Mergers in Durable Goods Industries*

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December 2003

Abstract

This paper is concerned with the study of durability as an aspect of competition and market structure that contributes to determining the incentives for mergers. We find that relative to the incentives in industries that produce non-durable goods the durability of the good produced by an industry enhances the incentive for mergers in the presence of intertemporal consistency problems. Contrary to a classic result in the literature, and even though time-consistency problems may make durable goods industries more competitive, these enhanced incentives for merging mean that social welfare and consumer surplus may be greater if firms *rent* their output rather than if they sell it. That is, restrictive policies regarding the use of renting may hurt competition.

Keywords: Durable Goods, Mergers, Intertemporal Consistency, Strategic Behavior.

JEL Classification: D43, L12, L41.

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*Financial support from the Ministerio de Ciencia y Tecnologia of Spain (grant MEC 2000-0301) and the Universidad del Pais Vasco (grants HB-8238/2000 and 00035.321-13460/2001) is grateful acknowledged. We also thank seminar participants at the XIX Jornadas de Economia Industrial in Castellon, Spain, and the ASSET 2003 Annual Meeting in Ankara, Turkey.

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1 Introduction

This paper studies the relationship between the durability of the good produced by an oligopolistic industry and the incentives for mergers in this industry.

The interactions that may exist between durability and mergers are important for various reasons. Durable goods constitute a very important part of economic production. In 2000, for instance, personal consumption expenditures on durables exceeded $800 billion in the U.S., and in the manufacturing sector durable goods production constituted roughly 60 percent of aggregate production. Mergers, on the other hand, have also been the subject of keen interest in an important theoretical and empirical literature. For instance, as noted in Pesendorfer (2003), mergers and acquisitions have long been a public policy concern. In the United States, Section 7 of the Clayton Act prohibits mergers that "substantially decrease competition or tend to create a monopoly." In recent years, the volume of mergers and acquisitions in U.S. industries has increased substantially. Antitrust regulators reviewed a total of 3,072 deals in 1997, compared to just 1,451 in 1991. Given the importance of durable goods in aggregate production, it is no surprise that many of these mergers involved durable goods firms.

The literature on mergers has studied a number of important issues such as short run price and output effects, welfare and long-run effects, the effects on research and development and shareholder wealth, investment decisions, and others.[1] From the theoretical perspective, however, it is not clear when mergers are likely to take place. In a non-durable good setting, Kamien and Zang (1990) study the limits of monopolization through acquisition in the absence of any legal barriers but in the presence of firms fully aware of the consequences of acquiring or being acquired by rivals, not susceptible to incredible threats, and behaving strategically with respect to this activity. One of the results of their analysis is that neither complete monopolization nor partial monopolization can be a subgame perfect Nash equilibrium outcome as the number of firms in the industry becomes sufficiently large. Only when the number of firms is sufficiently small, is complete or partial monopolization possible.

In a durable goods setting, no such analysis exists in the literature. In this paper we are motivated by the fact that durable goods constitute an important part of production and that many durable goods industries are highly concentrated to study

[1] See, for instance, Spector (2003), Pesendorfer (2003) and other references therein.

the feasibility and implications of mergers in durable goods industries, and to compare them relative to the non-durable goods case studied in the literature.[2]

With regard to the effects of durability, Carlton and Gertner (1989) note that there are a number of reasons why durable goods industries may be *more* competitive than non-durable goods industries and why it is difficult to create market power through mergers in durable goods industries. One reason is that the stock of durable goods may limit the increase in prices of the new units produced after the merger. The effectiveness of this constraint obviously depends on the specific circumstances of the industry. For example, the 1997 case of the Boeing-McDonnell Douglas merger in commercial aircraft may be quite different from mergers among firms that produce agricultural equipment. The reason is that there is much greater scope for more intensive use in agricultural equipment than in the case of aircraft. As such, there is greater potential for the existing stock of used machines to act as a constrain on the behavior of new equipment manufacturers in the case of agricultural equipment.[3] A second reason is the possibility of dynamic strategic interactions among rivals. These interactions may induce an oligopolist to choose to *sell* some of its output rather than rent it. Selling production in turn induces more competitive behavior than renting production. Either of these two effects may alleviate any detrimental effects of mergers.

The question we address in this paper is to what extent the *incentives* for merging are different between durable and non-durable goods industries, and then what are the implications of these differences in incentives. In anticipation of the results, we find that both the possibility of strategic interactions and the classic expectations problem associated with durable goods first identified by Coase (1972) *enhance* the incentives to merge.[4] We also find that this incentive may be such that it will offset the effect of the greater competitive behavior associated with firms that sell some of their production, relative to the case in which firms rent their production.

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[2] As indicated by Driskill (2001) and other authors, many durable goods industries are highly concentrated, so most durable good producers appear to have market power. For example, ninety percent of mayor household appliances are produced by just five companies.

[3] For a detailed analysis of the circumstances that may make the stock of durable goods constrain new durable good prices see Lexecon (2000).

[4] Coase (1972) conjectured that if consumers have perfect information and are rational then a monopoly seller of an infinitelly durable good without some commitment to limit future production would saturate the market with the competitive ouput "in the twinkling of an eye" (p. 143).

A standard result in the literature on the durable goods monopoly (e.g., Bulow (1982), Kahn (1986)) is that when the inverse rental demand for the good is linear and the firm may only choose the level of production, social welfare is greater if the monopoly sells its output instead of renting it. In practice, firms such as the United Shoe Company, IBM, Xerox and others began by renting their products but were later required also to sell their output. Contrary to the arguments often made as to why these firms should be required to sell, this paper shows that because of the different incentives to merge in durable-goods oligopolies, both consumer surplus and social welfare may be *greater* if firms *rent* their output than if they sell part or all of it. These results may thus be relevant in the context of a literature that studies the different aspects of competition and market structure that determine the incentives for mergers.[5]

The rest of the paper is organized as follows. In Section 2 we describe the framework of analysis. We assume that mergers take place through an acquisition process where the owner of each firm makes bids to buy other firms and sets an asking price for his own firm. In particular, we consider the centralized model of Kamien and Zang (1990), which is extended to allow for durability. Durability is modeled following the classic approach in Bulow (1982). In this framework we then compare the feasibility of endogenous mergers in the following three cases: (i) Renting firms, where firms rent the good in question, (ii) Selling firms, where firms cannot rent but must sell their production, and (iii) Renting-Selling firms where they may both rent and sell their production. In Section 3 we compute and compare the social welfare and consumer surplus in each of these three cases taking into account the incentives to merge. Section 4 concludes.

[5] Salant et al (1983) consider a model of Cournot competition and show that some exogenous change in market structure (exogenous mergers) may reduce the joint profits of the firms that collude. Considering linear demand and costs they show that in order for a merger to be profitable the number of firms which merge must be at least equal to 80 percent of the industry. Given the empirical evidence on mergers in different industries, this result has motivated the analysis of different aspects of competition that may explain the incentives for merger. In particular, it has been shown that the profitability of a merger is enhanced when, for instance, firms compete in prices (Deneckere and Davidson (1985)), the capital stock affects the marginal cost of production (Perry and Porter (1985)), or when the principal delegates production decisions to managers (Gonzalez-Maestre and Lopez-Cuñat (2001), Ziss (2001)). Fauli-Oller (2001) shows in a Cournot model that profitability of mergers is inversely related to the degree of concavity of demand.

2 Theoretical Framework

We consider an oligopolistic industry with $N \geq 2$ identical firms that produce a homogeneous durable good. Entry into the industry is assumed to be unprofitable. In order to analyze the implications that durability of the good produced by the industry and the inability of firms to commit to a future schedule of production have for mergers, the analysis must be implemented in an intertemporal context. There are two discrete periods of time $t = 1, 2$, and the good does not depreciate over time. Thus, every quantity used in the first period can be used in the second period without depreciation. All agents have perfect and complete information and potential buyers of the durable good have perfect foresight. Without loss of generality we assume that the discount factor is 1. The inverse rental demand function for the durable good in each period is: $P = a - bQ$, where Q represents the quantity used by consumers in that period. The marginal cost of production of each firm is zero and there exits a perfect second hand market for the durable good.

The analysis is modeled as a non-cooperative game that consists of two stages. In the first stage firms engage in a centralized game of acquisition. This game implies that an owner that acquires several firms behaves as one entity. Given the assumption of zero marginal cost of production, the owner would be indifferent between producing only in one of his firms or distributing production among all of the firms that he owns. For simplicity we will assume that the owner will operate in just one of them. In the second stage, active firms resulting from the merger game engage in quantity competition.

Note that this model can be readily considered as an extension of the monopolistic case considered by Bulow (1982) to the oligopolistic case by simply adding the previous acquisition stage. This model can also be considered as an extension of the model analyzed by Kamien and Zang (1990) to the durable goods case by incorporating Coase's (1972) time-consistency problem and the strategic interactions among durable good producers.

The solution concept is that of a subgame perfect Nash equilibrium in pure strategies. Therefore, the solution is derived by backward induction from the last stage. As we will see, given N, multiple structures of the industry may be supported as a subgame perfect equilibrium. In those cases, we will select the one that is *efficient* from the firms' point of view, that is, the one where there is no other structure that can be supported as subgame perfect equilibrium in which each firm obtains at least as many profits as in the one selected.

The following notation will be used:

q_1^s: quantity sold by the industry in the first period,

q_1^r: quantity rented by the industry in the first period,

q_2: quantity sold by the industry in the second period,

q_{1i}^s: quantity sold by firm i in the first period,

q_{1i}^r: quantity rented by firm i in the first period,

q_{2i}: quantity sold (or rented) by firm i in the second period.[6]

m: total number of active firms in the industry after the acquisition process.

We now proceed to the resolution of the intertemporal model, first when firms may only rent their output (renting firms); second, when they may only sell their output (selling firms) and, lastly, when they may both sell and rent their production (renting-selling firms).

2.1 Renting Firms

Every initial owner maximizes his payoff, given by his operating profits, less the payments he makes for the firms he purchased, plus the payment he receives for his own firm if it is sold. The problem is solved beginning from the second stage of the game.

SECOND STAGE:

After the acquisition process, each active firm will choose the quantity to be produced in periods 1 and 2 in order to maximize the discounted value of its total profits. Thus, each firm solves:

$$\max_{\{q_{1i}^r, q_{2i}\}} (a - bq_1^r)q_{1i}^r + (a - bq_2)q_{2i}.$$

The first order conditions of this problem are:

$$\begin{aligned} a - bq_1^r - bq_{1i}^r &= 0, \\ a - bq_2 - bq_{2i} &= 0. \end{aligned}$$

Hence, in equilibrium:

[6] Given that the second period is the last one, renting is identical to selling in that period. Hence, we do not need to distinguish between the quantity sold and the quantity rented in this period.

$$q_1^r = q_2 = \frac{am}{b(m+1)}, \qquad i = 1, ..., m.$$

As a result, the present discounted value of the total profits derived from production for each of the m active firms in the industry, $\pi(m)$, will be:

$$\pi(m) = \frac{2a^2}{b(m+1)^2}. \tag{1}$$

Clearly, $\pi(m)$ is decreasing in the number of active firms. This property will hold in each and every situation that will later be analyzed in this paper.

As various authors have noted, the solution of the above maximization problem is dynamically inconsistent except if firms rent their output or, alternatively, if they sell it but can precommit to current buyers that the value of their stock of durable goods will be taken into account in future production.[7] Precommitment is possible, for example, by offering best-price provisions (Butz (1990)), a practice that has been used extensively in the electric turbo generating industry and others (see Goering and Boyce (1999)).[8]

We analyze next the first stage of the game.

FIRST STAGE:

As mentioned earlier, we will assume that mergers take place through an acquisition process where the owner of each firm simultaneously announces a bid for each of the firms that he does not own and sets an asking price for his own firm. The allocation of firms to owners is the following: if a firm is sold then it is bought by the owner offering the highest bid. In the case that the highest bid is equal to the asking price, then the transaction occurs. If the tie occurs among bids, then the owner with the lowest index takes the firm. Given that all firms are identical we may assume without loss of generality that the number of firms acquired by owner i, $i = 1, ..., N-1$, is greater than or equal to the number of firms acquired by owner $i+1$.

[7] Bulow (1982) offers examples of markets in which renting is not feasible. For example, durable intermediate products must be sold and not rented. In our analysis, we will not differentiate between the different situations in which the solution given in this subsection is dynamically consistent, that is between the situation in which the good in question is rented and the situation in which the good is sold but firms precommit by offering best-price provisions. We will just refer to them as the case of renting firms or as the case in which firms coordinate to rent their output.

[8] For example, General Electric and Westinghouse used best price guarantees during the period 1963-1977.

We define a merged subgame perfect equilibrium as a subgame perfect equilibrium in which at least one owner owns more than one firm. If in equilibrium there are m active firms and firm j has been acquired by firm i, then the bid of firm i for firm j must be at least $\pi(m+1)$. The reason why this is the case is that otherwise the owner of firm j would have an incentive to change his asking price in order to become a non-seller since his profits, in that case, would be equal to $\pi(m+1)$. Hence, if an owner has $k \geq 2$ firms in a subgame perfect equilibrium, his payoff must be greater than the payoff he would obtain if he did not buy any other firm, taking into account that he must pay for any acquired firm at least $\pi(m+1)$. Therefore, in equilibrium the following inequality must hold:

$$D(m,k) = \pi(m) - (k-1)\pi(m+1) - \pi(m+k-1) \geq 0. \tag{2}$$

As is well known, in this kind of game, for a given N, there are subgame perfect equilibria in which $m = N$. Following Kamien and Zang (1990) we will call them unmerged subgame perfect equilibria. One set of bids and asking prices which supports such structure as subgame perfect equilibrium is the following: every owner's asking price is sufficiently high, say above the monopoly profits, and each bid is sufficiently low, say below $\pi(N)$. In this case, given that $\pi(m)$ is decreasing in m, no owner will become a seller and, moreover, no owner would be better off by changing his asking price or his bids.

Since the profits of a firm are decreasing in the number of active firms and in a merged equilibrium $m < N$, then given N the profits of a firm in an unmerged subgame perfect equilibrium cannot be greater than his profits in a merged subgame perfect equilibrium. In other words, given N, every merged subgame perfect equilibrium will dominate the unmerged subgame perfect equilibria.

Let us now consider the feasibility of merged subgame perfect equilibria. Taking into account (1) and condition (2), the following proposition can be established:

Proposition 1a. *The only one merged subgame perfect equilibrium is a monopoly if $N = 2$.*

Proof: From (1), we have that:

$$D(m,k) = \frac{2a^2}{b(m+1)^2} - (k-1)\frac{2a^2}{b(m+2)^2} - \frac{2a^2}{b(m+k)^2} =$$

$$= \frac{-2a^2(k-1)A(m,k)}{b.(m+1)^2(m+2)^2(m+k)^2}.$$

Given that $\frac{\partial A(m,k)}{\partial k} > 0$ for all $k > 1$, $A(m, 2) > 0$ for all $m > 1$, $A(1, 3) > 0$, and $A(1, 2) < 0$, we may conclude that $D(m, k) > 0$ if and only if $m = 1$ and $k = 2$. As a result, from (2), the only feasible merged subgame perfect equilibrium is a monopoly if $N = 2$. In addition, there is at least one set of bids and asking prices that supports the monopoly structure as a subgame perfect equilibrium. This set may be, for example, the following: the asking price set by firm 2, $\pi(2)$, is equal to the bid set by firm 1, the bid set by firm 2 is zero, and the asking price set by firm 1 is $\pi(1)$. The payoffs for owners of firms 1 and 2 will be $\pi(1) - \pi(2)$ and $\pi(2)$ respectively, and, obviously, no owner has an incentive to change his bid or asking price. ■

Taking into account the refinement procedure described above and Proposition 1a, we may establish the following proposition with regard to the structure of the industry resulting from the acquisition game in the case of renting firms:

Proposition 1b. *If firms producing a durable good can commit to rent their production, then the structure of the industry resulting from the acquisition game is such that:*

(i). $m = N$ if $N > 2$, and

(ii). if $N = 2$ then $m = 1$.

The analysis by Kamien and Zang (1990) implies that with a linear demand function for a non-durable good and constant returns to scale there are no mergers in equilibrium with more than two initial firms if they compete a là Cournot. Thus, Proposition 1b implies that when a durable goods industry rents its output, the structure of the industry after the acquisition process is identical to the one corresponding to a non-durable goods industry. The intuition behind this result is that in our context, given the demand function for the services of the durable good, the quantity rented each period by a durable goods industry coincides with the quantity produced by a non-durable good industry with the same number of active firms, m. As a result, $\pi(m)$ is equal to the profits that would be obtained by each of the firms in the repeated Cournot game that arises with non-durable goods. Therefore $D(m, k) > 0$ for the durable goods industry if and only if $D(m, k) > 0$ for the non-durable goods industry.[9] Therefore, the comparison of the results concerning the

[9] If firms have constant and positive marginal cost of production, then the quantity rented each

feasibility of merged subgame perfect equilibria in the other two cases to be analyzed in the paper (selling firms and renting-selling firms) with those corresponding to renting firms is identical to the comparison with the results corresponding to the case of a non-durable good industry.

Next we study the case of firms that have no commitment ability, that is firms that cannot rent their output.

2.2 Selling Firms

For an oligopoly model when firms do not have commitment ability, durability introduces the same complexities concerning the interplay between consumer expectations and the time-consistent behavior of the producer that are present in the classic durable-goods monopoly problem. Each period selling firms maximize the present discounted value of profits starting from that period. Thus, in order to calculate the intertemporal consistent schedule of production that maximizes the discounted value of profits for firm i, the maximization problem has to be resolved recursively by backward induction: first we need to determine the optimal production for period $t = 2$, given any production in period $t = 1$, and then calculate the optimal production corresponding to period 1. At $t = 2$, each firm sells the quantity that maximizes its profits corresponding to the second period, given the quantity sold in the first period. So, firm i, $i = 1, ..., m$, will solve the following problem:

$$\max_{q_{2i}} (a - bq_2 - bq_1^s)q_{2i}$$

subject to:

$$q_{2i} \geq 0.$$

The first order conditions of these $i = 1, ..., m$ problems imply:

$$q_2 = \frac{ma - bmq_1^s}{b(m+1)}.$$

Notice that the cumulative quantity sold by the industry, $q_2 + q_1^s$, increases with the quantity sold in the first period. Hence, the sale price corresponding to the

period coincides with the quantity produced by a non-durable good industry with identical technology that faces instead the inverse demand function $P = \alpha - \beta Q$ with $\alpha = 2a$ and $\beta = 2b$. Hence, as expected, the result in Proposition 1a applies.

second period, which coincides with the rental price of that period, decreases with the quantity sold in the first period.

In the first period, each firm sells the quantity that maximizes the present value of its total profits taking into account that the production at $t = 2$ depends on the production at $t = 1$. In equilibrium, since the good is durable and does not depreciate over time, the sale price of the good at $t = 1$ is equal to the sum of the rental prices corresponding to periods 1 and 2. Hence, at $t = 1$ each firm i solves the following problem:

$$\max_{q^s_{1i}} \ (a - bq^s_1)q^s_{1i} + (a - bq_2 - bq^s_1)(q_{2i} + q^s_{1i})$$

subject to:

$$q_{2i} = \frac{a - bq^s_1}{b(m+1)} \geq 0.$$

Assuming interior solutions, the first order conditions for each of these problems are:

$$m(m+3)a - bm(m+3)q^s_1 - b(m^2 + 3m + 2)q^s_{1i} = 0, \ i = 1, ..., m.$$

Adding up these m first order conditions we get:

$$q^s_1 = \frac{m^2(m+3)a}{b(m^3 + 4m^2 + 3m + 2)}; \ \ q_2 = \frac{m(m+2)a}{b(m^3 + 4m^2 + 3m + 2)}.$$

Therefore, the present value of the total profits of each firm i is equal to:

$$\pi(m) = \frac{(2+m)^2(m^2 + 3m + 1)a^2}{b(m^3 + 4m^2 + 3m + 2)^2}. \quad (3)$$

Let us now consider the first stage of the game. Following the same arguments used in subsection 2.1 we have that for every N there is an unmerged subgame perfect equilibrium. Thus, we must analyze the feasibility of merged subgame perfect equilibria. From (3) and condition (2) the following proposition may be established:

Proposition 2a. *If firms sell their output and the marginal cost of production is zero, then the merged subgame perfect equilibria will be a monopoly if* $N \in \{2, 3\}$.

Proof: Taking into account (3) we get that:

$$D(m,k) = \frac{(2+m)^2(m^2 + 3m + 1)a^2}{b(m^3 + 4m^2 + 3m + 2)^2} - (k-1)\frac{(3+m)^2(m^2 + 5m + 5)a^2}{b(m^3 + 7m^2 + 14m + 10)^2} -$$

$$-\frac{(1+m+k)^2(m^2+k^2+2mk+m+k-1)a^2}{b((m+k-1)(m+k)(m+k+2)+2)^2} = -\frac{a^2\cdot(k-1)\cdot C(m,k)}{b\cdot F(m,k)},$$

where $F(m,k) > 0$, $\frac{\partial C(m,k)}{\partial k} > 0$ for all $k \geq 3, C(m,3) > 0$ for all $m \geq 2$, $C(m,2) > 0$ for all $m \geq 2$ and $C(1,4) > 0$.[10] Thus, it is straightforward to show that $D(m,k) > 0$ if and only if $m = 1$ and $2 \leq k \leq 3$. In addition, the following set of bids and asking prices supports those structures of acquisitions as subgame perfect equilibria: the bids (or bid) set for firm 1 coincide(s) with the asking prices(price) set by the rest of the firms, $\pi(2)$. The asking price set by firm 1 is high enough, $\pi(1)$, and the bids set by firms other than firm 1 are low enough, for example zero. ■

>From the analysis above we may establish the following proposition with regard to the structure of the industry resulting from the acquisition game when firms do not have any commitment ability:

Proposition 2b. *The structure of the industry resulting from the acquisition game when firms do not have any commitment ability is such that:*
(i). $m = N$ *if* $N > 3$,
(ii). $m = 1$ *if* $N = 2$, *and*
(iii). if $N = 3$ *then* $m = 1$.

A simple comparison of Propositions 1b and 2b allows us to conclude that mergers are more likely to take place in a selling durable-goods industry than in a renting industry: a monopoly is obtained as a result of the acquisition game for $N \in \{2,3\}$ rather than for just $N = 2$.

In the analysis we have assumed that the marginal cost of production of firms is zero and that the discount factor is equal to one. It is important to discuss the role that these two simplifying assumptions play. On one hand, it is not difficult to show that if the marginal cost of production is independent of the level of production and *sufficiently high* relative to a (in particular, greater than $\frac{a}{2}$) then, given m, the level of production and the profits of each firm would be identical to the ones corresponding to the rental case. As it was shown earlier, in this case the only one merged subgame perfect equilibrium is a monopoly if $N = 2$. On the other hand, we have that it is precisely when the future is important enough, that is, when the discount factor is

[10] Proofs are available from the authors upon request.

high enough, that the intertemporal consistency problem is more relevant. Obviously, in the extreme case in which the discount factor is zero there is no such a problem and the analysis is identical to the one corresponding to the non-durable goods case: the only one merged subgame perfect equilibrium is a monopoly if $N = 2$. In fact, it is not difficult to show that with selling firms and zero marginal cost of production a monopoly is a subgame perfect equilibrium when $N = 3$ if and only if the discount factor v is high enough (more precisely iff $v > 0.65$).

Lastly, we consider the case in which firms may both rent and sell their outputs but they do not coordinate to rent them.

2.3 Renting-Selling Firms

If firms can rent and sell their outputs but they do not coordinate to rent them, then each firm, in equilibrium, will sell part of its production. Contrary to what happens in the durable goods monopoly industry, the strategic behavior among oligopolistic firms is such that in equilibrium it induces firms to sell part of their production even though their profits would be greater if all of them coordinated to rent their production. The reason is that when a firm sells a durable good today it is stealing sales from its rivals today and tomorrow. Therefore, given that consumers have perfect foresight, the problem involves both the dynamic reactions among oligopolists and the time-consistency problem identified by Coase (1972). As a result, we must solve the maximization problem of each firm by backward induction starting from the second period. In period $t = 2$, each active firm i solves the following problem:

$$\max_{q_{2i}} (a - bq_1^s - bq_2)q_{2i}.$$

The first order condition of this problem is:

$$a - bq_1^s - bq_2 - bq_{2i} = 0.$$

Adding up the m first order conditions we get:

$$q_2 = \frac{m(a - bq_1^s)}{b(m+1)}. \tag{4}$$

In period $t = 1$, each firm chooses those production levels q_{1i}^s and q_{1i}^r that maximize the present value of its profits. Thus, each firm solves the following problem:

$$\max_{\{q^r_{1i}, q^s_{1i}\}} (a - bq^s_1 - bq^r_1)(q^r_{1i} + q^s_{1i}) + (a - bq^s_1 - bq_2)(q^s_{1i} + q_{2i})$$

subject to:

$$q_{2i} = \frac{a - bq^s_1}{b(m+1)}.$$

The first order conditions are:

$$\begin{aligned} a - bq^s_1 - bq^r_1 - bq^s_{1i} - bq^r_{1i} &= 0, \qquad i = 1, ..., m, \\ \frac{m(m+3)}{(m+1)^2}(a - bq^s_1) - bq^r_1 - bq^i_{1r} - \frac{m+2}{m+1}q^i_{1s} &= 0, \qquad i = 1, ..., m. \end{aligned}$$

Adding up the m first order conditions we get:

$$q^s_1 = \frac{am(m-1)}{b(m^2+1)}; \quad q^r_1 = \frac{2am}{b(m+1)(m^2+1)}.$$

Notice that $q^s_1 = 0$ if and only if $m = 1$. As mentioned earlier, in equilibrium, a monopolist that can rent its output will choose not to sell at all, while in this case an oligopolist chooses both to sell and to rent its production. By replacing q^s_1 in equation (4) we get:

$$q_2 = \frac{am}{b(m^2+1)}.$$

Hence, the present value of total profits of firm i, $i = 1, ..., m$, is:

$$\pi(m) = \frac{a^2(m^4 + m^3 + 4m^2 + m + 1)}{b(m+1)^2(m^2+1)^2}. \tag{5}$$

>From this expression, and using condition (2), we may establish the following proposition with regard to the merged subgame perfect equilibria for renting-selling firms:

Proposition 3a. *If in equilibrium firms rent and sell output then the merged subgame perfect equilibria are:*
(i). a monopoly if $N \in \{2, 3\}$, *and*
(ii). a duopoly if $N \in \{3, 4\}$.

Proof: Taking into account (5), we get that:

$$D(m,k) = \frac{a^2(m^4+m^3+4m^2+m+1)}{b(m+1)^2(m^2+1)^2} - (k-1)\frac{a^2(m^4+5m^3+13m^2+16m+8)}{b(m+2)^2(m^2+2m+2)^2} -$$

$$\frac{a^2((m+k-1)^4+(m+k-1)^3+4(m+k-1)^2+m+k)}{b(m+k)^2(m^2+k^2+2mk-2m-2k+2)^2} = -\frac{a^2(k-1)G(m,k)}{bH(m,k)},$$

where $H(m,k) > 0$, $\frac{\partial G(m,k)}{\partial k} > 0$ for all m, k such that $m \geq 2$ and $k \geq 2$, $G(2,3) > 0$, $G(m,2) > 0$ for all $m \geq 3$ and $G(1,4) > 0$. Thus, it is straightforward to show that $D(m,k) > 0$ if and only if either $m = 1$ and $k \in \{2,3\}$ or $m = 2$ and $k = 2$. Notice that $D(2,2) > 0$ implies that if either $N = 3$ or $N = 4$ then a duopoly is a feasible merged subgame perfect equilibrium. The set of bids and asking prices given in the proof of Proposition 2a support the structure of acquisitions necessary for having a monopoly for $N = \{2,3\}$ as subgame perfect equilibrium.

Lastly, for $N = 3$ or $N = 4$ the following set of bids and asking prices supports the structures of acquisitions that induce the industry to become a duopoly as a subgame perfect equilibrium: the bid set by every firm that acquires another firm coincides with the asking price set by the acquired firm and it is equal to $\pi(3)$; the rest of the bids are sufficiently low, say zero, and the rest of asking prices are sufficiently high, say $\pi(1)$. ■

It is not difficult to show that the results in Proposition 3a are maintained for constant marginal costs of production that are low relative to a, and also for discount factors that are sufficiently high (in particular, when $v > 0.69$).

$>$From Proposition 3a we may establish the following result with regard to the final structure of the industry after the acquisition process:

Proposition 3b. *The structure resulting from the acquisition game with renting-selling firms is such that:*
(i). $m = N$ *if* $N > 4$,
(ii). $m = 2$ *if* $N = 4$,
(iii). $m = 1$ *if* $N = 3$, *and*
(iv). $m = 1$ *if* $N = 2$.

Proof: From Proposition 3a it is straightforward to show that parts (i), (ii) and (iv) hold true. Thus, we only need to show that if $N = 3$ then the structure $m = 2$ is dominated by the structure $m = 1$. Let us denote by π_i the profits of the owner of firm i. Given that for $m = 2$, π_3 is at most equal to $\pi(2) - \pi(3)$, whereas for $m = 1$, π_3 is at least as high as $\pi(2)$, it is clear that the structure $m = 1$ cannot be dominated by the structure $m = 2$.

We analyze now whether the structure $m = 2$ can be dominated by the structure $m = 1$. Consider those equilibria in which an owner who acquires a firm pays for it a quantity equal to $\pi(m + 1)$. From (5) we get that if $m = 1$ then $\pi_1 = \pi(1) - 2\pi(2) = \frac{53a^2}{450b}$ and $\pi_i = \pi(2) = \frac{43a^2}{225b}$ with $i = 2, 3$, whereas if $m = 2$ then $\pi_1 = \pi(2) - \pi(3) = \frac{71a^2}{720b}$, $\pi_2 = \pi(2) = \frac{43a^2}{225b}$ and $\pi_3 = \pi(3) = \frac{37a^2}{400b}$. Just comparing the profits of each firm in these cases, we obtain that the structure $m = 1$ dominates the structure $m = 2$. Therefore, (iii) also holds true. ■

Lastly, a simple comparison of Propositions 1b, 2b and 3b allows us to establish the main result of the paper:

Proposition 4. *If the good produced by the industry is durable, then complete monopolization and partial monopolization are more likely to take place in the presence of the time-consistency problems induced by durability.*

As discussed throughout the paper, the presence of time-consistency problems makes durable goods industries more competitive. This in turn implies that mergers are more likely to take place than in non-durable goods industries.[11] Given these differences, in order to analyze the effects of the different practices (renting or selling) on social welfare and consumer surplus it is important to take into account the incentives to merge. We turn to study this aspect next.

3 Consumer Surplus and Social Welfare

The literature on durable goods industries has studied a number of different issues (e.g., the determinants of planned obsolescence, social welfare, etc) assuming that firms can either rent or sell its production but not both (see, for example, Bulow (1986), Kahn (1986), Goering (1992), Driskill (2001) and other references therein). As indicated by Bulow (1982), renting may often be ruled out for legal reasons. For example, United Shoe Company, IBM, and Xerox all began by only renting their products but were later required at some point to also sell them. The results in the

[11] It is not difficult to show that the result in Proposition 4 also applies to the case of exogenous mergers.

previous section, however, indicate that it is just in this situation where mergers in durable goods industries turn out to be more likely to take place. This aspect raises the question of what are the net effects on social welfare of the different practices (renting or selling) once we take into account the incentives to merge.

Social welfare will be measured as the sum in present value of firms' profits and consumer surplus. From Section 2, we know that a necessary condition for a merged subgame perfect equilibrium to exist in at least one of the three possible situations considered (renting, selling, renting-selling firms) is that the number of firms in the industry is at most four (i.e., $N \leq 4$). In this section we will first compare consumer surplus and social welfare in each of these situations in the cases where there is no merged subgame perfect equilibrium and as a result $m = N$. Then, for $N \leq 4$ we will analyze the effects on consumer surplus and social welfare that derive from the interplay between the different practices, renting or selling, and the incentives to merge.

3.1 Social Welfare When There Are No Merged Subgame Perfect Equilibria

Given that the cost of production is zero, it follows that both social welfare and consumer surplus increase with the quantity of goods used by consumers each period.[12] The quantity used in the market each period t, Q_t^j, where $j = r, s, r-s$ denotes the cases of renting firms, selling firms, and renting-selling firms respectively, is such that:

a. On one hand, we have $Q_1^{r-s}(m) = Q_1^r(m)$ and $Q_2^r(m) < Q_2^{r-s}(m)$. As result of the strategic effects that exist in the renting-selling oligopoly industry we have that behavior is more competitive than in the renting firms oligopoly industry or, equivalently, than in the repeated Cournot game that arises with non-durable goods. Thus, given m, social welfare and consumer surplus are greater in the case of renting-selling firms than in the renting case. The incentive to sell arises solely for strategic reasons and tends to cause both the price and the deadweight loss to be lower than they would be in the case of renting firms.

b. On the other hand, we have that $Q_1^{r-s}(m) > Q_1^s(m)$ and $Q_2^{r-s}(m) < Q_2^s(m)$. Due to the time-consistency problem, selling firms produce in the first period a quan-

[12] The quantity used in the second period will be equal to the sum of the quantities sold each period. The quantity used in the first period will be equal to the sum of the quantity sold and the quantity rented in that period.

tity that is lower than that produced by renting or renting-selling firms. The reason is that this is the only commitment mechanism that firms have for not flooding the market in the second period. Otherwise, since consumers are rational, flooding the market would imply a decrease in the prices at which the good is sold in each of the periods.

In general, given a number of active firms m, social welfare $W(m)$ and consumer surplus $CS(m)$ may be written as:

$$\begin{aligned} W(m) &= \int_0^{q_1^s(m)+q_1^r(m)} (a - bQ)dQ + \int_0^{q_1^s(m)+q_2(m)} (a - bQ)dQ, \\ CS(m) &= \frac{b}{2}[(q_1^s(m) + q_1^r(m))^2 + (q_1^s(m) + q_2(m))^2]. \end{aligned}$$

Hence, from the analysis in Section 2 it is straightforward to conclude that social welfare $W^j(m)$ and consumer surplus $CS^j(m)$ in each of the three cases considered, $j = r, s, r - s$, are:

$$\begin{aligned} W^r(m) &= \frac{a^2 m(2+m)}{b(m+1)^2}, \\ CS^r(m) &= \frac{m^2 a^2}{b(m+1)^2}; \end{aligned}$$

$$W^s(m) = \frac{a^2 m(2m^5 + 16m^4 + 43m^3 + 50m^2 + 36m + 8)}{2b(m^3 + 4m^2 + 3m + 2)^2},$$

$$CS^s(m) = \frac{a^2 m^2(2m^4 + 14m^3 + 29m^2 + 16m + 4)}{2b(m^3 + 4m^2 + 3m + 2)^2};$$

$$W^{r-s}(m) = \frac{a^2 m(2m^5 + 4m^4 + 5m^3 + 8m^2 + 3m + 2)}{2b(m^2 + 1)^2(m + 1)^2},$$

$$CS^{r-s}(m) = \frac{m^2 a^2(2m^4 + 2m^3 + 3m^2 + 1)}{2b(m^2 + 1)^2(m + 1)^2}.$$

As a result:

$$W^{r-s}(m) > W^s(m) > W^r(m) \text{ and } CS^s(m) > CS^{r-s}(m) > CS^r(m) \text{ for all } m > 1$$

whereas:

$$W^s(1) > W^{r-s}(1) = W^r(1) \text{ and } CS^s(1) > CS^{r-s}(1) = CS^r(1).$$

Hence, if there is no merged subgame perfect equilibria and firms cannot coordinate to rent all of their production, then it is optimal, from the social point of view, that renting output is allowed. However, this is not optimal from the consumers point of view.

Given that the incentives to merge are different depending on whether we have renting, selling, or renting-selling firms, we next compare social welfare and consumer surplus for these three cases when there are merged subgame perfect equilibria. As we have shown, the likelihood of a merger is greater when there are intertemporal consistency problems. As we shall show, this implies that both social welfare and consumer surplus may be greater if firms are not allowed to sell their output.

3.2 Incentives to Merge and Social Welfare

Merged subgame perfect equilibria are feasible only if $N \leq 4$. We next analyze and compare social welfare and consumer surplus under the different practices of the firms in each of the three initial structures of the industry in which there is some merged subgame perfect equilibrium:

(i) If $N = 2$, we know that in every situation there is one merged subgame perfect equilibrium which is a monopoly. From the analysis above, we know that

$$W^s(1) > W^{r-s}(1) = W^r(1) \text{ and } CS^s(1) > CS^{r-s}(1) = CS^r(1).$$

Hence, in this situation it would be optimal from both the social welfare and the consumer surplus' points of view not to allow firms to rent.

(ii) If $N = 3$, there are merged subgame perfect equilibria only when firms sell their production either totally or partially (see Propositions 1b, 2b and 3b). In both of these cases the result of the acquisition problem would be complete monopolization: $m = 1$. As a result, on one hand social welfare and consumer surplus are greater in the case of selling firms; on the other hand, with renting firms we have $m = 3$ and, therefore, by comparing social welfare and consumer surplus for renting firms and selling firms we may conclude that:

$$W^r(m = 3) - W^s(m = 1) = \frac{15a^2}{16b} - \frac{155a^2}{200b} > 0$$

and

$$CS^r(3) - CS^s(1) = \frac{9a^2}{16b} - \frac{13a^2}{40b} > 0.$$

Hence, it would be optimal from the viewpoints of social welfare and consumer surplus not to allow firms to sell their output because of the incentives they have to merge.

(iii) If $N = 4$, then the only merged subgame perfect equilibrium corresponds to the case of renting-selling firms. Such equilibrium is a duopoly. If firms are either renting or selling then there would be 4 active firms in the industry. As a result we have that:

$$W^r(4) - W^{r-s}(2) = \frac{24a^2}{25b} - \frac{208a^2}{225b} > 0$$

and

$$CS^r(4) - CS^{r-s}(2) = \frac{16a^2}{25b} - \frac{122a^2}{225b} > 0.$$

Therefore, because of the incentives to merge, it would be desirable from the viewpoint of social welfare, and even from the consumers' viewpoint, that if firms are allowed to rent production then they coordinate to rent it. Obviously, recall from the previous analysis in this section that the optimal behavior from the social perspective is not to allow firms to rent their production.

The analysis in this section has shown that because of the incentives to merge it may be desirable from the social point of view, and even from the consumers' point of view, that firms rent all of their production. As already mentioned previously, however, in some concentrated durable goods industries firms were induced to sell part of its output. The results in this paper indicate that such a practice may not be optimal from the point of view of consumers in any circumstance, that is not even in the presence of legal barriers to merge.

4 Conclusions

We have analyzed the effects of durability on the incentives to merge. These effects have relevant implications for the literature on mergers and for the analysis of the effects on social welfare and consumer surplus of the different practices used in the commercialization of durable goods. Our main conclusion is that, relative to the case of non-durable goods, Coase's (1972) intertemporal consistency problem and the strategic interactions among firms in a durable good industry enhance the incentives for mergers.

Contrary to the classic result whereby consumer surplus and social welfare are greater when firms sell all or part of their output than when they rent it, the enhanced incentives to merge in a durable goods industry may imply just the opposite: renting production can generate greater consumer surplus and social welfare than selling. In this sense, restrictive policies regarding the use of renting might hurt competition, that is selling might not enhance competition.

As indicated previously, durable goods occupy a prominent role in aggregate economic production in the US and other developed countries, and mergers and acquisitions have experienced a substantial increase in recent years. Despite an important body of theoretical and empirical work in the literature on mergers and acquisitions, the relationship between the intertemporal consistency problem present in durable goods and the incentives for mergers have not been studied in the literature. The implications of the analysis are far from trivial and are relevant for public policy issues regarding antitrust policies, for the analysis of the effects of different commercialization practices concerning durable goods, and may be a valuable source of empirical research in the future.

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