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Non-Profit Firms and the Provision of Durable-Goods

Gregory E. Goering
Department of Economics
University of Alaska
&
Louisiana State University
email: ffgeg@uaf.edu

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Gregory E. Goering
Department of Economics
University of Alaska
PO Box 756080
Fairbanks, AK 99775-6080
USA

e-mail: ffgeg@uaf.edu
Ph. (907) 474-5572

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Abstract: A simple linear demand two-period durable goods is analyzed where the durable good is provided by private non-profit organization (NPO). A novel flexible objective function is utilized that allows for both the "commercial" and "social concern" aspects of NPOs. The model indicates NPO's will not typically provide the efficient cost-minimizing durability in sales markets. Indeed, if the NPO cannot credibly commit to its own stakeholders it will manufacture output with less durability than a pure for-profit seller. We show the NPO's level of commitment ability and social concern with its stakeholders is crucial for determining the amount of "planned obsolescence" that would prevail if NPOs expand into durable goods markets.   Interestingly, the social concern commonly cited for the existence of NPOs, is a double edged sword since it may cause more or less product obsolescence.

I. Introduction

The efficiency of imperfectly competitive durable goods manufacturers has been a topic of interest for the past 40 years. Initially, the census was the market structure did not tend to have an impact on the durability of products *per se* and monopolistic firms offered the same durability levels as their competitive counterparts, the so called Swan independence result (see Swan (1970)). However, later authors noted that these models were dynamically inconsistent in sales markets and found that "planned obsolescence", i.e., inefficiently short-lived products may well occur in sales markets.

Coase (1972) initially argued that rational early buyers would anticipate that a seller would decrease the price in future periods since the resulting capital loss in existing units was borne by buyers and not the seller. Hence, a monopoly seller would be forced to price the durable good close to marginal cost (the Coase conjecture). As later authors, such as Bulow (1982 and 1986) and Butz (1990), show the firms may also decrease the durability of their product to mitigate this commitment problem with buyers, indicating planned obsolescence may well occur in sales markets.

This paper explores the phenomena of planned obsolescence in a private non-profit firm/organization (NPO) setting. There has been a large expansion of NPOs in recent years and they generate significant economic activity. NPOs have also moved more into "commercial" markets. For example, in the US economy Case (2005) shows these commercial non-profit activities create billons in revenue and are rapidly growing. Additionally, Marwell and McInerney (2005) show that in many markets there is a "profit continuum" from pure for-profit firms to traditional NPOs. Currently NPOs have not made any significant impact on durable goods markets (they tend to provide services and non-durable goods). However, Benz (2005) notes that non-profits may well prove successful in the high tech sectors of the economy (which do tend to manufacture durable output). Hence, the question: what impact would NPOs have on durable goods markets and planned obsolescence? This is of particular interest since many NPO operate, ostensibly, to improve the efficiency of market outcomes particular for their stakeholders. Thus one question is whether or not a selling durable goods manufacturing NPO would tend to practice more or less planned obsolescence than its traditional for-profit counterpart.

II. Basic NPO Durable Goods Model

Suppose a private NPO operates in a given market and is the sole provider of units. By NPO we mean an organization/firm that operates for the benefit of its stakeholders (see Salomon (1999)). Unlike previous NPO analysis it is assumed that the NPO provides the services of a durable product over a two-period horizon (see Bulow (1982, 1986) for the basic durable goods framework). This allows us to explore the likely outcome if NPOs are allowed to move into durable goods markets.

The NPO is allowed to select its periodic output levels x_t as well as the product's durability $\delta \in [0, 1]$. The product durability δ represents the fraction of first period output

that is still in service in the second period. This indicates the stock in period equals period two

production plus the durable first period units that remain in service.   We further suppose the

period one stock is simply equal to first period output.   Thus the total stock of durable units

available for use in each period is $X_1 = x_1$ and $X_2 = \delta x_1 + x_2$, respectively.   For tractability we

suppose the linear inverse service (periodic) demand for output is linear in the output stock, i.e.,

$p_t = a - bX_t$.

As in earlier works (e.g., Swan (1970) and Goering (1997, 2002)), the production cost are

assumed to be constant returns with respect to output but increasing in product durability. This

implies marginal costs in the first and second period are $c_1(\delta) > 0$ and $c_2 > 0$ respectively, where

$c_1(\delta)$ is strictly convex in product durability δ.

Although we now have the NPO's demand and costs specified, the question still remains

as to their objective. As Goering (2005) notes in a static non-durable goods oligopoly setting, a

NPO may well seek to maximize profit plus the fraction of consumer surplus that accrues to the

NPO's stakeholders. Among other things, this incorporates Salomon's (1999) NPO notion of

"public benefit" or more generally the notion of "social concern" through the NPO's interest in

consumer surplus in the durable goods market. It also incorporates the "commercial" or "profit"

activities of NPOs which Case (2005) shows generates billons in revenue in the US. Note,

however, that since the firm is only interested in the fraction of consumer surplus $\theta \in [0,1]$ that

accrues to the NPO's stakeholders/consumers, the NPO does not typically seek to maximize

social welfare (profits plus the entire market consumer surplus). The only time this would be

true is if its members constitute the entire market $\theta = 1$.[1]   Conversely, if the NPO stakeholders

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[1] In a more general mixed market oligopoly case, even if the NPO included the entire market consumer surplus
($\theta = 1$) it would not act as a public social planning firm since it would not likely take the profits of its rivals into

do not benefit directly from the services of the durable good $\theta = 0$ and the NPO would engage in pure profit-maximizing behavior.[2]

Letting $\beta \in [0,1]$ represent the discount factor, the NPO's discounted profits and fraction of consumer surplus accruing to NPO stakeholders for the durable good are given by (1) and (2) respectively:

$$(1) \qquad \pi = (a - bx_1 - c_1(\delta))x_1 + \beta((\delta x_1 + x_2)(a - b(\delta x_1 + x_2)) - c_2 x_2)$$

$$(2) \qquad \theta CS = \theta(.5bx_1^2 + .5\beta b(\delta x_1 + x_2)^2).$$

Note that equation (1) represents the discounted stream of profits of manufacturing a durable good in period one with durability δ. Likewise (2) shows the corresponding fraction of consumer surplus of the durable good that accrues to NPO stakeholders over the two period horizon. The model supposes that the NPO jointly maximizes (1) and (2) implying its objective function is $V = \pi + \theta CS$, or:

$$(3) \quad V = (a - bx_1 - c_1(\delta))x_1 + \beta((\delta x_1 + x_2)(a - b(\delta x_1 + x_2)) - c_2 x_2) + \theta(.5bx_1^2 + .5\beta b(\delta x_1 + x_2)^2).$$

Although the NPO always seeks to maximize (3) it can only do so unconstrained if it leases/rents all period one units. If the NPO sells first period units then, as Coase (1972), notes

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account in its maximization. Note also that the parameter $\theta \in [0,1]$ can simply be interpreted as the degree to which a NPO deviates from pure profit maximization, thus capturing Marwell and McInerney (2005)'s notion of profit continuum in real word firm behavior.

the NPO faces a potential commitment problem with rational period one buyers and effectively must maximize (3) subject to their expectations. Given that in period two the NPO will seek to re-maximize, we need to find the dynamically consistent path. If the NPO still owns all the remaining durable units from period one, as it would under leasing, it simply maximizes the discounted portion of (3). This implies that the simple (unconstrained) maximization of (3) with respect to durability and periodic outputs will be dynamically consistent in the rental case. However, if the NPO sells first period units, it fundamentally faces a different objective function in period two since the surviving durable period one units δx_1 are owned by *buyers* and not the NPO. Consequently, a selling NPO may well not take these durable δx_1 units into account in its future re-maximization. In the traditional durable goods literature it is typically assumed that the profit-maximizing seller cannot credibly commit to period one buyers that it will take the capital loss born by them into account as it sells future units (decreases price). This implies a selling NPO with no commitment power will maximize:

(4) $\qquad V_2^s = \pi_2^s + \theta CS_2 = (a - b(\delta x_1 + x_2) - c_2)x_2 + .5\theta b(\delta x_1 + x_2)^2$,

in period two. Since buyers rationally recognize that the selling firm will maximize (4) they will take this into account in their period one behavior and the maximal solution to (4) becomes a constraint on the seller. Thus a seller must maximize (3) subject to the maximal solution of (4). In other words, a NPO that cannot credibly commit to any buyers will be constrained by their rational expectations of future behavior given in (4). However, in some cases the NPO perhaps can credibly commit to its buying stakeholders but not other buyers. Indeed, Ben Ner and Van

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[2] Note more generally there maybe different weights on current and future consumer surplus (social concern)

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Hoomisen (1993) argue NPOs typically only exist if stakeholders monitor contract compliance and "have a voice" in the NPO's operations. This creates a dichotomy between buyers; those that are affiliated with the NPO and those that are not. In this limited commitment case the NPO would keep the fraction of period one output sold to its members $\theta \delta x_1$ in its second period profit function:

$$(5) \qquad V_2^{sc} = \pi_2^{sc} + \theta CS_2 = (a - b(\delta x_1 + x_2))(\theta \delta x_1 + x_2) - c_2 x_2 + .5\theta b(\delta x_1 + x_2)^2 .$$

In this sales case with partial commitment the NPO would maximize (3) subject to the maximal solution of (5). Note that if the NPO could commit to its stakeholders *and* they purchased all period one units ($\theta = 1$) this committed selling solution collapses to the rental case as one would expect. If the NPO can fully commit to all buyers there is no difference between sales and rental solutions, i.e., the Coase conjecture collapses.

In summary, a seller with no commitment ability must maximize (3) subject to maximal solution of (4) for dynamic consistency and with limited commitment power (can commit only to its buying members) it maximizes (3) subject to maximal solution of (5). In both of these scenarios we still are assuming that the NPO will take members' consumer surplus into account. One could also think of commitment in a wider sense where the NPO "tricks" its members by promising initially to take their consumer surplus into account in the future period but then reneges and simply maximizes its profits when it reaches this period. In this case the consumer surplus terms would not appear in (4) and (5). The NPO would still wish to maximize (3) but now has no credibility with respect to *any* of its future behavior. Even its stakeholders would

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θ_1 and θ_2. However, since the results are qualitatively similar the simpler specification $\theta_1 = \theta_2 = \theta$ is utilized.

expect the NPO to simply revert to pure profit maximizing behavior in the future. This sort of behavior seems to violate one of the basic assumptions of a NPO (e.g., Ben Ner and Van Hoomisen (1993)) and we suppose this sort of behavior does not occur in this analysis. However, it does raise the interesting question of what a NPO can really credibly convince its members and non-members it will do in the future.

III. NPO Rentals, Partially Committed Sales, and Uncommitted Sales

A. Rental Case

The rental solution is calculated first by differentiating (3) with respect to the output and product durability yielding the following first-order conditions:[3]

(6) $$\frac{\partial \pi^r}{\partial x_1} = a - 2bx_1 - c_1(\delta) + \beta\delta(a - 2b(\delta x_1 + x_2)) + \theta(bx_1 + \beta\delta b(\delta x_1 + x_2)) = 0$$

(7) $$\frac{\partial \pi^r}{\partial x_2} = \beta(a - 2b(\delta x_1 + x_2) - c_2 + b\theta(\delta x_1 + x_2)) = 0$$

(8) $$\frac{\partial \pi^r}{\partial \delta} = (-c_1'(\delta) + \beta(a - 2b(\delta x_1 + x_2) + \beta\theta b(\delta x_1 + x_2))x_1 = 0 .$$

Focusing on the first period behavior of the NPO we can simplify by substituting (7) into (6) and (8) giving:

(6)' $$\frac{\partial \pi^r}{\partial x_1} = a - 2bx_1 - c_1(\delta) + \beta\delta c_2 + \theta bx_1 = 0$$

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[3] Since $\theta \leq 1$ we know that the second-order conditions are satisfied. Thus these first-order conditions are maximizing, i.e., the Hessian matrix is negative definite here.

(8)' $$\frac{\partial \pi^r}{\partial \delta} = (\beta c_2 - c_1^{'}(\delta))x_1 = 0.$$

Among other things, from (8)' it is apparent that the NPO's optimal product durability will be independent of output levels (market structure). This is due to the cost-minimizing nature of durability in these models. Product durability in these models is set to minimize the discounted costs of providing service. In period two the NPO can either meet demand for units with surviving first period units or new second period units. The NPO simply selects the product durability that minimizes these costs and (8)' indicates it is not dependent upon output levels. Note that this efficient durability is also independent of the fraction of consumer surplus θ that accrues to the NPO's stakeholders. Thus Swan's (1970) market independence result can be extended to NPO rental markets as well.

Proposition one: *The socially optimal (cost-minimizing) durability will be provided by a NPO renter. Product durability will thus be independent of market structure in rental markets.*

The question, of course is; what type of dynamically consistent durability optimally occurs in NPO sales markets? As mentioned in the previous section, one can think of two plausible scenarios for a NPO. If the NPO has no commitment ability with first period buyers (including its own stakeholders) it maximizes (3) subject to the maximal solution of (4). With limited or partial commitment, it can commit to its stakeholders but not other buyers and maximizes (3) subject to maximal solution of (5).

2. Uncommitted sales

In the dynamically consistent solution, the NPO must maximize (3) subject to buyers rational expectations about future behavior, i.e., the maximal solution of (4). The maximal solution to (4) is:

(9)
$$x_2^s = \frac{a - c_2}{b(2 - \theta)} - \frac{\delta x_1 (1 - \theta)}{(2 - \theta)}.$$

This can be contrasted to the rental solution for period two production shown by (7) where simplification gives

(10)
$$x_2^r = \frac{a - c_2}{b(2 - \theta)} - \delta x_1.$$

Thus in comparison we see the uncommitted seller, ceteris paribus, will produce more in the second period than a renter since the capital loss on the existing stock is borne by buyers and not the NPO.

The NPO seller without commitment ability will still wish to maximize (3) but is subject to (9). The resultant dynamically consistent (sub-game perfect) first-order conditions for period one output and durability are:[4]

(11)
$$\frac{\partial \pi^s}{\partial x_1} = a - c_1(\delta) + \beta \delta c_2 + \frac{1}{(\theta - 2)}[\beta b \delta^2 x_1 + \theta^2 b x_1 - 4b x_1 (\theta - 1)] = 0$$

(12)
$$\frac{\partial \pi^s}{\partial \delta} = (\beta(\frac{b \delta x_1}{(\theta - 2)} + c_2) - c_1'(\delta)) x_1 = 0.$$

By comparing a NPO's uncommitted sales solutions to their rental counterparts in (6)' and (8)' it is apparent that a selling NPO will tend to produce less durability and output in the first period. Focusing on product durability in (12), we see the NPO no longer minimizes the cost of providing service given by (8)' but instead will select a durability that is below this efficient level (since $(\theta - 2) < 0$). The NPO tends to decrease both its output and durability below their unconstrained rental levels in an attempt to mitigate the commitment problem with buyers. Put differently, by decreasing output and durability levels, it reduces the number of durable units surviving until the second period which effectively decreases the number of units it does not own that will compete with its newly produced period two units. Hence, "planned obsolescence" will occur with NPO in the same manner, and for the same reason, as pure profit maximizing firms. Swan's (1970) market independence result will not hold since (12) shows the product durability is now dependent upon output levels (market structure).

Proposition two: *The socially optimal (cost-minimizing) durability will not be provided by a NPO seller that does not have commitment power with buyers. Product durability will not be independent of market structure in these types of sales markets.*

One interesting aspect that is unique to NPO's is shown in (12). This equation shows that the NPO's selling durability depends directly upon fraction of consumer surplus θ that accrues its stakeholders. Thus in selling markets, a NPO will not typically choose the same product durability as a pure profit-maximizing firm. Indeed by totally differentiating (11) and (12) it is easy to show that the NPO will decrease product durability and move farther away from the socially optimal rental level as θ is increased.

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[4] Once again the Hessian matrix here is negative definite so these solution are maximizers.

(13)
$$\frac{\partial \delta^*}{\partial \theta} = \frac{2\beta b^2 \delta^* x_1^{*2}}{|H|(\theta - 2)} < 0.$$

In (13), $|H| > 0$ is the determinant of the negative definite Hessian matrix. Equation (13) shows

that as the level of consumer surplus accruing to the NPO stakeholders (social concern) increase

the NPO will tend to decrease product durability.

Proposition three: *An uncommitted NPO seller will manufacture a less durable product than a pure profit maximizing firm and product durability will decline as the NPO's level of concern with stakeholder welfare θ rises.*

Somewhat paradoxical to conventional wisdom (13) and proposition three indicate a

NPO in this case will engage in more planned obsolescence than a pure profit maximizer with no

social concern ($\theta = 0$). NPOs in the popular press are often portrayed as more "environmentally

friendly", "socially concerned" etc., suggesting they would be less likely to embrace the "throw

away mentality". In durable goods markets, however, this increased concern for stakeholder

social welfare ($\theta > 0$) may actually compel a NPO to decrease the durability of its product below

the pure profit maximizing level. Once again the reason this occurs here is that the NPO cannot

credibly commit to its stakeholders and as such the direct impact on period two output as θ rises,

causes a corresponding increase in their commitment problem and consequently, they reduce

durability below the pure for-profit level.[5] Product durability bears the brunt of the commitment

problem here since it does not directly influence period one consumer surplus as decreases in

period one output will. However, we show that this result depends critically on the NPO's

commitment ability, or lack thereof, with its stakeholders. If the NPO can credibly commit to stakeholders, this result is reversed as we show next.

It is worth noting that the lowest product durability (highest planned obsolescence) will be offered when $\theta = 1$. In this case even though the NPO seeks to maximize discounted profits plus the entire market consumer surplus as a social planner would, the NPO is *not* endowed with commitment ability (in terms of its profit motive) and cannot credibly convince period one buyers.[6] In essence this can be viewed as a dynamically consistent solution for a social planner who is not fully endowed with commitment power (as is typically implicitly assumed in these models). This illustrates the importance of the commitment ability of *all* agents in time dependent models such as the durable goods setting.

3. Partially committed sales

We now suppose the NPO can credibly commit to its stakeholders but not the rest of the buying market. One can speculate that this might be the most likely outcome with a NPO durable goods seller since the NPO has no problem credibly committing to its members (but not the wider market). In this case the NPO seller maximizes (3) but is subject to the maximal solution of (5). The maximization of (5) with respect to second period output gives:

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[5] In other words, if we compare equation (9) and (10) for a given existing first period surviving stock δx_1 we see that the uncommitted seller tends to product more output in period two than the renter (or equivalently a seller with full commitment ability).

[6] Remember, here the NPO does have commitment power with its stakeholders in terms of future consumer surplus as (4) indicates. It does not "trick" its members by promising initially to take their consumer surplus into account in the future period but then reneging and becoming a pure profit maximizer. It only lacks commitment ability with respect to its "commercial" profit motive.

(14)
$$x_2^{sc} = \frac{a - c_2}{b(2 - \theta)} - \frac{\delta x_1}{(2 - \theta)}.$$

Thus the dynamically consistent (sub-game perfect) first-order conditions for first period production and product durability (maximizing (3) subject to (14)) are:[7]

(15)
$$\frac{\partial \pi^{sc}}{\partial x_1} = a - c_1(\delta) + \beta \delta c_2 + \theta \beta b \delta^2 x_1 + \frac{1}{(\theta - 2)}[\beta b \delta^2 x_1 + \theta^2 b x_1 - 4 b x_1 (\theta - 1)] = 0$$

(16)
$$\frac{\partial \pi^{sc}}{\partial \delta} = (\beta(\frac{b \delta x_1 (1 - \theta)^2}{(\theta - 2)} + c_2) - c_1'(\delta)) x_1 = 0.$$

We can compare this partially committed sales solutions to the rental (fully committed) solutions in (6)' and (8) as well as the uncommitted solutions in (11) and (12).

First note with $\theta = 1$, equations (14), (15), and (16) collapse to the social optimum, as one would expect. In this case the NPO maximizes discounted profits plus the entire market surplus and consequently, the first best solution occurs. Here the NPO is simply acting like a social planner with commitment power and sets the cost-minimizing durability ((8)') and prices at true discounted marginal costs. This only occurs when $\theta = 1$. If we take the other extreme, where $\theta = 0$, we see that this solution collapses to the uncommitted solution in (11) and (12). The NPO's commitment ability is zero once again with respect to its "commercial" profit motive in this case.

Focusing on product durability, we see that it is scaled between the lowest durability set by the uncommitted NPO in (12) and the highest (efficient cost-minimizing) durability of the

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[7] Since the second-order conditions are satisfied these equations are once again maximizing.

renter. As before, by totally differentiating these first-order conditions (15) and (16) with respect to δ and θ, it is easy to show that the NPO will now increase the durability of its output and move closer to the socially optimal rental level as θ is increased.

(17)
$$\frac{\partial \delta^*}{\partial \theta} = \frac{2\beta b^2 \delta^* x_1^{*2}(\theta - 1)}{|H|(\theta - 2)} > 0.$$

Given the negative definite Hessian matrix, (17) now indicates the opposite of (13). In this case as the level of consumer surplus accruing to the NPO stakeholders (social concern) increase the NPO will tend to increase durability of its output.   Additionally, note that as long as $\theta > 0$ the NPO with commitment ability will produce a more durable product (less obsolescence) than a pure for profit firm. Summarizing these results we have:

Proposition four: *An uncommitted NPO seller will manufacture a more durable product than a pure profit maximizing firm and product durability will increase as the NPO's level of concern with stakeholder welfare θ rises. With $\theta = 1$ the socially optimal cost-minimizing durability and output levels prevail.*

Proposition three and four illustrate the critical nature of NPO's commitment ability to its members. With commitment ability to its members the NPO's social concern will cause it to manufacture a more durable product and move closer to the efficient level than a pure for-profit counterpart . The opposite occurs if the NPO cannot fully commit to its stakeholders. Thus the social concern commonly cited for the existence of NPOs is a double edged sword since it may cause more or less product obsolescence.[8]

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[8] Note even though a NPO may move farther from the cost-minimizing durability than a profit-maximizing monopolist it does not follow that the social welfare (profits plus market consumer surplus) is lower under a NPO

IV.   Conclusion

Given the rapid increase of Non-Profit Organizations (NPOs) entry into "commercial" markets and activities in recent years (Case (2005)), the question arises about their effect on these markets.   NPOs are typically believed to have an element of "social concern" that is not present in their pure for-profit counterparts.   In this paper a simple two-period linear demand durable-goods model is analyzed to ascertain the likely impact of NPOs moving into durable goods markets.   A flexible objective function is utilized that allows for a blending of a NPO's social concern (in terms of consumer surplus accruing to its stakeholders) and profits.   One relevant question here is: would a sole NPO tend to practice more or less "product obsolescence" than a pure profit maximizing monopolist?

The key findings are summarized by the propositions in the text.   But among other things, the analysis indicates that the answer depends critically upon the NPO's ability, or lack there of, to commit to its stakeholders.   If the NPO faces a commitment problem with its stakeholders the same way it likely does with the wider market, we find a NPO will actually move father away from the efficient cost-minimizing durability.   Thus, the NPO's concern with the welfare of its members, does not necessarily imply less product obsolescence.   However, in the perhaps more likely case that a NPO can commit to its buying members but not other buyers, a NPO will manufacture a more durable product than a pure profit-maximizing firm.   This indicates that the

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regime. The higher output levels that tend to prevail under a monopolistic NPO setting can offset any efficiency loss due to the durability choice (second-best type solution) vis-à-vis a profit maximizing monopolist that restricts output to lower stock levels but manufactures a more durable product.

NPO's ability, or lack thereof, to credibly convince its members of its future behavior is of critical importance in durable good (or other time dependant) models.

The current model is obviously only a basic attempt at analyzing the important issues here. In a fuller mixed-oligopoly setting one could explore the impact of NPO and profit maximizers competing in durable goods markets. As Marwell and McInerney (2005) argue, there is a "profit continuum" from pure for-profit firms to NPO's who compete against one another in mixed markets. Also rather than focusing on the durability implications (as the extant durable goods literature almost exclusively does), a full comparison of the social welfare impacts of NPOs in renting and selling durable goods markets would likely reveal interesting, albeit complicated, results.

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