of Wicksell's long run equilibrium methodology would point to the invariance of product durability with respect to the market structure.

On the other hand, the effect of a competitive second-hand market on the durability of consumer goods has also been studied by many authors. Swan (1972) showed that the profits of a monopolist seller coincide with profits of a monopolist renter of durable commodities and therefore the existence of a second-hand market per se does not act as a constraint to the monopolist in extracting the consumer surplus through sales price alone. Coase (1972), however, argued that a monopolist who can change his price very quickly over time loses his monopoly power completely as he cannot engage in intertemporal price discrimination in view of consumers' expectations about future prices. This cojecture due to Coase has been formally proved by Stokey (1981) and Bulow (1982) for specific demand functions and equilibria and by Gul, Sonnenschein and Wilson (1986) for more general demand structures. Olsen (1992) and Ausubel and Deneckre (1992) have also discussed the Coase conjecture in models of learning by doing and incomplete information respectively.

Rust (1986) has shown that the existence of a second hand market, through endogenous scrappage, gives the consumers a substitution possibility constraining the profits of a monopolist. Hence, under some circumstances the monopolist may want to kill off the this competition from used durables by producing new assets of 'zero' durability. Basu (1988) has shown, in a different framework, the possibility of a monopolist using the durability choice as a screening device for consumers. By reducing the durability the monopolist ensures that the better off — 'lavish' — consumers

make more frequent replacements increasing sales and profits. In his example, the monopolist produces assets of less durability than those by a competitive firm. This model of Basu (1988) is in fact that of a quasi -durable good where the consumers do not leave the market after making the first purchase. In a recent paper van Ackere and Reyniers (1995) have modelled discount offers to repeat buyers (trade-ins) or new buyers (introductory offers) of a quasi-durable good. They analyzed the potentiality of these market prices for intertemporal and third degree price discrimination. In an earlier attempt, Bond and Samuelson (1984) did consider a market for quasi-durable good but did not consider the possibility of a third degree price discrimination.

In a recent unpublished paper by Chakravarty and Chattopadhyay (1997), they formulate an explicit model of quasi-durable goods which depriciate in terms of quality over time and the consumers have different responses to the quality of the good. In fact most of the above survey of the literature is taken from this work — we will call it CC hereafter for the two authors. CC seek to address the problem by considering alternative market structures, especially the monopoly and the existence of second hand markets. They base the result on the calculations that involve the maximisation of profit by the monopolist and they obtain the optimum solution to the durability as an interior one between the minimum possible 0 and maximum possible 1. This itself is an interesting result as it seems counterintuitive. They go on to argue about how the monopolist utilises second hand markets for getting exta profits.

There are a number of problems with their formulation and proofs. The purpose of this paper is to confirm if the result is indeed valid and suggest alternative framework to take care of the percieved drawbacks of their formulation. This is expected to lead to some further work — jointly

with CC or otherwise — in future.

Section II illustrates the essential CC assumptions and we sketch the results — using what we consider slightly less cumbersome notation than theirs. Section III considers the drawbacks and possible problems with their presentation. Section IV presents the alternatives. The last section concludes by presenting some simple results and conjectures what results seem possible.

II. The Durable Good CC Model

The durable good considered here lasts for one period. It remains in top quality for the first q period of use ($0 < q \leq 1$). The consumer earns a utility level N units per period of time. After this use it depriciates and becomes old for the rest of the period and the consumer earns a strictly lower level of utility D per period of time. By durability, CC mean q, the period for which it remains in top quality.

They assume a continuum of consumers who have identical tastes but are different in income. Part of the income is spent on this good and the rest on some composite commodity. Utility is assumed to be of the Shaked -Sutton (1982) type: The product of this remaining income and the utility derived from the durable good.

The consumers' choice variable t denotes the fraction of the time that a consumer wishes to have the durable good at the top quality. As the good lasts in top quality condition for period q, he would then buy the quantity t/q in order to enjoy the novelty for fraction t of the period 1. If t is to be less than q then there is no way the individual can buy the good. If he buys at all then he must hold it for the period q. That is to say, on the average he must buy one or more per period or not at all. In any case he will at most buy 1/q and in that case he will be enjoying the newness for the entire

period of 1 unit.

A consumer with income X then, given the price of the durable as p and the time period q, maximizes the utility u(X, t) given by:

$$\left(X-\frac{t}{q}p\right)\left[tN+(1-t)D\right] \quad \cdots\cdots(1)$$

It is easy to check that the marginal utility of the comsumer is positive and decreasing. If the consumer were free to choose in the interval (0, 1) then the first order condition requires that:

$$t=\frac{X}{2p}q-\frac{D}{2(N-D)} \quad \cdots\cdots(2)$$

It may be noted that higher the income X the greater is the time that the consumer wants to enjoy the good of the top quality. The consumer however must buy the good for at least the period q or not at all. The least income — call it X_q — that will allow him to purchase the good is by setting t equal to q in (2):

$$X_q=\frac{2p}{q}\left[q+\frac{D}{2(N-D)}\right] \quad \cdots\cdots(3)$$

And the minimum income that will allow him to purchase the maximum amount of good is by setting t equal to 1 in (2):

$$X_1=\frac{2p}{q}\left[1+\frac{D}{2(N-D)}\right] \quad \cdots\cdots(4)$$

CC assume further that the consumers are distributed uniformly over some range (0, M) and thus the density f(x) is 1/M for $0<x<M$ and 0 elsewhere.

Assuming constant marginal costs c, CC obtain the monopolist's profit as the sum of two integrals over the ranges (X_q, X_1) and (X_1, M) taking p and q as parameters. The profit function is

$$\Pi(p, q)=\frac{p(p-c)}{M}\left[\frac{M}{pq}-\frac{1}{q^2}\left\{\frac{N}{N-D}+q^2\right\}\right] \quad \cdots\cdots(5)$$

This profit function is then differentiated partially w. r. t. p and q with the result equated to zero. This obtains

$$p = \frac{1}{2}\left[c + \frac{Mq}{\frac{N}{N-D} + q^2}\right] \quad \cdots\cdots(6)$$

CC further argue that the profit function is increasing in q near 0 and decreaing at unity provided the maximum income level is big enough. The entire paper rests on this assertion.

III. Some Problems with the CC Modelling

We think there are a few problems with the CC framework as well as the technique. It is easily arguable that they have overlooked the situation when a consumer simply does not buy the durable good. It is not specified as to what happens to the utility function as t tends to 0. In the present form it tends to XD and it is not clear what is the basis of this level of utility. Since the consumer is not buying the durable good it seems strange to have the old good utility D in the utility function. Secondly, it seems natural that the minimum possible durability is not to be 0. We should be looking at the goods which are durable as new for at least a certain lapse of time in order to be marketed. Otherwise we are looking at a vacuous problem. The correct way seems to be to allow the consumer a basic minimum period for enjoyment of the novelty of the good before he enjoys it as an old one. Thirdly, the utility of the durable good — N and D — should be substantially higher than the utility of the a unit of money. This may sound a little arbitrary but the interesting examples of durable goods viz, cars, electronic gadgets and such like are important only because they are much saught after. People buy them with much relish rather than holding on the money balance to buy other goods. Fourthly, CC ignore the

fact that some marginal consumers whose optimal choice of t might be less than the durability q but still may pinch themselves a little and buy the good for the period q. This may happen because going without the good might make them even worse off than pinching themselves a little and buying the good. This will be an important class of people in the light of the assumption that D is much bigger than 1. Lastly, CC claim to get an interior solution to the variable q in (0, 1) and the price p associated with it from the maximization exercise but the argument seems not foolproof. They do not check if the second order condition is satisfied or not and also do not check if the levels X_1 and X_q actually exist. They do not get an explicit solution for p and q. This really calls for a new exercise and we do that in the next section.

IV. The Alternative Model

The monopolist's choice variable q is allowed to range between a number α-possibly small and unity. That is to say, $q \in [\alpha, 1]$. The basic utility to the consumer is the amount of income. When the consumer buys the good his total utility is given by the remaining income plus the utility from the durable good which is the Shaked and Sutton type. That is to say,

$$u(X, t) = \left(X-\frac{t}{q}p\right)+\left(X-\frac{t}{q}p\right)\left[tN+(1-t)D\right] \text{ for } t \in (0, 1).$$
$$= X \text{ for } t = 0$$

It is easy to check that the marginal utility of the consumer is positive and decreasing. If the consumer were free to choose in the interval (0, 1) then the first order condition requires that:

$$t = \frac{X}{2p}q-\frac{1+D}{2(N-D)}$$

It may be noted that higher the income X the greater is the time that

the consumer wants to enjoy the good of the top quality. The consumer however must buy the good for at least the period q or not at all. The least income — call it X_q — that will allow him to purchase the good is by setting t equal to q in the above:

$$X_q = \frac{2q}{q}\left[q+\frac{1+D}{2(N-D)}\right]$$

And the minimum income that will allow him to purchase the maximum amount of good is by setting t equal to 1 yields:

$$X_1 = \frac{2p}{q}\left[1+\frac{1+D}{2(N-D)}\right]$$

In order to reduce cumbersome notation we will denote hereafter $\frac{N-D}{1+D}$ as n and $\frac{D}{1+D}$ as d.

Given the durability level q there are four groups of consumers. The poor class simply does not enter the market and their demand for the good in 0. This class ranges from the income level 0 to X_* given by $\frac{p(1+nq)}{(d+nq)}$. The next class is the typical lower middle class who have to pinch themselves in order to buy the good at the minimum level possible. Their demand is 1 unit of the good over the entire time period which they enjoy as new for the time q and as old for 1-q. This class ranges from the above X_* to X_q, the latter given by $\frac{p(1+2nq)}{nq}$. The next class can be called upper middle class who can and do choose the optimum level t which ranges between q and unity. The level clearly depends on the incomes which range from X_q to X_1, the latter given by $\frac{p(1+2n)}{nq}$. Above this class are the rich who choose to own the durable good always as new. The range of incomes for this class is between X_1 and M. It is very important to note

here that all these classes depend on what p and q are.

V. Some Results and Conjectures

The monopolist would like to choose a level q for duability so as to maximize his profits by making the three classes — apart from the poor — buy the good. The profits from each of the three classes are obtained as integrals of the revenue over the respective ranges. The profits from the lower middle class are given by the term $\frac{p(p-c)}{M}\left[1+\frac{d(1+nq)}{nq(d+nq)}\right]$. Those obtained from the upper middle class are given by $\frac{p(p-c)}{M}\left[\frac{1}{q^2}-1\right]$ and from the rich are $\frac{p(p-c)}{M}\left[\frac{M}{pq}-\frac{2}{q^2}-\frac{1}{nq^2}\right]$. The profit function Π (p, q) is then the sum of the 3 terms. In order to make the analysis clearer and less cumbersome we will consider the approximation $d=1$. As pointed earlier, D is supposed to be much larger than 1 and this approximation is not bad. In any case the following arguments do not depend on this approximation. Also M is assumed to be sufficiently large. The profit function Π (p, q) is then given by $\frac{p(p-c)}{Mnq^2}\left[\frac{Mnq}{p}+q-n-1\right]$ and is differentiated partially w.r.t. p and q with the result equated to zero. This obtains

$$p=\frac{1}{2}\left[c+\frac{Mnq}{n+(1-q)}\right]$$

$$q=\frac{2(n+1)p}{Mn+p}$$

This looks like a very impressive result although the two equations for p and q contain each other. It seems that p would be above the marginal cost and q is a positive number. Further it is easy to check that the profit function is rising in q for very small q and falling at $q=1$ (given a condition on M is satisfied). CC use this technique to show that the interior solution

for $q \in [\alpha, 1]$ exists. However :

Result : The solution to the above equations are not viable.

This can be easily seen by explicitly solving for p and getting $p = \frac{c}{2} + \left(\frac{c^2}{4} - 2Mnc\right)^{\frac{1}{2}}$ which is clearly less than c.

Thus we get an impossibility result. Clearly the solutions obtained do not constitute a maxima. What is the problem ? Some conjectures follow.

Conjecture 1 : The maxima for q is either α or 1 depending on what class are we talking about.

Conjecture 2 : As the limits of class incomes depend on p and q, the solution levels decide if the class in empty or not.

Conjecture 3 : As the maximization throws up different prices and durability levels for different classes a possibility of introducing different durable goods for different classes arises naturally.

Conjecture 4 : The second hand markets with different duable goods will not necessarily harm the interests of the monopolist.

The proofs of these conjectures and a reworking of the model in the above section require further investigation.

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