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Pacman Refutes the Coase Conjecture: Durable-Goods Monopoly with Discrete Demand[1]

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Abstract

We analyze a dynamic game between consumers with unit demands and the sole seller of a durable good. Unlike previous analyses, we assume there exists a finite collection of buyers rather than a continuum. We show that none of the main conclusions of the durable-goods literature survives this change in assumption. In particular, for any demand curve there exists a subgame-perfect equilibrium such that for discount factors near one the monopolist's profit approaches the profit attainable under perfect price discrimination. This contradicts Coase's conjecture (1972) — proved formally for the continuum case by Gul, Sonnenschein, and Wilson (1986)—that the monopolist's profit must always converge to zero. It also implies that renting or precommitting to a path of prices—which Bulow (1982) and Stokey (1979) have shown, respectively, must always increase profit with a continuum of buyers—may strictly reduce profits when the collection of buyers is finite. Hence, while in other contexts the assumption of a continuum of consumers has proved an innocuous and useful simplification, in the context of durable-goods monopoly it has proved misleading.

1. Introduction

While models of strategic interactions among firms abound, models with buyers as active players are comparatively rare. In his pioneering analysis of one such game, Coase (1972) conjectured that a durable-goods monopolist would be unable to exert monopoly power, since buyers—anticipating a drop in price—would refuse to buy as long as the price remained above the competitive level. Recent papers by Bulow (1982), Stokey (1979, 1982), and Kahn (1986) have formally modeled durable-goods monopolies. These papers confirm Coase's conjecture when marginal production costs are constant, the monopolist is unable to credibly commit to future behavior, and the discount factor approaches one.[1] More recently, Gul, Sonnenschein, and Wilson (1986) have reformulated the durable goods monopoly problem as a dynamic game. Under the same cost and demand assumptions, they showed that for discount factors near one every subgame-perfect equilibrium of the game satisfies Coase's conjecture about monopoly profits.

Until now, the literature has confined itself to demand curves with a continuum of non-atomic buyers. We retain the formal structure of a dynamic game but consider the case of an arbitrarily large, *finite collection* of buyers. We show that none of the main conclusions of the durable-goods literature survives this change in assumption.

Following most of the literature, we consider a game with an infinite number of trading periods.[2] Buyers have an inelastic demand for a single unit of the monopolist's product and are characterized by a reservation price that represents their maximum willingness to pay for the unit. As in Gul, Sonnenschein, and Wilson (1986), the monopolist is assumed to know the reservation price of each buyer.[3]

We show that for any distribution of buyers' reservation prices, there is a range of discount factors for which the following strategies constitute a subgame-perfect equilibrium. In each period, the monopolist offers the good for sale at a price equal to the highest remaining reservation price. Each buyer accepts the good at the first price that is less than or equal to his reservation price. The buyer's strategy is referred to as a "get-it-while-you-can" strategy since the buyer accepts any offer that generates nonnegative utility. Since the monopolist "eats his way" down the demand curve, we refer to the monopolist's strategy as the "Pacman strategy."

In this equilibrium, the present value of the monopolist's profits approaches the value obtained by a perfectly discriminating monopolist as the discount factor approaches one. Hence, rather than losing all market power as Coase conjectured is inevitable, the monopolist attains almost *perfect* market power for discount factors near one.

The intuition behind this result can be seen by considering the game with two buyers and no production costs. Suppose that buyer 1 has reservation price v_1, buyer 2 has reservation price v_2, and $v_1 > v_2$. From any stage onward, the get-it-while-you-can strategy is optimal for any buyer since it achieves a surplus of zero and nothing larger can be achieved against the Pacman strategy. It is straightforward to show that when both buyers use the get-it-while-you-can strategy, it is optimal for the monopolist either to sell immediately to both buyers at the price v_2 or to use the Pacman strategy. (These propositions are proved in section 3.)

Compare the present value of the monopolist's profits from these two alternative strategies. By selling immediately to both buyers, the monopolist obtains $2v_2$. If instead the monopolist uses the Pacman strategy, he charges v_1 to buyer 1 in period 1, v_2 to buyer 2 in period 2, and obtains the present value: $v_1 + \beta v_2$, where β is the monopolist's discount factor. Hence, the Pacman strategy is a best reply for the monopolist to get-it-while-you-can if and only if: $v_1 + \beta v_2 \geq 2v_2$. Rewriting this comparison slightly, we obtain the following condition for the Pacman strategy to be optimal:

$$v_1 - v_2 \geq (1 - \beta)v_2. \tag{1}$$

The left hand side of equation (1) is the marginal cost of deviating from the Pacman strategy. By lowering the price immediately to v_2, the monopolist loses the difference in the reservation prices, that is, the additional surplus that could have been extracted from buyer 1. However, the monopolist gains by lowering the price since the date at which buyer 2 purchases the good is advanced. The right hand side of equation (1) is the additional interest obtained when buyer 2 purchases the good in period 1 rather than period 2.

The marginal cost of deviating from the Pacman strategy is independent of the discount factor. On the other hand, the additional interest obtained by deviating from the Pacman strategy approaches zero as the discount factor approaches 1. In particular, for $1 \geq \beta > 1 - (v_1 - v_2)/v_2$, the Pacman strategy is optimal for the monopolist, and the Pacman strategy and the get-it-while-you-can strategy constitute a subgame-perfect equilibrium of the market game. Note that as the discount factor approaches one, the present value of the profits obtained by using the Pacman strategy approaches $v_1 + v_2$, the value obtained by a perfectly discriminating monopolist.

In addition to refuting the Coase conjecture, our analysis shows that two other propositions—valid for the continuum case—are false if the collection of buyers is finite. First, as Stokey (1979) and Sobel and Takahashi (1983) demonstrate for a continuum of buyers, a monopolist seller of durable goods can increase the present value of its profits by precommitting to a time path of prices (or quantities). However, for a *finite number* of buyers and a discount factor near one, the Pacman strategy extracts virtually all the consumer surplus, so that the monopolist would lose money if instead he precommitted to a time path of prices. While precommitting to a pricing rule which depends on the observed history can never be harmful, *requiring* that the rule *ignore* past buyer behavior does reduce profits in this case.

A second, closely related proposition is that a durable-goods monopolist can do better by renting rather than selling his product. As discussed by Bulow (1982), a rental policy is one way to implement Stokey's commitment strategy. Since the Pacman strategy strictly dominates Stokey's commitment strategy, it dominates Bulow's rental strategy as well.

In Section 2, we introduce notation and formulate our model. Section 3 analyzes the equilibrium in the market game. Section 4 contains concluding remarks.

2. The Specification of the Market Model

This section describes the assumptions of the model and our notation and terminology.

There are a countable number of periods indexed by $t = 1, \ldots, \infty$. Each period consists of two stages. In the first stage, the monopolist offers to sell to any and all buyers at the price $p(t)$. In the second stage, each buyer simultaneously decides whether to accept the monopolist's current offer or to reject the offer and continue.

There are initially N buyers, each of whom can consume either one or zero units of the monopolist's good. A type l buyer who accepts the monopolist's offer in period t obtains the utility:

$$U_l = \beta^{t-1}[v_l - p(t)]. \tag{2}$$

A buyer that never accepts an offer obtains a utility of zero, so that a buyer of type l is never willing to pay more than his reservation price, v_l. There are at most L distinct reservation prices, with $L \leq N$, and the reservation prices are indexed so that $v_1 > v_2 > \ldots > v_L \geq 0$. For simplicity, we follow the literature and assume that the discount factor, β, is the same for all buyers and for the monopolist, and that $0 < \beta \leq 1$. However, as will become clear from the proofs of the propositions, the Pacman and get-it-while-you-can strategies form a subgame-perfect equilibrium whenever the discount factor of the *seller* lies within the interval we derive; no restriction is needed on the discount factors of the buyers (except that they lie between zero and one).

Following Gul, Sonnenschein, and Wilson (1986), we assume that the reservation price of each buyer is common knowledge.[4]

The monopolist is assumed to produce the good at constant marginal cost. Hence, without loss of generality, the price, $p(t)$, and the reservation prices, v_l, can be considered as net of marginal cost. Equation (2) remains the same under this interpretation.

Without loss of generality, we can restrict attention to the case where $v_L > 0$. If $v_L = 0$, then it is never optimal for type L buyers to buy at a positive price. As a result, the equilibrium strategies that we consider for the monopolist and other buyers are also equilibrium strategies in a game with a finite number of zero-reservation-price buyers added, and the monopolist's equilibrium profits are the same in both cases.[5] (Once all the buyers with positive reservation prices have purchased the good, we can assume that the monopolist sells (or not) to the zero-reservation-price buyers at a zero price.)

If $B(t)$ is the number of buyers accepting the monopolist's offer in period t, then V, the present value of the monopolist's profits, is given by the equation:

$$V = \sum_{s=1}^{\infty} \beta^{s-1} p(s) B(s). \tag{3}$$

The monopolist's goal is to maximize V.

The history of the game prior to period t is described by a list of the monopolist's price offers in periods 1 through $t-1$ and a list of the buyers who accept the monopolist's offer in each period. A pure strategy is a function specifying a player's choice at each stage for each history of the game prior to that stage. Hence, a pure strategy for the monopolist specifies the monpolist's price offer in each period t as a function of the game's history up to t. A buyer's pure strategy specifies the choice "accept" or "continue" in stage 2 of each period t as a function of the history up to t and the monpolist's current price offer, $p(t)$. Since we seek not to characterize the set of subgame-perfect equilibria but merely to exhibit one equilibrium with characteristics at odds with accepted wisdom, we restrict attention throughout this paper to subgame-perfect equilibria in pure strategies.[6] For brevity, we omit explicit reference henceforth to this restriction on the strategies of the players. A subgame-perfect equilibrium is a strategy combination such that the strategy for each player is a sequential best reply, i.e. optimal at every stage and for every history given the strategies of the other players.

The following rule defines a get-it-while-you-can strategy for type l buyers:

$$\text{accept in period t if and only if } p(t) \leq v_l. \tag{4}$$

A buyer using such a strategy is willing to accept the first offer that generates nonnegative utility.

Let $v_{\max}(t)$ be the highest reservation price belonging to some buyer who is still in the game at the beginning of period t.

The following rule defines the Pacman strategy for the monopolist:

$$p(t) = v_{\max}(t). \tag{5}$$

A monopolist who uses the strategy specified in equation (5) sets the price in each period to the highest remaining reservation price and drops this price if and only if *all* buyers with the highest reservation price have purchased the good.

3. Monopoly Power in the Market Game

The combination of the Pacman strategy for the monopolist and the get-it-while-you-can strategy for each buyer constitutes a subgame-perfect equilibrium of the market game as long as the discount factor is sufficiently close to one. The smallest allowable discount factor depends on the initial distribution of reservation prices.

If the monopolist plays the Pacman strategy, then no buyer can achieve positive utility. Hence, for a buyer of type l, a sequential best reply to the Pacman strategy requires that—if an information set with $p(t) < v_l$ is ever reached—the buyer accepts the monopolist's offer. For, in this case the consumer would gain strictly positive surplus from accepting the offer and would anticipate zero surplus from continued play against the Pacman strategy. If $p(t) = v_l$, then either choice, "accept" or "continue", is optimal for type l buyers. We focus on the get-it-while-you-can strategy, which assigns the choice "accept" in this case. Finally, if an information set with $p(t) > v_l$ is ever reached, declining the offer is a sequential best reply since the consumer can get a strictly larger surplus (zero) just by declining all future offers. The above observations are formalized in lemma 1.

LEMMA 1. The get-it-while-you-can strategy is a sequential best reply for a buyer playing against the Pacman strategy.

It remains to determine conditions under which the Pacman strategy is a sequential best reply for the monopolist when all buyers use the get-it-while-you-can strategy. The following lemma simplifies the analysis.

LEMMA 2. If all buyers use the get-it-while-you-can strategy, then in each period t there exists some l such that setting $p(t) = v_l$ is a sequential best reply for the monopolist where at least one buyer still in the game at t has the reservation price v_l.

Proof. From the definition of $v_{max}(t)$ and the get-it-while-you can strategy, the monopolist has no incentive to choose $p(t) > v_{max}(t)$. No buyer would accept such an offer and, for discount factors strictly less than one, the delay decreases the present value of the monopolist's profits; for discount factors equal to one, the monopolist could do just as well if instead he chose $p(t) = v_{max}(t)$.

Let $l = 1, \ldots, L(t) \leq L$ now index the reservation prices of buyers still in the game at period t, and suppose that it were optimal for the monopolist to choose

$p(t)$ such that $v_{l+1} < p(t) < v_l \leq v_{max}(t)$ for some $l \leq \mathrm{L}(t) - 1$. By choosing instead $p(t) + \epsilon$ with $\epsilon > 0$ and $p(t) + \epsilon < v_l$, the monopolist can strictly increase his profits without changing the behavior of any buyer. Hence, the original choice could not have been optimal. The same argument also shows that $p(t) < v_{\mathrm{L}(t)}$ is not optimal. Q.E.D.

Lemma 2 indicates that we can restrict attention to strategies for the monopolist that set the price in each period to the reservation price of some remaining buyer.

The following notation will be useful. For $\mathrm{L} \geq 2$, define Δ via the equation:

$$\Delta = \min_{1 \leq l \leq \mathrm{L}-1} v_l - v_{l+1} \ . \tag{6}$$

For $\mathrm{L} = 1$, let $\Delta = v_1/2$. Δ is the minimum distance between reservation-price levels. It will be used as a lower bound on the monopolist's marginal loss from deviating from the Pacman strategy.

Denote the initial number of buyers at each reservation-price level by the vector $\mathbf{n} = (n_1, \ldots, n_{\mathrm{L}})$, where n_l is the initial number of buyers with reservation price v_l. Let $\mathbf{n}_2 = (0, n_2, \ldots, n_L)$. $\mathbf{n}_2$ represents the same distribution of buyers as $\mathbf{n}$ except that buyers with the highest reservation price have been removed. More generally, let $\mathbf{n}_l = (0, \ldots, 0, n_l, \ldots, n_L)$ be the same distribution as $\mathbf{n}$ but with the highest $l - 1$ levels removed ($l \leq \mathrm{L}$).

The final lemma presents accounting identities which will simplify the proof of our main theorem. For a given set of reservation prices and initial buyers, let $V^*(\mathbf{n})$ be the present value of the monopolist's profits when all buyers use the get-it-while-you-can strategy and the monopolist uses the Pacman strategy. Let $V(p, \mathbf{n})$ denote the present value of the monopolist's profits when all buyers use the get-it-while-you-can strategy, the monopolist chooses an initial price p, and thereafter uses the Pacman strategy. The following formulas follow immediately from these definitions.

LEMMA 3.

$$V(v_1, \mathbf{n}) = n_1 v_1 + \beta V^*(\mathbf{n}_2) \tag{7}$$

$$\begin{aligned} V(v_2, \mathbf{n}) &= n_1 v_2 + \{n_2 v_2 + \beta V^*(\mathbf{n}_3)\} \\ &= n_1 v_2 + V^*(\mathbf{n}_2) \end{aligned} \tag{8}$$

$$\begin{aligned} V(v_l, \mathbf{n}) &= n_1 v_l + \{n_2 v_l + n_3 v_l + \ldots + n_l v_l + \beta V^*(\mathbf{n}_{l+1})\} \\ &= n_1 v_l + V(v_l, \mathbf{n}_2) \quad \text{for all } l \geq 3. \end{aligned} \tag{9}$$

Lemma 3 shows how the present value of the profits obtained by setting an initial price v_l and thereafter using the Pacman strategy can be decomposed into the value obtained by selling to the buyers with the highest reservation price and the value obtained by selling to the other buyers.

Define $S(\mathbf{n})$ by the equation:

$$S(\mathbf{n}) = \sum_{l=1}^{L} n_l v_l. \tag{10}$$

$S(\mathbf{n})$ represents the area under the initial demand curve (above marginal cost) and also the surplus available to a perfectly discriminating monopolist. $(1-\beta)S(\mathbf{n})$ turns out to be an upper bound on the monopolist's gain from deviating from the Pacman strategy.

The main result of the section is a corollary of the following theorem.

THEOREM 1. (PACMAN) If all buyers use the get-it-while-you-can strategy, then for all values of the discount factor such that:

$$1 - (\Delta / S(\mathbf{n})) < \beta \leq 1, \tag{11}$$

the Pacman strategy is a sequential best reply for the monopolist.

Proof. In order to prove the theorem, we must show that it is optimal to use the Pacman strategy starting from any remaining subset of the initial collection of buyers. The technique of mathematical induction provides a systematic procedure for verifying the optimality of the Pacman strategy for all possible subsets of buyers.

For any subset of buyers, let L_s be the number of distinct reservation prices of buyers in the subset. For all subsets where $L_s = 1$, lemma 2 implies that the Pacman strategy is a sequential best reply for the monopolist for any $0 < \beta \leq 1$. Hence if initially there is only one distinct reservation price, then the theorem is proved.

Otherwise, we complete the proof of the theorem by demonstrating that if the Pacman strategy is a sequential best reply for all subsets of buyers with L_s distinct reservation prices, then the Pacman strategy is a sequential best reply starting from any subset with $L_s + 1$ distinct reservation prices.

Consider some subset of buyers with $L_s + 1$ distinct reservation prices. Re-index their reservation prices as follows. Let l index the reservation prices of buyers in the subset, with $v_1 > \ldots > v_{L_s}$. First, note that the initial distributions of buyers: $\mathbf{n}$ and $\mathbf{n}_2$, the quantity: Δ, and the values: $S(\mathbf{n})$, $V^*(\mathbf{n})$, and $V(p, \mathbf{n})$, can all be defined for the subset just as for the initial collection of buyers. In the rest of the proof, the above variables refer to "subset" quantities. Note also that if the inequality in equation (11) is satisfied for the initial set of buyers, then it is also satisfied for the subset, since deleting buyers reduces S without decreasing Δ—thereby reducing the lower end of the interval of admissible discount factors. Let $t = 1, \ldots, \infty$ now index the periods of the subgame beginning with the above collection of buyers.

Lemma 2 implies that only initial prices $p = v_l$ need to be considered. For any such price, buyers with reservation prices of v_l or higher will buy in period 1. Hence, the induction hypothesis implies that it will be optimal for the monopolist to use the Pacman strategy from period 2 onward. Therefore, the present value of the monopolist's profits must be given by $V(v_l, \mathbf{n})$ for some l. The Pacman strategy is optimal in period 1 if $V(v_1, \mathbf{n}) > V(v_l, \mathbf{n})$ for $l = 2, \ldots, L_s$. We first verify that it is better to play Pacman from period 1 onward than to charge v_2 in the first period and play Pacman thereafter. That is, $V(v_1, \mathbf{n}) > V(v_2, \mathbf{n})$.

Subtracting equation (8) from equation (7) produces the result:

$$V(v_1, \mathbf{n}) - V(v_2, \mathbf{n}) = n_1(v_1 - v_2) - (1-\beta)V^*(\mathbf{n}_2) > n_1\Delta - (1-\beta)S(\mathbf{n}) > 0. \quad (12)$$

The first inequality follows from the definition of Δ and the definition of the Pacman strategy which, together with equation (10), implies that $S(\mathbf{n}) > S(\mathbf{n}_2) \geq V^*(\mathbf{n}_2)$. The second inequality follows from equation (11).

It remains to show that charging v_2 in period 1 and playing Pacman thereafter is in turn superior to charging any lower price in the first period and then playing Pacman. That is, $V(v_2, \mathbf{n}) > V(v_l, \mathbf{n})$.

Since the induction hypothesis implies that it is optimal to use the Pacman strategy once the buyers with the highest reservation price have been eliminated, $V^*(\mathbf{n}_2) \geq V(v_l, \mathbf{n}_2)$ for all $l \geq 3$. Hence, equations (8) and (9) imply that $V(v_2, \mathbf{n}) > V(v_l, \mathbf{n})$ for all $l > 2$.

Since $V(v_1, \mathbf{n}) > V(v_2, \mathbf{n}) > V(v_l, \mathbf{n})$ for $l > 2$, Pacman is a sequential best reply to get-it-while-you-can. Q.E.D.

COROLLARY 1. The use of the Pacman strategy by the monopolist and the get-it-while-you-can strategy by each buyer constitutes a subgame-perfect equilibrium of the market game for all discount factors satisfying the inequality in equation (11).

The intuition underlying theorem 1 is similar to the intuition underlying our introductory example. Indeed, equation (12) generalizes equation (1). In this generalization, $n_1(v_1 - v_2)$ is the marginal cost incurred by the monopolist when the price is prematurely lowered to v_2. Δ is a lower bound on this cost that is independent of the discount factor.

$(1-\beta)V^*(\mathbf{n}_2)$ is the monopolist's marginal gain from dropping the price to v_2. It represents the additional interest obtained by advancing the receipt of the payments from all inframarginal buyers by one period. Since $V^*(\mathbf{n}_2)$ is bounded above by the available surplus, the additional interest approaches zero as the discount factor approaches one.

From the definition of the Pacman strategy, we obtain the following equation for the present value of the monopolist's profits in the subgame-perfect equilibrium referred to in corollary 1.

$$V^*(\mathbf{n}) = \sum_{l=1}^{L} \beta^{l-1} n_l v_l. \tag{13}$$

A comparison of equations (10) and (13) indicates that as $\beta \to 1$, $V^*(\mathbf{n}) \to S(\mathbf{n})$. The present value of the monopolist's profits approaches the surplus achievable by a perfectly discriminating monopolist as the discount factor approaches one.

4. Concluding Remarks

We have shown that for an arbitrarily large, finite collection of buyers and an infinite horizon, there exist subgame-perfect equilibria in which a durable-goods monopolist extracts virtually all the consumer surplus for discount factors near one. This refutes the Coase conjecture. Moreover, precommitting to a time path of prices or, alternatively, renting the durable instead of selling strictly reduces the monopolist's profits. These results differ strikingly from the case of a continuum of non-atomic buyers considered by all of the previous literature. There, the monopolist loses virtually all monopoly power in *every* subgame-perfect equilibrium as the discount factor approaches one; moreover, he can *always* increase his profits by renting (optimally) or precommitting to a price path.

Other subgame-perfect equilibria exist in our model with more conventional characteristics. One might question therefore whether the equilibrium we study (as well as other equilibria with similar characteristics) are somehow mere artifacts—either of the assumption that the horizon is infinite or of the subgame-perfect solution concept.

It is straightforward to show that—for some sets of reservation prices—Pacman and get-it-while-you-can form a subgame-perfect equilibrium even when the horizon is finite. The example in the introduction can serve as an illustration. Assume that $v_1 \geq 2v_2$. In this case, lemma 2 (which also holds for finite-horizon games) and the analysis in the introduction confirm that the Pacman strategy is a sequential best reply to get-it-while-you-can for *any* discount factor between zero and one provided that *two or more* periods remain in a finite-horizon game. It is trivial to verify that Pacman is a sequential best reply in the final period. Since get-it-while-you-can is also a sequential best reply to Pacman for each buyer from any stage onward, the strategy combination we have studied forms a subgame-perfect equilibrium in this example for any finite horizon (and any discount factor).

For discount factors near one, the monopolist in this finite horizon example extracts nearly all the surplus—contradicting Coase's conjecture and the standard results about the superiority of renting or precommitment to a price path derived for the continuum case. Hence, introducing a finite horizon will not rescue these results.

Nor will refinements of the subgame-perfect equilibrium concept. In this example, one can show by working backward from the end of the horizon that the payoff of the monopolist is unique in every subgame-perfect equilibrium. Hence, whatever refinement of subgame perfection is used to select a different equilibrium in this finite horizon example would inevitably select another which *also violates* the standard results derived for the continuum case.

We conclude, therefore, that equilibrium behavior when the the collection of buyers is finite may differ markedly from the corresponding behavior when there is a continuum of non-atomic buyers. There is no disputing the fact that—both in the "naturally occurring world" and in laboratory settings—the set of buyers is finite. The artifice of assuming a continuum of non-atomic buyers may nonetheless be a useful approximation if it facilitates analysis *without* distorting results. It is for this reason that the approximation has proved so valuable in *other* contexts. However, it is plainly misleading in the analysis of durable-goods monopoly.

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Footnotes

1. Bulow (1982) observes that capacity constraints can raise the monopolist's profits by allowing an explicit commitment to higher prices. Kahn (1986) observes the same result for rising marginal costs, where the need for intertemporal production smoothing permits an implicit commitment to higher prices. However, for a finite number of buyers and discount factors near one, our analysis demonstrates that the ability to commit to a price path is not needed to achieve almost perfect market power.

It is generally assumed that the limit as the discount factor approaches one, or, equivalently, as the discount rate approaches zero, is the appropriate representation of patient buyers and sellers.

2. Our results do not depend on the assumption that the horizon is unbounded. A finite-horizon example is discussed in the concluding section.

3. Our results do not depend on the assumption that the monopolist knows the reservation price of each buyer. Bagnoli, Salant, and Swierzbinski (1988) demonstrates that for discount factors near one, the Pacman and get-it-while-you-can strategies introduced in this paper constitute a sequential equilibrium in a game where the monopolist knows the initial aggregate distribution of reservation prices, observes aggregate purchases in each period, but *cannot* identify the reservation prices of individual buyers.

4. The assumption that the reservation price of each buyer is common knowledge is used to simplify the analysis but is inessential. See footnote 3 and Bagnoli, Salant, and Swierzbinski (1988) .

5. The zero-profit form of the Coase conjecture, where the monopolist prices at marginal cost, assumes that the lowest reservation price is equal to the monopolist's marginal cost. In the context of our model, this occurs when $v_L = 0$. More generally, the Coase conjecture predicts that the monopolist sets the price at (or arbitrarily

close to) the lowest reservation price. See Gul, Sonnenschein, and Wilson (1986) for further discussion.

6. Any strategy combination which forms a subgame-perfect equilibrium when players are restricted to pure strategies will remain a subgame perfect equilibrium if players are allowed to play behavioral (mixed) strategies. To see this, suppose the contrary. Then there must be some subgame where this combination of pure strategies no longer forms a Nash equilibrium. For that to be true, some player must be able to strictly improve his payoff by unilaterally switching to a behavioral strategy in that subgame while the other players continue to play their pure strategies. But for this deviation to be strictly profitable there must be some pure strategy over which the mixing occurs that yields a higher payoff to the deviant than his initial pure strategy. If such a strategy did exist, however, he could have played it 100 percent of the time previously (a pure and hence admissible strategy) and thereby strictly increased his payoff. But this contradicts the assumption that the orignal strategy combination was subgame perfect in pure strategies.

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