MARKET POWER AND MERGERS IN DURABLE-GOOD INDUSTRIES*

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I. INTRODUCTION

This article investigates the effect on competition of mergers in industries that produce durable goods and shows how difficult it is to create market power through merger in a durable good industry. The implications of the analysis are that mergers in durable-good industries do not raise the same antitrust concerns as mergers in non-durable-good industries and, therefore, that it would be a mistake to blindly use the same type of analysis in a durable-good industry that has been developed to analyze mergers in a non-durable-good industry. Our results are separate from those in the recent theoretical literature on a durable-good monopolist and instead depend on the nature of competition in a dynamic setting with used goods.2

The implication of recent theoretical work following Coase is that one may not have to worry about monopoly or its creation through merger in durable-good industries. The reason has to do with the inability of the

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1 Several of the issues discussed in this article were presented to the Department of Justice in 1986 in a case involving a proposed acquisition in the tractor industry. Carlton made the presentation on behalf of a major tractor company.


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monopolist to credibly commit himself not to expand output. This reason is sometimes called the “expectation problem” because consumers’ expectations of the future depend on what they think the monopolist will do. If consumers know that a monopolist who sells at a price exceeding marginal cost in period $t$ will optimally sell to some residual consumers in period $t + 1$, then this will result in a lower price in period $t + 1$, which limits the amount consumers are willing to pay in period $t$ since they can wait until $t + 1$. Consumers’ knowledge of a monopolist’s future behavior may greatly limit the market power of the monopolist unless the monopolist can rent and not sell or can commit to limit production through capacity constraints, fixed production runs, or reputation. Many have questioned the policy relevance of the theoretical result that a durable-good monopolist may have no market power (for example, Froeb).  

This article examines in detail the market power that can be created through merger in a durable-good industry. We find that there are several reasons that have not been adequately understood or analyzed that explain why durable-good industries are naturally more competitive than non-durable-good industries and why it is difficult to create market power through merger in a durable-good industry. We focus on reasons different from the Coase point, reasons that result from the inherited stock of used equipment, the natural dynamics of the problem, and the dynamic strategic interaction among rivals.

In this article we first examine the incentive of a monopolist who is created as the result of merger. We show that it may not be in his interest to significantly reduce output or raise price for a long time. We next examine what seems to us a main concern of enforcement officials—namely, when there is a group of consumers whose demands cannot be satisfied by used equipment. We then turn to an analysis of competition among rivals in a durable-good industry. We show how strategic considerations make competition from only a few rivals more potent in a durable-good industry than in a non-durable-good industry. Finally, we discuss tractors as an example of a durable-good industry.

II. Mergers to Monopoly

Consider a durable-good industry that is in a competitive equilibrium at some stock of output, $Q_c$. Suppose that there is a merger in this industry of all the firms and that there can be no further entry. How will the monopolist behave? The important point is that the monopolist does not

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3 See L. Froeb, Evaluating Mergers in Durable Good Industries (Working paper, Department of Justice 1986).
control the stock of existing equipment, \( Q_c \), and this constrains his pricing. In particular, the monopolist's restriction of his flow of output today may have a relatively insignificant effect on price today, and this reduces his incentive to restrict output. In other words, because of the presence of the existing stock, the elasticity of demand facing the monopolist is very high. His incentive to restrict output depends, of course, on the rate at which \( Q_c \) depreciates.

It is not true, as it might first appear, that the optimal solution for the monopolist is to produce nothing until depreciation reduces the existing stock to the monopoly level. The basic reason is that the monopolist does not receive the benefit of an increase in the value of the existing stock but does bear the cost of a reduced sale (or reduced rental) of a new good. In order to see this point and, at the same time, emphasize that this result has nothing to do with the Coasian point of expectations and inability to commit, consider the following example.

Let the flow demand curve each period be

\[
Q = a - R,
\]

where

\[
R = \text{one-period rental rate};
\]

\[
Q = \text{quantity demanded}; \text{ and}
\]

\[
a = \text{constant}.
\]

For simplicity, let costs equal 0 so that the competitive solution is \( Q_c = a \), and \( R = 0 \). Suppose, now, that a monopolist is created by a merger of all the firms in the industry. Suppose, further, that no one else can enter the industry and that the monopolist rents the durable goods that he produces. (It is this renting assumption that guarantees that the expectation problem does not arise.)

The monopolist faces a residual flow demand at period \( t \) subsequent to the merger that equals

\[
Q_t = a - R_t - (1 - \delta)^t Q_c,
\]

where \( \delta \) equals one period-depreciation rate. The monopolist's problem is to choose the \( R_t \), and production in period \( t \), that maximizes his profit. It is obvious from the form of \( Q_t \) that as \( t \) increases, \( R_t \) approaches \( a/2 \), the monopoly solution. What is a little less obvious is that the monopolist may take a good bit of time to approach the monopoly solution. For example, at any time \( t \), the optimal policy for the monopolist is

\[
R_t = \frac{a}{2} - \frac{(1 - \delta)^t Q_c}{2},
\]
where \( Q_e = a \), or

\[
R_t = \frac{a}{2} \left[ 1 - (1 - \delta)' \right],
\]

and

\[
q_t = \frac{a}{2} \left[ 1 - (1 - \delta)' \right],
\]

where \( q_t \) = rental sales in period \( t \). Therefore, as long as \( \delta \) is near 0, it might take several years to even approach the monopoly solution. Notice that the dynamic incentives facing the monopolist are such that \( q_t \) is positive even though the existing stock of goods exceeds the smaller stock that is optimal for the monopolist.

Of course, antitrust enforcement should be concerned not with how long it takes to reach monopoly, but with the deadweight loss that is created. The deadweight loss created by a merger must be weighed against any benefits the merger brings. We want to show how the fact that the good is durable should be used to assess a merger. Using the case of a non-durable-good industry as a frame of reference, we analyze the monopoly harm that arises from a merger in a durable-good industry.

If the goods were not durable \( (\delta = 1) \), then a merger to monopoly would immediately create a permanent deadweight loss whose annual value is \((1/2)(a/2)^2\). In contrast, in the case of a durable good, a merger to monopoly creates an annual deadweight loss at time \( t \) of \((a^2/8) \left[ 1 - (1 - \delta)' \right]^2 \).

To see how these deadweight loss calculations, suppose that one believes that entry can occur within, say, five years. That is probably a sufficiently long period for most industries. When the government opposes a merger in such an industry, it should be because the deadweight loss over the first five years exceeds the present value of benefits. Table 1 presents the deadweight loss in the first five years for the durable-good

<table>
<thead>
<tr>
<th>( r ) Value</th>
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<tr>
<td>0</td>
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\( r = \) real annual interest rate; \( \delta = \) annual depreciation rate.
case as a ratio of the deadweight loss for the non-durable-good case for various assumptions on the annual real rate of interest and annual rate of depreciation. As the table shows, the ratio approaches 1 as $\delta$ rises. The surprising feature of the table is the low ratios when depreciation is slow. For example, if the annual depreciation rate is around 5 percent, then the deadweight loss from monopoly in a durable good is only 2 percent of the usual deadweight associated with the non-durable-good case. For depreciation rates of 10 percent, the ratio is still below .10.

Of course, numerical examples are only illustrative, and the particular ratio to apply depends on factors such as the initial state of competition prior to merger, economic growth, and entry time. The dramatically low ratios in Table 1 would be higher if the initial stock were at a level below the competitive one. So, for instance, if initially the industry output is at the noncompetitive level of $(3/4)a$ (rather than the competitive level of $a$ as is assumed in Table 1), then a merger to monopoly in a durable-good industry would create 37 percent of the deadweight loss it would cause in a non-durable-good industry where entry can occur within five years when $r = .02$ and $\delta = .20$. The corresponding number from Table 1 is 24 percent.

It is surprising that even in the presence of growth in demand, the ratios remain low for the case when entry can occur within five years. For example, if demand is growing at 10 percent per year, then the relevant ratio for $\delta = .20$ and $r = .02$ is still .41. (See Appendix A for the ratios for various combinations of $r$ and $\delta$ and growth.)

Table 2 shows that if entry takes one hundred years, then the ratios are no longer in the range of .10 though, even here, the ratios for low annual rates of depreciation are surprisingly low. For example, if $\delta = .05$ and $r = .05$, the ratio is .35. The difference between Tables 1 and 2 emphasizes the usual importance of entry in constraining deadweight loss. The only twist here is that entry can be a powerful protector of welfare in a durable-good industry even when entry takes a much longer time than is usually thought.

<table>
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**Ratio of Deadweight Loss of Merger in Durable-Good versus Non-Durable-Good Industries: Entry Takes 100 Years**

<table>
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<th>$\delta$</th>
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<td>$r$ Value</td>
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<tr>
<td>.02</td>
<td>0</td>
<td>.51</td>
<td>.74</td>
<td>.87</td>
<td>.96</td>
<td>1</td>
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<tr>
<td>.05</td>
<td>0</td>
<td>.35</td>
<td>.57</td>
<td>.76</td>
<td>.92</td>
<td>1</td>
</tr>
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</table>

**Note.**—See Table 1.
to be necessary to protect welfare in a non-durable-good setting (for example, two years).

Although the exact value of the ratio depends on particular industry circumstances, the point of the numerical examples is simple to state. In a durable-good industry, the initial deadweight loss from a merger to monopoly is much lower than in the case of a non-durable-good industry because of the dynamic incentives facing the monopolist in the presence of an existing stock of goods. The potential deadweight loss from monopoly in the future may not be relevant if entry can occur within even a pretty lengthy period of time, like five years. The combination of these two effects is to lower dramatically the deadweight loss that even a merger to monopoly can create.

III. The Relevance of Consumers Who Want Only New Goods

Let us continue to consider the case of a merger to monopoly, but now let us suppose that there is a group of consumers who have a separate demand for new goods. For these consumers, existing goods do not provide alternative consumption possibilities. These consumers are exactly analogous to consumers of a nondurable good, and it appears that a newly created monopolist could indeed exploit them.

Even in this case, though, there may be constraints on the monopolist’s pricing that arise in the durable-good problem that are missing in the more standard case of the non-durable-good industry. In the usual case, the manufacturer sells new goods and, once they are sold, he no longer controls them. Typically, he is not able to price discriminate between consumers who value the services of a new good more than those of an old good when he sells a new good. The monopolist has two choices. He can charge a rental for new goods that is above that for used goods and sell only to those wanting new goods. Or he can charge the same rental as in the used-good market and sell to customers who desire either a new or used good. The monopolist may not find it profitable to set a higher rental rate for new goods than for old goods.

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4 We treat the problem as one in which sales occur, so that the monopolist loses control of the goods once he has sold them. However, we will continue to talk in terms of implicit rental rates since, with no expectation problems, that is the simplest way to analyze the problem. We assume also that to produce an old good, one must first produce and sell a new one. A clever monopolist may try to overcome this problem by producing new goods, holding them in inventory, and selling them next year as old ones. This may not work if depreciation depends on use, if it is costly to produce and inventory equipment, or if a resale market for the new goods develops. The monopolist will likely have a more difficult time separating out and exploiting the customers with preferences for new equipment in the case of sale as opposed to rental.
To fix ideas, imagine a 2-period model. In the first period, a fraction of demanders \( F \) desires only new goods, while in the second period, everyone consumes a used good. Let the demand curve for the industry be as before so that

\[
q_n(1) = F[a - R_n(1)],
q_0(1) = (1 - F)[a - R_0(1)],
q_0(2) = a - R_0(2),
\]

where

\[
q_n(1) = \text{demand for new goods in period 1};
R_n(1) = \text{rental rate of new goods in period 1};
q_0(i) = \text{demand for old goods in period } i;
R_0(i) = \text{rental rate of old goods in period } i.
\]

Let \( Q_0 \) be the inherited stock of used equipment and, for simplicity, ignore depreciation. The firm wants to maximize profits, which is total revenue received from selling the good today. The sale price equals the sum of the rentals (we ignore interest). If the firm sets \( R_n(1) = R_0(1) \), then the firm’s maximization problem is

\[
\text{max } \pi_1 = q_n[R_n(1) + R_0(2)],
\]

where

\[
Q_0 + q_n = a - R_n(1),
\]

and

\[
Q_0 + q_n = a - R_0(2).
\]

It follows that \( R_n(1) = R_0(2) \) and that \( q_n = (a - Q_0)/2 \),

\[
R_n(1) = \frac{a - Q_0}{2} \text{ and } \pi_1 = 2 \frac{(a - Q_0)^2}{2}.
\]

If, instead, the firm sets \( R_n(1) > R_0(1) \), then the firm’s problem is

\[
\text{max } \pi_2 = q_n[R_n(1) + R_0(2)],
\]

where

\[
q_n = F[a - R_n(1)],
\]

and

\[
q_n + Q_0 = a - R_0(2).
\]
The optimal (interior) solution to this problem is

\[ q_n = \frac{F}{1 + F} \left( a - \frac{Q_0}{2} \right), \]

\[ R_n(1) = \frac{F}{1 + F} a + \frac{1}{1 + F} \frac{Q_0}{2}, \]

and

\[ \pi_2 = \frac{F}{F + 1} \left( a - \frac{Q_0}{2} \right)^2. \]

It follows that \( \pi_1 > \pi_2 \) when \( F \) is small and \( Q_0 \) is small.\(^5\) Hence, if \( F \) and \( Q_0 \) are sufficiently small, the monopolist sets \( R_n(1) = (a - Q_0)/2 \), which is less than the rental \((a/2)\) that would be set if the new users were unprotected by used goods. New users do receive protection from used goods when they constitute a relatively small share of the population and when the initial state of competition (prior to merger to monopoly) was far from the competitive one. There is a clear trade-off between the protection that users of new goods receive and the protection that users of old equipment receive.

The intuition for which users of new goods are treated the same as old users, and hence are protected somewhat, is straightforward. The monopolist can face, in the first period, either the demand curve \( F[a - R_n(1)] \), if he chooses to set \( R_n(1) \) above \( R_0(1) \), or the demand curve \( a - R - Q_0 \), if he chooses to set \( R_n(1) = R_0(1) \). The smaller \( F \) and \( Q_0 \) are, the more likely the second demand curve is to generate greater profit.

Suppose that \( \pi_1 < \pi_2 \) and the monopolist sets \( R_n(1) > R_0(1) \). In this case, \( R_n(1) \) may or may not exceed the price \((a/2)\) that a monopolist of a nondurable good would charge. The reason is easy to explain. Optimality requires equating the sum of marginal revenues in periods 1 and 2 equal to zero. The marginal revenue curve in period 1 crosses zero at an output of \((Fa/2)\), which is the optimal output of a non-durable-good monopolist. If the marginal revenue curve in period 2 crosses zero to the left of where the marginal revenue in period 1 crosses zero, then, at the quantity that a non-durable-good monopolist would provide \((Fa/2)\), marginal revenue in period 2 is negative. This means that at the optimal output, marginal revenue in period 1 must be positive (so that the sum of marginal revenue in each period is zero), which implies that output in period 1 is below \( Fa/2 \)

\(^5\) Notice that \( \pi_2 = (F(F + 1)[a/2 + (a - Q_0)/2]^2 \). Hence, \( \pi_1 > \pi_2 \) if and only if \( \sqrt{\pi_1} > \sqrt{\pi_2} \) or if and only if \((a - Q_0)/2 > \sqrt{(F/2)(1 + F)[a/2 + (a - Q_0)/2]} \) or if and only if \((1 - g) [(a - Q_0)/2] > g(a/2) \), where \( g = \sqrt{(F/2)(1 + F)} \) or if and only if \( Q_0 < a(1 - 2g)/(1 - g) = a[1 - g/(1 - g)] \).
and \( R_n(1) \) is above \( a/2 \), the price that a non-durable-good monopolist would charge. The demand curve facing the newly created monopolist in period 1 is \( F[a - R_n(1)] \), while the demand curve in period 2, which determines \( R_0(2) \), is \( a - Q_o - R_0(2) \). The larger \( F \) and \( Q_0 \) are, the more to the left the second-period demand and marginal revenue curve lie relative to the curves corresponding to the first period. In such a situation, users of the new good are harmed by the presence of the used equipment market, compared to the case of a non-durable-good monopolist.

By the same logic, it is possible for \( R_n(1) \) to be below \( a/2 \). This result would occur if the marginal revenue in the second period at \( Fa/2 \) is positive so that the marginal revenue curve in period 2 crosses zero to the right of the corresponding point \( (Fa/2) \) for period 1. This situation is most likely when \( F \) and \( Q_0 \) are small. Notice how, in this case, users of the new good pay a lower price than they would in the case of the non-durable-good monopolist, even though \( R_n(1) > R_0(1) \).

In summary, when there is a group of consumers who want only new durable goods, this group may be protected from the full exercise of market power that would occur when goods are nondurable. This protection is most likely to arise when the fraction of users wanting only new goods is small and when the inherited stock of equipment is small. (Of course, the value of the protection diminishes as the inherited stock diminishes.) It is also possible that the users of new durable goods can be worse off than in the non-durable-good case, especially if these users constitute a large fraction of consumers and if the inherited stock is large.

So far, we have assumed that there are a group of demanders who want the services of only a new good. Even when this is the result of preferences, as when consumers desire the latest model car, it is often the case that there is some cross-elasticity of demand between new and used goods. Obviously, as the cross-elasticity rises, we approach the model of the previous section. The ability of consumers to substitute away from new goods toward old ones produces a constraining effect on the monopolist's ability to exploit any one customer class. This provides an additional reason, beyond the ones just given, why a monopolist may have difficulty exploiting even a class of customers with special preference for new goods.

It is worth exploring when a cross-elasticity between new and used goods might be high, so that one does not leap to the conclusion that there is an unprotected consumer class (which, as we have already seen, is not as unprotected as it might initially appear, even if there is a zero cross-elasticity between new and used goods). Suppose that the durable good is a machine that is used to produce output that is sold in a competitive industry. Suppose also that there is a group of firms who buy only new
machines and sell them after a year. Should we necessarily infer that this group of firms is subject to the (perhaps very limited) exploitation by a newly created monopolist?

We think not for two reasons. First, competition among firms in the output market constrains the prices that can be charged for new machines. If the price of new equipment is too high, then the firm that buys the new equipment will not be able to compete with the other firms that buy less expensive used equipment. Second, the mere fact that some firms buy only new machines does not mean that there is no cross-elasticity of demand with old machines. Firms that buy older equipment might have a comparative advantage in repair labor and therefore specialize in equipment that requires repair service. But the full price (maintenance included) of a unit of service could still be the same between new and used equipment. Therefore, the monopolist may have little ability to influence the price of new equipment unless he is able to influence the price of old equipment. But, as seen in the previous section, this ability can be quite limited in the presence of a stock of used goods. In other words, even when there are firms that buy only new goods, the price that those firms pay may be severely constrained by the presence of used equipment. The prices of new and used goods can, in this case, be closely linked.

IV. Strategic Interaction among Competitors in Durable-Good Industries

One aspect of pricing in durable-good industries that has largely been ignored is the nature of strategic competition. In this section, we demonstrate several ways in which strategic behavior causes a non-durable-good industry to behave differently from a durable-good industry. These differences in behavior can be important in guiding one's view of the appropriateness of different merger policies in durable-good and non-durable-good industries. We first focus on sales policies and then on more complicated sales and rental policies.\(^6\) Our comparisons between a durable-good and non-durable-good industry hold all factors other than product durability constant between the two industries.

The results in this section are largely driven by a simple intuition. When a firm sells a durable good today, it is not only stealing a sale today from

\(^6\) Strategic issues disappear in rental only policies. Strategic issues arise because a rival's first-order conditions are affected by other rivals' past production. But with no cost of production, past production cannot influence future first-order conditions in a model involving only rental, where production decisions are assumed to depend only on the observable stock and, unlike a supergame, not on the entire history of production.
its rivals; it is also stealing their future sales. It is as if the firm today faces competition from rivals’ sales today and from rivals’ sales in future periods. In a non-durable-good setting, firms respond only to the competition from each other today. The future does not matter. In a durable-good setting, the decision about how much to sell today is also affected by rivals’ future behavior. Roughly speaking, in a 2-period model with two firms, it is as if each firm in the first period faces two rivals, one today and one tomorrow. Competition is more intense in the durable-good setting the greater the number of future periods over which there is competition. For this reason, competition can intensify rapidly as the number of firms increases.

There is another way to explain this intuition about why competition is more intense in a durable-good industry than in a non-durable-good industry. A durable-good monopolist’s production decision is based upon the trade-off between increasing profit today by producing an additional unit and decreasing profit tomorrow by facing a lower residual demand. An oligopolist’s production decision differs from a monopolist’s in two important ways. First, the reduction in today’s price from producing an additional unit affects not only one’s current profits but also those of one’s rivals. This is the standard externality in Cournot competition that increases the gain to producing more today compared to the gain faced by a monopolist. In a durable-good industry, however, there is a second externality. The decrease in future profits from an additional unit of production is shared with one’s rivals. This externality exists independent of whether we analyze a quantity competition model or a differentiated-product model with price as the strategic variable. Acting more competitively (increased production or lower price) in period t increases the outstanding stock in period t + 1 and reduces both firms’ future profits independent of the strategic variable. This externality reduces the loss from expanding production today and exacerbates the incentive to produce more than a monopolist. It results in more dramatic improvements in competition—as the number of firms increases—than a static Cournot model would imply.

We demonstrate these effects by analyzing competition in a durable-good industry in an oligopolistic environment. We use the same type of model as used by Stokey and Bond and Samuelson in their analyses of an infinite-horizon discrete-period durable-good monopoly. In order to provide a useful comparison to Cournot competition, we assume

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7 Supra note 2.
8 Id.
that rivals choose production simultaneously each period.\textsuperscript{9} It is well established that, in the absence of restrictions on strategies, an infinite-horizon complete-information model results in many perfect Nash equilibria, some of which support a great deal of collusion. Ausubel and Deneckere analyze a supergame version of the durable-good problem.\textsuperscript{10} Since we choose to focus on comparisons with Cournot and have chosen the infinite horizon model merely to simplify the analysis, we restrict strategies in a natural way. Production decisions are allowed to depend on history only through the one aspect of history that is relevant to future profitability: the outstanding stock of the durable good.

We are consistent with the existing literature and impose rational expectations on consumers. This is not essential, however, for the intuition based on the externalities described above to operate. Even if consumers incorrectly believe that price will remain constant over time, the externalities are the same and the equilibrium output path is similar to the one we derive below.

We use the same assumptions as before. The inverse rental demand for the good is \( R = a - X \) in each period where \( R \) is the one-period rental price and \( X \) is the total stock of the good. The one-period interest rate is \( r \) and the depreciation rate is \( \delta \). To simplify the analysis, we assume there are no marginal production costs. There are \( n \) identical firms in the industry, and we will use the subscript \( i \) for a representative firm.

At any time \( t \), firm \( i \) solves the following dynamic programming problem:

\[
\max_{Q_{it}} P_t(X_t)Q_{it} + \frac{1}{1 + r} V_{it+1}(X_t),
\]

where \( Q \) is production, \( P \) is sales price, and \( V \) is the value function, that is, the discounted value of equilibrium profits to firm \( i \) as a function of last period's stock, a fraction \((1 - \delta)\) of which is the outstanding stock at the beginning of period \( t + 1 \). The first-order condition is

\[
P_t(X_t) + Q_{it}P'_t(X_t) + \frac{1}{1 + r} V'_{it+1}(X_t) = 0.
\]

\textsuperscript{9} It would be valuable to compare simulations of both price and quantity games since it is possible that the choice of strategic variable may have some effect on the size of the externality. Unfortunately, dynamic, differentiated-product pricing games are significantly more complicated than the model we present. Simulations of a 2-period duopoly game indicate that the choice of strategic variable does not lead to qualitatively different results.

Imposing symmetry, it follows that

\[ P_t(X_t) + \left( \frac{X_t - \delta X_{t-1}}{n} \right) P_t(X_t) + \frac{1}{1 + r} V_{i+1}^{t+1}(X_t) = 0. \]

Since \( P_t \) equals the expected present value at time \( t \) of rental valuations, it follows that

\[ P_t(X_t) = a - X_t + \sum_{s=t+1}^{\infty} \left( \frac{1 - \delta}{1 + r} \right)^{s-t} [a - E_t(X_s|X_t)], \]

where \( E_t(X_s|X_t) \) equals the expected stock at time \( t + s \) if the stock equals \( X_t \) at time \( t \). Following Stokey\(^{11}\) and Bond and Samuelson,\(^{12}\) we assume that the equilibrium policy function has the form

\[ X_{t+1} = K + \theta X_t. \]

Imposing perfect foresight, this implies

\[ P_t(X_t) = \frac{a[1 + r - \theta(1 - \delta)] - (r + \delta)X_t - (1 - \delta)K}{[1 + r - \theta(1 - \delta)](r + \delta)}. \]

Using the equation defining \( Q_{it}, X_t, \) and \( P_t \), it is possible to express \( V_{i+1} \) solely as a function of \( X_t \) and \( P_t \). This expression for \( V_{i+1} \) simplifies as follows:

\[ V_{i+1}(X_t) = \]

\[ [r(1 + r - \theta)(1 + r - \theta^2)]^{-1} \{ r(1 + r)\theta P_t X_t[\theta - (1 - \delta)](1 + r - \theta) \]
\[ + r(1 + r)\theta P_t K[1 + r - \theta(1 - \delta)] \]
\[ + r(1 + r)(1 - \theta)P(X_t[\theta - (1 - \delta)]) \]
\[ + (1 + r)^2(1 - \theta)P^* K [r + \delta(1 + \theta)] \}, \]

where \( P^* \) is the steady-state price:

\[ P^* = \frac{[a(1 - \theta) - K](1 + r)}{(1 - \theta)(r + \delta)}. \]

Substituting these expressions into the first-order condition and equating coefficients permit us to solve for \( \theta \) and \( K \). Solutions cannot be written in closed form. The implicit expressions are very complicated, so we present simulation results instead on the assumption that the initial stocks are zero.

\(^{11}\) Supra note 2.

\(^{12}\) Id.
Table 3 reports the long-run equilibrium stock and sale price as a function of the number of firms for the case \( a = 10, \ r = .05, \) and \( \delta = .05. \) (Appendix B contains the results for different values of \( r \) and \( \delta. \)) The columns showing the speed with which price is driven to zero by entry reveal the dramatically different effects of the number of firms on competition in a durable-good rather than a non-durable-good industry. The next-to-last column reports the present discounted value of deadweight loss in a durable-good industry expressed as a fraction of the deadweight loss that is created by a durable-good monopolist who sells.\(^{13}\) The last column reports the deadweight loss that occurs in the standard non-durable-good Cournot model as a fraction of the deadweight loss created by a monopolist in such an industry. As Table 3 and the tables in the Appendices show, the decline in deadweight loss from competition in a durable-good industry is dramatically greater than that in the standard non-durable-good setting. For example, as Table 3 shows, the addition of one competitor to a durable-good monopoly causes deadweight loss to drop to 12 percent of the monopoly loss, while in the standard Cournot model with two firms for a nondurable good, the decline is to only 44 percent of the deadweight loss associated with monopoly.

Table 4 presents the incremental deadweight loss that arises as the number of firms declines for the same case as analyzed in Table 3. So, for example, a merger of the only two firms at the beginning of time raises the

\(^{13}\) We have also calculated the decline in deadweight loss that results from selling rather than renting (that is, the Coase point) and report it in the note to Table 3 and in Appendix B. The monopolist who sells retains some monopoly power because of his implicit ability to commit for discrete periods.
TABLE 4
INCREMENTAL DECLINE IN DEADWEIGHT LOSS FROM ELIMINATION OF COMPETITION:
DURABLE-GOOD VERSUS NON-DURABLE-GOOD INDUSTRIES

<table>
<thead>
<tr>
<th>n</th>
<th>DWLD ($)</th>
<th>Change in DWLD ($)</th>
<th>DWLND ($)</th>
<th>Change in DWLND ($)</th>
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<td>21.00</td>
</tr>
</tbody>
</table>

Note.—n = number of firms; DWLD = deadweight loss in durable-good industry; DWLND = deadweight loss in non-durable-good industry.

deadweight loss in a durable-good industry from $8.70 to $69.60. Table 4 indicates that the most substantial decline in competition in a durable-good industry occurs as the number of competitors declines from two to one. In every case, though, the elimination of a competitor raises much more serious antitrust concerns in the non-durable-good industry than in the durable-good industry. For example, a merger in a durable-good industry that reduces the number of competitors from five to four raises about the same antitrust concerns as a merger in a non-durable-good industry that reduces the number of competitors from thirteen to twelve.

Rational expectations by consumers play a role in determining the level of profits and market power but are not essential for the key result on which we focus: the relative market power of a monopolist to an oligopolist. The central feature that drives the results is the realization by firms of the externalities of current production on rivals’ current and future profits, and this feature is present no matter how consumers form expectations.

So far, we have not paid much attention to the consumers’ expectation problem and the distinction between selling and renting. Here we wish to focus explicitly on this distinction because we want to show how, in an oligopoly setting, strategic motivations lead an oligopolist to choose to both rent and sell, even if he can only rent. Notice how this contrasts with the result under monopoly. As Coase showed, the consumer-expectation problem implies that profits are higher if the monopolist rents rather than sells.\(^{14}\) If he can, every durable-good monopolist should rent rather than sell. Only concerns with transaction costs or moral hazard could offset this preference.

\(^{14}\) Supra note 2.
We show that strategic interaction provides a reason why an oligopolist will choose to sell some of its output rather than rent it, even in the absence of transaction cost or moral hazard. The intuition is very similar to the intuition given above for the increased competitiveness of durable-good oligopolists. By selling an extra unit today, a firm steals current and future sales from its rivals. In the absence of marginal production costs, rental production has no effect on future competition.\textsuperscript{15} Therefore, oligopolists choose to sell some output, even though this ultimately results in lower equilibrium profits than would arise if they could agree only to rent.

We now consider a simple 2-period version of the durable-good problem in order to demonstrate the strategic incentives for an oligopolist to sell, rather than rent, a durable good.\textsuperscript{16} As before, let the inverse rental demand be $R = a - Q$ in each of the two periods. Let $Q_s$ be the total amount sold in period 1 and $q_2$ the amount a firm sells in period 2. There is no discounting and there are zero production costs. Depreciation is at rate $\delta$. There are $n$ identical firms and a subscript $i$ identifies variables associated with the $i$th firm. In the second period, it does not matter whether the firm sells or rents, as it is the last period. Therefore, firm $i$ solves the following problem in period 2:

$$\max_{q_2} [a - (1 - \delta)Q_s + q_{2i} + (n - 1)q_2]q_{2i}.$$ 

The first-order condition is

$$a - (1 - \delta)Q_s - (n - 1)q_2 - 2q_{2i} = 0.$$ 

Imposing symmetry gives

$$a - (1 - \delta)Q_s - (n + 1)q_2 = 0.$$ 

Solving, this gives

$$q_2 = \frac{a - (1 - \delta)Q_s}{n + 1},$$

\textsuperscript{15} Rental production, when costly, does have some effect on future competition because it alters future costs of incremental sales and rentals.

\textsuperscript{16} D. Malueg & J. Solow, Endogenous Contract Choice and Market Structure (Discussion Paper No. 86-13, Dept. of Justice, Economic Analysis Group, Washington, D.C., 1986), also address this question and reach similar conclusions. See also D. Malueg & J. Solow, On Requiring the Durable Goods Monopolist to Sell, 25 Econ. Letter 283 (1987). We are grateful to David Malueg for bringing this work to our attention. J. Bulow, An Economic Theory of Planned Obsolescence, 101 Q. J. Econ. 729 (1986), addresses a related topic when he examines the endogenous decision of how durable to make a good. In a finite-period model, a choice of zero durability is equivalent to renting.
\[ P_2 = \frac{a - (1 - \delta)Q_s}{n + 1}, \]
\[ \Pi_{2i} = \frac{(a - (1 - \delta)Q_s)^2}{(n + 1)^2}. \]

In the first period, representative firm \( i \) solves
\[ \max_{q_{is}, q_{ir}} P q_{is} + R q_{ir} + \Pi_{2i}, \]
where
\[ R = a - [(n - 1)(q_s + q_r) + q_{is} + q_{ir}], \]
\[ P = R + \frac{(1 - \delta)}{(n + 1)} \{a - (1 - \delta)[q_{is} + (n - 1)q_s]\}, \]
where subscript \( s \) represents sales and subscript \( r \) represents rentals. The first-order conditions are
\[ a - (n + 1)(q_s + q_r) + \frac{(1 - \delta)}{(n - 1)} \left[a - (1 - \delta)(n + 1)q_s\right] \]
\[ - \frac{2[a - (1 - \delta)nq_s](1 - \delta)}{(n + 1)^2} = 0, \]
\[ a - (q_s + q_r)(n + 1) = 0. \]
Simplifying, this gives
\[ q_s = \frac{a(n - 1)}{(1 - \delta)(n^2 + 1)}, \]
\[ P = \frac{a}{n + 1} + \frac{(1 - \delta)a}{n^2 + 1}. \]

Notice that \( q_s \) is positive when there is more than one firm.\(^{17}\)

In equilibrium, a monopolist does not sell, while an oligopolist chooses to both sell and rent. The incentive to sell arises solely for strategic reasons and tends to cause price and deadweight loss to be lower than it would otherwise be in the case of Cournot competition in a non-durable-good industry.

There are strategic reasons, not captured by this model, why a firm may wish to sell rather than rent a durable good. Suppose that there is potential entry or cost-reducing research and development by a rival. By selling

\(^{17}\) The second-order conditions for a maximum are also satisfied.
rather than renting, a firm, in effect, assures itself of market share and profits tomorrow through the sale price today. Rentals cannot do this. Thus, if a firm rents and a rival discovers a better product or lowers production costs, this firm’s profits can be reduced or eliminated. This reduction in profits can be mitigated if the firm sells. For example, a rival’s profits upon innovation or entry will be lower if consumers own, rather than rent, equipment. This reduces the incentives to enter or to devote resources to research and development. Thus, sales can act as an entry-deterrence device. These types of strategic incentives therefore explain why sales, not rentals, will be used. As already discussed, this makes competition more vigorous because of the strategic interaction effect. These strategic considerations also provide even greater incentives to expand production than those identified in the previous models.

Let us briefly summarize the results of this section. In an oligopoly setting, the sale of durable goods creates strategic externalities that encourage production and make the industry look more competitive than one would otherwise think. Renting rather than selling can reduce the full force of these strategic externalities, but even here, the self-interest of oligopolists leads them to sell at least some of their output, in marked contrast to the behavior of a monopolist. Moreover, there may be additional strategic reasons that encourage the use of sales rather than rentals. It is impossible to discuss these issues without dealing with consumer expectations. Our point, though, is not that consumer expectations lead to competitive behavior but that strategic interactions among competitors are potent forces for competition in durable-good industries, especially when renting is not possible.

V. Application

We now show how to apply the analysis by discussing an example. The example involves four-wheel-drive tractors, a special type of tractor (one with four big wheels, each of which is powered) used heavily in certain types of farming, such as wheat.\textsuperscript{18} There is a very active market for used equipment and there is both a rental and a sale market for equipment. (The rental market is organized by fleet operators who put together a fleet of tractors and drive them through wheat country). The fact that these machines are inputs to a highly competitive industry means that new and used prices should be highly linked. Moreover, maintenance of used equipment is an important alternative to new equipment purchases.

\textsuperscript{18} Carlton once served as a consultant on a transaction involving tractors on behalf of a major tractor manufacturer.
The fact that prices and sales of new and used equipment are closely linked is well recognized in the industry, as the following passage indicates:

As U.S. farmers purchase less new farm machinery for the sixth consecutive year, on-farm machinery needs are being met in other ways. In many areas of the country, particularly the Midwest, there is an abundance of good used farm machinery on the market at attractive prices. Midwest farmers and machinery dealers from surrounding areas have taken advantage of the availability of this used machinery, which has further dampened demand for new machinery. 19

The prices of new and used goods are highly correlated. Using information from the National Farm Tractor and Implement Blue Book (National Market Reports, Inc., Chicago), we were able to obtain list prices for new tractors and average selling prices for used tractors for specific models for the years 1976–84. Despite the fact that list prices were the only prices available for new tractors (transaction prices were not available), the correlations between prices of new equipment, and equipment of age one, two, three, or four years, were always in excess of .95.

Using these price data, we estimated the rate of depreciation from the model:

\[ \ln P(t, i) = c + d \text{ age}, \]

where \( P(t, i) \) = price at time \( t \) of tractor of model \( i \); \( \text{age} \) = age of the tractor of model \( i \) in year \( t \), and \( c, d \) = coefficients.

This estimation produced an annual depreciation rate of about 8 percent. These tractors apparently last a long time, in excess of fifteen years.

Using information on total past sales in North America, 20 one can construct the “effective” stock of tractors by depreciating past sales by the depreciation rate of 8 percent. As of 1985 at least, it appeared as if the new sales were just about offsetting the loss caused by depreciation.

There are several other factors that relate to the competitiveness of the industry. First, in 1986 there were only four major competitors left in an industry that had once supported numerous competitors. Of the four remaining, two were in a precarious financial position. Sales of new equipment were less than 30 percent of peak sales achieved in the late 1970s and early 1980s. The industry was expected to change in the near fu-

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20 This information is available from the Farm and Industrial Equipment Institute, Chicago, and from the Canadian Farm and Industrial Equipment Institute, Burlington, Ontario.
ture because of technological developments, and one new entrant was expected.

The tables that appeared earlier showed that, for rates of depreciation between 5 and 10 percent, and for a five-year time horizon for entry, even a monopolist is severely constrained in his ability to exercise market power. Perhaps one crude way of reflecting this constraint is to consider used goods as being in the same market as new goods and to ask whether a firm with a market share of below 8 percent could adversely affect competition. (This market-share calculation is not quite right because it is a static concept that ignores the dynamic incentives of the monopolist.) In any event, the analysis of this article, together with the facts of the industry, would suggest little risk of anticompetitive harm from a merger in this industry.\(^{21}\)

VI. CONCLUSION

This article has shown that mergers in durable-good industries are less likely to raise antitrust concerns than mergers in non-durable-good industries and therefore should be analyzed differently. The reason is that the stock of existing equipment puts tight constraints on the initial prices, and entry in the future constrains subsequent prices. Roughly speaking, it is usually a mistake to exclude used goods from the market definition, even though market shares present a snapshot and fail to capture all the dynamics of the problem. The constraint of used goods can be present even when there is a consumer group that purchases only new equipment. Our second main point is that competition in durable-good industries is likely to be more intense than in non-durable-good industries because of the strategic incentive facing firms.

The place where mergers in durable goods are most likely to raise antitrust concerns are industries where, after the merger, \((a)\) goods depreciate rapidly, \((b)\) the market is growing, \((c)\) the sales of new goods is high relative to the effective stock, \((d)\) entry is unlikely even over as long a period as five years, \((e)\) a substantial fraction of consumers have strong preferences for new goods, \((f)\) the good is a final consumption good, not an input to another industry, and \((g)\) goods are rented, not sold.

In many cases, despite initial appearances, mergers in durable-good industries may have little effect on price, and, therefore, any benefits the merger creates will likely tip the balance in favor of allowing the merger to occur. That pricing in durable-good industries is more competitive than

\(^{21}\) Since 1986, there has been one new entrant and one consolidation of existing competitors.
one might think is a point made forcefully by Coase. Our results are complementary to his and show why this conclusion may be true for very different reasons in the context of mergers in durable-good industries.

APPENDIX A

<table>
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<th>Time of Rivals</th>
<th>5 Years</th>
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Note.—g = growth rate; r = interest rate; δ = depreciation rate.
## APPENDIX B

### TABLE B1

The Differing Effect of the No. of Firms on Competition: Durable-Good versus Non-Durable-Good Industries

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<td>.91</td>
<td>.0076</td>
<td>.03</td>
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<td>.0051</td>
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</table>
TABLE B1 (Continued)

<table>
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<tr>
<th>$n$</th>
<th>PD</th>
<th>PND</th>
<th>RDWLD</th>
<th>RDWLND</th>
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<td>Where $r = .1$ and $\delta = .2$:</td>
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<tr>
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<td>8.6614</td>
<td>5.0</td>
<td>1.0**</td>
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<td>3.33</td>
<td>.1615</td>
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<td>.5794</td>
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<td>.2376</td>
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</tr>
<tr>
<td>100</td>
<td>.0204</td>
<td>.01</td>
<td>.0001</td>
<td>.0004</td>
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<tr>
<td>Where $r = .1$ and $\delta = .5$:</td>
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<tr>
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<td>.2561</td>
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</table>

Note. $r =$ real rate of interest; $\delta =$ annual depreciation rate; $n =$ no. of firms; PD = long-run equilibrium price for durable goods; PND = long-run equilibrium price for nondurable goods; RDWLD = ratio of present value of deadweight loss to present value of deadweight loss of a monopolist (durable-good sales); RDWLND = ratio of present value of deadweight loss to present value of deadweight loss of a monopolist (non-durable-good sales).

* The ratio of deadweight loss of a durable-good monopolist who sells to one who rents is .33.
† The ratio of deadweight loss of a durable-good monopolist who sells to one who rents is .57.
‡ The ratio of deadweight loss of a durable-good monopolist who sells to one who rents is .12.
§ The ratio of deadweight loss of a durable-good monopolist who sells to one who rents is .27.
¶ The ratio of deadweight loss of a durable-good monopolist who sells to one who rents is .27.
* The ratio of deadweight loss of a durable-good monopolist who sells to one who rents is .38.
** The ratio of deadweight loss of a durable-good monopolist who sells to one who rents is .40.
†† The ratio of deadweight loss of a durable-good monopolist who sells to one who rents is .60.

BIBLIOGRAPHY


