Multilateral Vertical Contracting: Opportunism, Nondiscrimination, and Exclusivity

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Abstract

This paper considers an input monopolist selling to competing downstream firms, each of whom is therefore concerned with the terms offered to its rivals. Extant literature on such multilateral contracting has largely assumed public commitment: the monopolist commits at the outset, publicly, to the terms it will offer to all. Such commitment is problematic, however. A firm might not observe secret price cuts offered to a competitor; even if firms observe all contracts, efficient commitment would entail writing and enforcing complete, state-contingent contracts. Given such difficulties, we analyze the monopolist's problem if it contracts bilaterally, without commitment regarding other contracts.

Absent commitment, each firm rationally fears "third-party" opportunism: once the firm makes certain investments (pays a franchise fee, purchases inputs), the monopolist wants to renegotiate a rival's contract in order to increase bilateral profit at the expense of the first firm. We allow the monopolist to charge two-part tariffs, which ordinarily help allign the monopolist's incentives with those of downstream firms, and show that in a variety of environments firms' fear of opportunistic recontracting backfires on the monopolist. Surprisingly, nondiscrimination clauses—making a firm eligible to exchange its previous contract for any contract later offered to a rival—can be ineffective in curbing opportunism. To reassure firms, the monopolist therefore may adopt crude forms of commitment, despite their attendant inefficiencies. This may explain the pervasive use of exclusive territory arrangements, even independent of standard free rider effects, and the striking degree of uniformity of franchise contracts and their rigidity over time.

"Once he has made a deal, Mr. Lorenzo can't sleep on it. He wants to renegotiate."
David Shapiro, court-appointed examiner in Eastern Airlines bankruptcy. Washington Post, April 22, 1990.

This paper studies the contracting problem of an input supplier who deals with several firms that are actual or potential competitors in the sale of outputs. Examples of this relationship include a manufacturer selling to distributors, a patent holder licensing several producers, and a franchisor with several franchisees. To focus on the vertical contracting aspect, we abstract from supplier competition by considering an input monopolist. Since the monopolist's customers compete with one another, their input demands will be interdependent: each firm is concerned with the terms that the monopolist offers to all.

With a few recent exceptions discussed below, the literature addressing such a setup assumes "public commitment." The monopolist publicly makes committed offers to all, hence each firm can predict rivals' marginal costs before accepting its contract. (See, e.g. Frank Mathewson and Ralph Winter, 1984, and Martin Perry and Robert Porter, 1990. Further references can be found in Jean Tirole, 1988, and Michael Katz, 1989.) The commitment assumption is significant, because once a firm undertakes certain investments—buying the monopolist's inputs, paying a franchise fee, investing in product promotion, or acquiring other relation-specific assets—the monopolist's incentives typically are altered. As the initial firm is somewhat locked in, the monopolist could gain by recontracting with another firm, for instance, by reducing the latter's input price in exchange for a higher fixed fee. Such opportunistic recontracting generally reduces overall profit, and anticipation of it can backfire on the monopolist.

There is abundant evidence of businessmen's concern with opportunism. Allegations have included attempts to force out existing franchisees or dealers from profitable locations through various means, and encroachment on incumbents' market area by the addition of independent outlets or outlets owned by the

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franchisor or manufacturer itself (Gillian Hadfield, 1990; Wall Street Journal, 1991). In two of the oldest distribution systems—automobiles and gasoline retailing—federal statutes govern termination and non-renewal of dealers; a myriad of similar state legislation covering these and other industries has been passed since the 1970s (ABA, 1990; Hadfield, 1990). In automobiles, since 1963 thirty seven states have also adopted "relevant market area laws" restricting encroachment by the manufacturer into areas served existing dealers (ABA, 1990). While some characterize these initiatives as special interest legislation, various commentators and the Supreme Court have seen them partly as attempts to protect franchisees against perceived abuses of bargaining power (ABA, 1990).[1] The absence of comparable legislation in business format franchising (e.g. as in fast foods) is probably due to its being a relatively young industry, dating only to the 1960s; with franchise disputes showing no sign of abating, pressure has mounted to extend legislation to this industry. Iowa has recently enacted a law that would restrict termination and encroachment in all franchise relationships, and several states are contemplating following suit (Wall Street Journal, 1992).

Opportunism of course is a concern also in bilateral relationships, as stressed by Benjamin Klein et al. (1976), Oliver Williamson (1985) and others. When the supplier sells to *competing* firms the problems of guarding contractually against opportunism are compounded, as opportunism can take the additional form of changing the terms offered to a firm's rivals. Committing efficiently to prospective customers about one's dealings with third parties can be particularly problematic.

A problem unique to multilateral contracting is that the monopolist's contracts can be unobservable even to insiders: with secret discounts, a firm simply may not know the true prices charged to its rivals. (And inferring the prices ex post from rivals' market behavior also can be difficult if there are exogenous shocks that are firm specific, since a firm must then disentangle whether a rival expanded because it got a discount or experienced a productivity gain.)

When insiders *can* observe all that is relevant—hence their information is symmetric—the problem

[1]Even reputable companies are not immune. For example, in 1987 General Motors launched a plan to designate some 2000 independent repair shops nationwide as Delco-Tech Service Centers stocking GM parts, in an attempt to capture some of the business in service and minor repairs that was being lost to independents (such as Jiffy Lube). GM suspended the program in 1990 under stiff opposition from its dealers, who complained vociferously that the proposed program would divert even more repair business away from them, after they had invested heavily in repair facilities (Automotive News, 1990).

remains that *efficient commitment* would require writing and enforcing complete state-contingent contracts. In practice contracts are highly incomplete, due to the sheer difficulty of anticipating all contingencies and spelling out appropriate performance in each case and the inability of outsiders (courts) to verify either performance or the state of nature (Perry, 1989; Hadfield, 1990; ABA, 1991). These difficulties with attaining efficient commitment can be worse in multilateral contracting than in bilateral, for several reasons. First, the universe of items that must be specified and verified increases with the number of parties.

Second, courts may be able to verify compliance with the terms of a given contract but unable to value different terms; this presents a problem if the efficient contract for providing a given "bottom line" price varies across firms. When contracts are multidimensional (specifying delivery, promotion allowances, etc.), different contracts can result in the same implicit price. The monopolist may wish to assure one firm that it will sell to a second firm at a particular price but preserve the flexibility of tailoring the details of the second contract to best fit the second firm's attributes (e.g. whether the second firm is relatively proficient at providing its own delivery), attributes which may be unknown at the time the monopolist is contracting with the first firm. However, a court might have difficulty valuing individual dimensions and therefore inferring the implicit price in a given contract; for instance, the court might observe whether the product was delivered and at what price, but not know the value to the firm of delivery services. Assuring the first firm then requires specifying the second firm's contract prematurely, at the time of initial contracting. That courts have serious difficulty evaluating different contracts is vividly illustrated by the U.S. experience with the law against price discrimination, the Robinson-Patman Act, which has spawned voluminous litigation over whether a given price cut represents a selective discount or is "cost-justified" because the buyer undertakes some functions otherwise performed by the supplier (ABA, 1980; Marius Schwartz, 1986).

Since contracts are incomplete, parties in a bilateral relation will often renegotiate terms as new information emerges, in order to move towards ex post efficiency. In a multilateral setting, of course, recontracting that is bilaterally profitable can be harmful to others.[2] Those other parties cannot be protected

[2]Various authors have noted the advantages in a bilateral setting of committing to a default option (the status quo) and readjusting terms whenever this is mutually beneficial. Steven Shavell (1984) analyzes damages for breach and renegotiation as substitutes to complete contracts. Milton Harris and Bengt Holmstrom (1987) study the optimal frequency of recontracting. Both papers employ models where readjustment of terms has no impact on initial decisions. Oliver Hart and John Moore (1988) consider a

if they cannot observe such bilateral recontracting. Where firms eventually can observe all the monopolist's contracts, however, the challenge is to preserve flexibility for legitimate recontracting while providing assurance to third parties. Giving each firm veto power over the monopolist's ability to change any other contract would create serious hold up problems; it may also raise antitrust issues (Philip Zeidman, 1991). A less drastic option is to let a firm "back out" of its contract if it disapproves of any new contract offered by the monopolist to another. This option too is problematic. A firm could threaten to back out simply as blackmail; perhaps more importantly, the firm may be locked in by other investments in relationship specific assets, limiting its ability profitably to back out.

Nondiscrimination or "most-favored-customer" clauses have been suggested as mechanisms for assuring customers against selective price cuts while retaining some flexibility to cope with changing conditions. Nondiscrimination clauses are not feasible if courts cannot observe parties' performance (e.g. as in Sanford Grossman and Hart, 1986). However, nondiscrimination clauses potentially do serve a role if the reason that contracts are incomplete—hence efficient price commitments are precluded—is that courts can verify performance but not the state of nature (was price reduced because the monopolist's cost fell or for other reasons?) or that courts cannot value multidimensional contracts (hence making a price commitment would entail specifying the details of a contract inefficiently at the outset, as explained earlier). A major goal of our paper is to study the effectiveness of nondiscrimination clauses in preventing opportunism.

The above discussion explains why making price commitments in a multilateral relation can be impossible or costly. In this paper we explore the consequences for the monopolist of dealing with competing firms and not committing to any one regarding terms offered to others. Our unifying theme is that fear of opportunism harms the monopolist in variety of settings, hence the monopolist may accept some

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model in which ex post division of surplus affects ex ante investment decisions and show that adjusting terms once parties learn the state can help reconcile the goals of inducing efficient trade ex post and securing correct investment ex ante. Gur Huberman and Charles Kahn (1988) show that the ability to renegotiate can allow parties to achieve superior outcomes in a sequential game, by including in initial contracts terms that would be inefficient if adhered to but will be renegotiated; such terms serve the strategic purpose of tilting the division of surplus in the (foreseen) renegotiation in a way that induces the correct initial action by the party whose action is not contractable (because it is not verifiable). There is also a literature showing how foreseen renegotiation can be disadvantageous because it hinders commitment (e.g. Hart and Tirole, 1988; Drew Fudenberg and Tirole, 1990). Our interest here is not in the net impact of renegotiation in a bilateral setting but in how bilateral renegotiation affects third parties. In the formal model we consider renegotiation designed solely to exploit third parties.

distortions arising from inefficient commitment in order to reassure firms.

We assume throughout that the monopolist can share in downstream rent via a two-part tariff—a constant marginal price and a fixed fee. The two-part tariff is important because it is one of the most basic pricing schemes, and has been emphasized in the vertical control literature as a powerful instrument for alligning incentives in a bilateral relation (e.g. by alleviating double-marginalization and downstream moral hazard problems). In order to unify the exposition we therefore focus on two-part tariffs, but will indicate how results change with more general pricing schemes. [3]

The paper is organized as follows. Section I presents the model, defines the commitment-solution benchmark, and shows why this joint-maximizing (commitment) arrangement generally is susceptible to opportunism. This is shown in a simple perfect-information game, so as to make the argument transparent and defer the delicate issue of firms' beliefs about rivals' contracts.

In Section II we ask if nondiscrimination clauses would prevent the monopolist's opportunism. In the Coase-conjecture literature, the durable-good monopolist eliminates his incentive to offer future price cuts (the expectation of which would drive all prices toward the competitive level) if it commits to make past customers retroactively eligible for any future discounts (David Butz, 1990; see also Ronald Coase, 1972 and Tirole, 1988). Thomas Cooper and Timothy Fries (1991) consider a monopolist bargaining sequentially with two noncompeting buyers, and show that adopting a nondiscrimination policy can stiffen the monopolist's resistance to demands of price cuts by the second buyer. Patrick DeGraba and Andrew Postlewaite (1987), like us, study an input monopolist selling to *competing* buyers and still find that when the monopolist charges only fixed fees, nondiscrimination clauses prevent opportunism.

We interpret "nondiscrimination" clauses as allowing the monopolist to offer different contracts but entitling each firm to exchange its previously-accepted contract for any other offered to a rival (as discussed later, U.S. case law is mixed on this point, but tilted towards permitting such "nondiscrimination"). We

[3] In practice, simple affine pricing schemes are common. Lafontaine (1992) surveyed franchisors in different industries and finds that of the 127 respondents, 122 charge an up-front franchise fee and 123 charge a royalty rate; of the 123, 93 state that the royalty rate is constant (20 state that it is piecewise linear, 18 increasing and 2 decreasing). In such franchise contracts, the royalty rate is typically a percentage of revenue ("sales") rather than based on quantity. However, since the royalty acts as a revenue tax, raising the royalty rate has qualitatively similar effects to raising the marginal price in a two-part tariff: both will decrease a firm's optimal output.

show that for two-part tariffs (or more complicated contracts), nondiscrimination clauses to competing firms can be ineffective. This is perhaps our most novel finding. The intuition is that once one firm has accepted a lower marginal price in exchange for a higher fixed fee, it need not be profitable for another firm to follow suit; the second firm may well prefer to stay with the higher input price and lower fee even if the deviation contract is made available to it ex post ("nondiscrimination"). Nondiscrimination clauses therefore can have little bite—even when firms are ex ante identical.

Section III takes up the opportunism problem in a more natural way than the perfect information game of Section I. In that model, the last firm receiving an offer is not concerned about itself being exposed to opportunism. Arguably, every firm should fear that once it accepts a contract, the monopolist might recontract with rivals. We model this by assuming that contracts are offered simultaneously and secretly, so that each firm is ignorant of others' offers when it makes its acceptance decision. A firm either never learns others' acceptances, hence costs (Unobservability Game), or learns them after accepting its contract but before competing downstream (Ex Post Observability Game). The former is designed to capture cases where price commitments are impossible because of secret discounts; the latter, cases where firms do observe each others' contracts but verifiability problems (and other contracting costs) preclude complete contracts, and committing to uncontingent fixed-price contracts would be inefficient.

In both games contract offers are secret, hence firms' beliefs are crucial. There will be many equilibria, since the offer that a firm receives could affect its beliefs about offers made to others. We consider two sets of beliefs: Symmetry Beliefs (each firm believes all receive same contract as it does) and Passive Beliefs (each firm does not revise its beliefs about other offers based on what it receives). Under Symmetry Beliefs (and symmetric firms), the outcome in either game is the same as under commitment.

Under Passive Beliefs, opportunism surfaces. With Unobservability, the monopolist charges all firms price equal to marginal cost, and its profit thus can be driven to zero. This marginal-cost-pricing result is independent of whether downstream competition features strategic complements or strategic substitutes (reaction function slopes are positive or negative, respectively). With Ex Post Observability, the monopolist still cannot attain the commitment solution but the precise outcome depends on the nature of downstream competition. The more interesting results are for strategic substitutes, which we illustrate by

considering homogeneous-products Cournot competition. In standard environments (e.g. two downstream firms and linear demand), there exists no pure-strategy equilibrium.

Section IV presents a different approach to firms' beliefs. Symmetry Beliefs and Passive Beliefs, considered in Section III, can be rationalized if firms interpret unexpected offers as trembles ("mistakes") by the monopolist: perfectly correlated and uncorrelated, respectively. A firm instead might plausibly view any offer as a conscious decision by the monopolist and expect the monopolist to offer to others what is best for the monopolist given that the firm accepts its offer. We present a set of beliefs, Wary Beliefs, that capture this notion. Symmetry Beliefs, that always support the optimum, are not Wary Beliefs in either game. For Unobservability, Wary Beliefs yield the same outcome as Passive Beliefs: marginal cost pricing by the monopolist. For Ex Post Observability, the analysis is considerably more complicated. We provide a Cournot example (in which there is no equilibrium under Passive Beliefs) and show that an equilibrium exists and displays the opportunism property: the monopolist's price is below the commitment level.

The common feature of these models is that lack of commitment injures the monopolist. Therefore, a monopolist may offer inefficient contracts, e.g. ones that do not allow the flexibility to adjust to changing conditions, in order to prevent it from recontracting opportunistically with others. Section V discusses some practices that can serve this purpose. Short of vertical integration, one possibility is to deal with only one firm. While this too entails some commitment, it is typically easier to determine if a new competitor (beyond some minimal threshold) has been brought in than to monitor and verify to a court the precise terms offered to rivals. Our analysis thus suggests an explanation for exclusive territorial franchises or exclusive dealing even in the absence of the usual free-rider problems associated with provision of "public" services or assets (Lester Telser, 1960; Howard Marvel, 1982). Indeed, committing to deal with a single firm might be profitable despite an efficiency loss. If the efficiency loss from dealing with a single firm is too high (e.g. due to sharply increasing costs) or if such an arrangement is infeasible (e.g. due to customer mobility), the monopolist would deal with several firms. In such cases we expect contract terms to be transparent and quite uniform across firms, to reduce the scope for selective discounts. This could help explain the remarkable and seemingly inefficient degree of uniformity observed in franchise contracts across franchisees and the rigidity of contract terms over time (LaFontaine, 1991, 1992; Shumeet Banerji and Carol Simon, 1992).

Before proceeding two points should be noted. First, for modelling convenience we do not explicitly introduce the factors that preclude complete contracting, although these factors are very real and motivate our inquiry. The second point concerns related work. The issue of a monopolist contracting with competing buyers without commitment was long overlooked in the industrial-organization literature. Quite recently, the opportunism problem has been noted by several other authors (all independently to our knowledge). DeGraba and Postlewaite (1987) consider identical buyers each demanding at most one unit of the monopolist's input (e.g. a machine), and show that input price is driven to marginal cost if the monopolist cannot commit to restricting the number of buyers to whom it will sell. Hart and Tirole (1990) are only tangentially concerned with opportunism. (Their main interest is in foreclosure possibilities when potentially there are competing parties at both levels). However, in a setup similar to our Unobservability Game with Passive Beliefs—under what amounts to Cournot duopoly downstream and assuming one unit of input is required per unit output—their Proposition 1 implies that a monopolist free to use any pricing scheme earns only the same profit as if it charged all firms a two-part tariff with the marginal price equal to its marginal cost. Daniel O'Brien and Greg Shaffer (forthcoming) obtain this result in the same environment for the more difficult case in which firms order their inputs only after learning their sales (and downstream competition is differentiated-products Bertrand). We discuss all three contributions further as appropriate.[4]

I. Commitment Benchmark and Opportunism Incentive

Consider an input monopolist facing $n \geq 2$ potential downstream firms that can use the input to produce substitute products (perfect or imperfect). The monopolist has no fixed cost and has constant marginal cost $z > 0$. A two-part tariff offered to firm i is a pair (r_i, f_i) where f_i is a fixed fee and r_i is the marginal price

[4]These authors, like us, abstract from issues of risk sharing. Mathias Dewatripont and Khalid Sekkat (1991) present a model in which demand is uncertain, an incumbent retailer can invest in cost reduction, and once demand uncertainty is resolved the manufacturer can threaten the retailer with replacement by or competition from a new retailer, and the two can renegotiate their initial contract in view of the threat. They show that such threats can serve a useful insurance function by making the retailer's payment vary with the state of demand. In their model, the usual problem of assuring efficient investment is solved by assuming that in the renegotiation stage the retailer captures the entire surplus associated with its investment (and that the retailer's investment is specific to it rather than the product—such as product advertising—else the investment would affect the manufacturer's threat point). In general, there will be a tradeoff between insurance and efficient investment.

per unit of the input. A firm's marginal cost increases with r, and a sufficiently high r would make marginal cost prohibitive. Suppose also that the monopolist can make take-it-or-leave-it offers.

Our benchmark, commitment solution is the (subgame-perfect) equilibrium to the following *Commitment Game:*

Stage 1 (offers): The monopolist publicly announces a set of offers, one for each firm: $\{r_i, f_i\}$, $i = 1, \ldots, n$.

Stage 2 (acceptances): Firms accept or reject offers simultaneously. Accepting means paying the fixed fee.

Stage 3 (learning): Accepted contracts announced. Firms learn others' marginal costs.

Stage 4 (competition): Firms simultaneously

(i) set their downstream instruments, prices or outputs; and

(ii) purchase the necessary amounts of the monopolist's input.

Begin with stage 4. We assume throughout the paper that for any vector of input prices $r = (r_1, \ldots, r_n)$, accepted in stage 2 and learned in stage 3, there is a unique noncooperative equilibrium to the downstream competition in stage 4, with firm i's indirect equilibrium-profit function denoted $\pi_i(r)$. (Idle firms are allowed in this formulation; an idle firm is offered $f = 0$, $r = \infty$.) Equilibrium-profit functions are assumed to display the normal properties: an active firm's gross profit decreases in its own input price and decreases in the input price of a rival: $\partial\pi_i(r)/\partial r_i < 0$, $\partial\pi_i(r)/\partial r_k > 0$, $k \neq i$. A firm's input demand function, which incorporates the downstream competition whether in prices or outputs, is denoted $q_i(r)$.

In Stage 2 of the game, if $f_i \leq \pi_i(r)$ then it is a (weakly) dominant strategy for firm i to accept its contract, since if rivals' reject theirs then firm i can only benefit. To simplify notation we assume throughout that a firm accepts whenever $f_i = \pi_i(r) \geq 0$. In Stage 1 the monopolist therefore sets $f_i = \pi_i(r)$; hence its objective in the Commitment Game is to choose r so as to maximize overall profit

$$(1) \qquad G(r) = \sum_{i=1}^{n} (r_i - z)\, q_i(r) + \sum_{i=1}^{n} \pi_i(r).$$

Let G^* denote the maximum profit, r^* any maximizing vector, and V the monopolist's profit. Thus, in the Commitment Game $V = G^*$. Intuitively, since firms know rivals' proposed costs before accepting their own contracts, the monopolist designs its offers so as to maximize overall profit. (G^* need not equal the

integrated profit, e.g. it will not if downstream production entails variable proportions. However, G^* will serve as our benchmark against which to compare solutions with no commitment.) In particular, it internalizes the effect of varying input price to one firm on a second firm's profit, since the latter determines the maximum fixed fee that can be collected from the second firm.

To see clearly the opportunism incentive, consider an alternative *Sequential Game* in which the monopolist does not commit at the outset to all contracts. In Stage 1 (offers), the monopolist approaches firms 1,...,n sequentially. Each firm accepts or rejects its offer having observed all prior offers and decisions. Once all firms have chosen, downstream competition occurs.[5] It will prove useful to define the term u_i, the monopolist's net revenue from input sales plus the profit of firm i,

$$(2) \qquad u_i(\mathbf{r}) = \sum_{j=1}^{n} (r_j - z)q_j(\mathbf{r}) + \pi_i(\mathbf{r}) = G(\mathbf{r}) - \sum_{k \neq i} \pi_k(\mathbf{r}).$$

Observe that u_i only depends on the marginal prices $\mathbf{r}$ and not on the fixed fees.

PROPOSITION 1: *If attaining G^* in the Commitment Game requires more than one firm to be active, then in the Sequential Game the monopolist's profit, V, is less than G^*.*

Proofs of all propositions can be found in the Appendix. The intuition underlying Proposition 1, however, is straightforward. Having collected fixed fees from all but the last mover the monopolist sets the last price to maximize joint profit with the last mover. The monopolist thus ignores the reduction in others' profits that results from cutting price to the last firm, an effect internalized when computing $\mathbf{r}^*$. This externality will be present whenever firms earn quasi-rents in equilibrium; thus, under quite general assumptions about the downstream competition, the monopolist has an incentive to cut price to the last firm in exchange for a higher fixed fee. Since input prices differ from their optimum values, overall profit also will be lower. Anticipating this, prior movers do not pay the same fixed fees as under Commitment,

[5]This game is chosen primarily for simplicity. However, the failure to commit initially to all prices can be reconciled with the implicit assumption of complete information. As noted in the Introduction, when contracts are multidimensional, committing to a "price" requires specifying in advance all contract dimensions. The monopolist and all firms may have a good idea of the "total" implicit prices that later movers will be offered, but the monopolist learns the optimal mix of attributes to offer a given firm only once it meets that firm. If courts cannot value such attributes, committing to a total price would require specifying inefficiently at the outset all the details of these multidimensional contracts.

thereby reducing the monopolist's profit below G^*.

The following example illustrates the various effects (derivations available on request). Suppose the monopolist faces two downstream firms that would compete Cournot with inverse demand $p(Q) = 1 - Q$. Firm i's cost is quadratic in output and increasing in the input price: $C(q) = q^2 + rq$. A firm's Cournot output is $q(r, s) = (3 + s - 4r)/15$, where r denotes own input price and s the rival's. The Commitment solution is to charge both firms $r^* = (1 + 5z)/6$, yielding total output $Q = (1 - z)/3$. In the Sequential Game the monopolist charges the first firm $r_1 = (3 + 11z)/14$ and the second $r_2 = z$, implying $q_1 = (1 - z)/7$, $q_2 = 3(1 - z)/14$, $Q = 5(1 - z)/14$. Thus: $r_2 < r^* < r_1$, $q_2 > q^* > q_1$. Therefore $V < G^*$, since with identical and increasing marginal costs as here, attaining G^* requires both firms to produce equal outputs.[6]

II. Nondiscrimination Clauses

As noted in the introduction, an important drawback of commitment stems from the loss of flexibility to cope with exogenous changes, given that complete state-contingent contracts are infeasible. For example, the monopolist may wish to preserve the option of reducing price in the future if its marginal cost falls but cannot guarantee contractually that price will be lowered only in such circumstances because courts cannot verify the reason for a price decrease. Given such imperfect verifiability, is there a mechanism that would assure early buyers that flexibility will be used only to make efficient changes and not for opportunistic recontracting with future buyers?

Natural candidates are nondiscrimination clauses (or most-favored-customer clauses), entitling each firm to replace the contract it initially accepts with any other contract later accepted by a rival. (Such nondiscrimination might be offered voluntarily by the monopolist or required by law. We discuss the U.S. legal status of nondiscrimination below.) Nondiscrimination clauses are informationally feasible if courts

[6]David Bizer and Peter DeMarzo (1992) obtain similar effects in a different context. They consider a borrower approaching several banks sequentially and show that the borrower would be better off if it could commit to borrow only from one bank. With sequential borrowing, later banks charge rates that do not incorporate the externality on prior loans caused by the increased probability of default due to increased borrowing (even with prioritized debt, increased indebtedness creates moral hazard by reducing the borrower's effort). Thus, there is more debt than under commitment, and the interest rate is correspondingly higher to reflect the greater default probability.

can observe whether a firm has been offered a certain contract—even though courts might be unable to evaluate different contracts or verify the state of nature (thereby ruling out efficient price commitments).

Consider the following *Nondiscrimination Game.* Initial contracting is the same as in the Sequential Game. But before downstream competition occurs, there now is a new recontracting stage. All contracts accepted in Stage 1 become part of the new menu, and the monopolist approaches all firms that have accepted contracts, sequentially and in reverse order, letting each firm exchange its previously-accepted contract for any new one. Once recontracting is completed, downstream competition occurs as in the Sequential Game.

The following notion will prove useful both here and in Section III.

DEFINITION: A set of contracts $\{r_k, f_k\}$, $k = 1,...,n$ is *Pairwise Proof* for the monopolist and firm i if holding all other contracts fixed, the joint profit of the monopolist and firm i cannot be increased by changing their contract: $u_i(r_i, r_{-i}) \geq u_i(r_i', r_{-i})$ for any r_i', where the first entry always denotes the own input price and r_{-i} denotes the vector of input prices charged to firms other than i. In addition, we include in the definition of pairwise proofness the individual rationality conditions: $u_i(r) \geq f_i$, $i = 1,...,n$.

It is not obvious that pairwise proofness should be a relevant property in the Nondiscrimination Game, since offering a new contract to one firm gives all the right to change theirs. However, the result below shows otherwise. We make the following assumptions.

ASSUMPTION 1: Firms are symmetric: $\pi_i(r_i, r_{-i}) = \pi(r_i, r_{-i})$, $i = 1,...,n$.

ASSUMPTION 2: In the Commitment Game, attaining G^* requires all firms to be active and to face the same input price.

ASSUMPTION 3: $\partial^2\pi_j/\partial r_k \partial r_j < 0$ for all active firms i, k, $i \neq k$.

Some remarks on these assumptions are in order. It would not be surprising if nondiscrimination clauses had limited effectiveness when firms are asymmetric; with asymmetries, it is well known that a common menu of contracts can be used to induce agents to self select. The symmetry assumption therefore focuses

attention on the more interesting case. Given symmetric profit functions, Assumption 2 also is fairly natural when the downstream industry is not a natural monopoly, e.g. because firms have increasing costs or produce (symmetrically) differentiated products. (Proposition 2 below holds if attaining G^* requires at least *two* active firms facing the same price; we impose the stronger Assumption 2 to simplify the proof.)

Assumption 3 says that a decrease in a firm's marginal cost is less valuable to it the lower is a rival's marginal cost. This property is satisfied in many standard models. Roughly speaking, a lower marginal cost to a rival makes the rival more aggressive in any equilibrium (produces a higher output or charges a lower price); the initial firm's residual demand thus will be lower, hence the value to it of having lower marginal cost also can be expected to be lower, as it plans to produce a lower output.[7] Given these three assumptions, we can establish the following result.

PROPOSITION 2: *Consider a symmetric equilibrium to the Nondiscrimination Game in which all firms are active and receive price r_o. Then r_o must be pairwise proof, and therefore the monopolist's equilibrium profit , V, is less than G^*.*

The intuition for this result is as follows. Suppose r_0 is not pairwise-proof, for concreteness, suppose the joint profit of the monopolist and any one firm can be increased by reducing price to that firm alone. Firm n is the last mover in Stage 1. If all prior movers have accepted r_o, the monopolist can offer to firm n the lower price along with a fixed fee sufficiently higher that firm n is just willing to accept the deviation, provided nobody else accepts it in the recontracting stage. Given $\partial^2\pi_i/\partial r_j\partial r_i < 0$, if firm n finds the deviation from (r_o, f_o) just profitable, then other firms $k < n$ will prefer to stay with their original contracts; although they are harmed by the price cut to firm n, their losses from switching would be greater still.[8]

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[7]We cannot be definitive, because demand might be such that (i) a reduction in the firm's own cost would lead to a larger contraction in the rival's planned output when a rival's cost is low than when high, and (ii) this strategic effect might be sufficiently stronger to outweigh the fact that the direct benefit from a cost reduction is smaller when a rival's cost is low (because the firm plans to produce less). The property must therefore be verified for the model at hand. It holds, for example, if firms have constant marginal costs additive in r (as under fixed-proportions production) and compete Cournot in homogeneous products with inverse demand $p = a - bQ$, $p = a - b\ln Q$, or $p = a + b/Q$ (Jennifer Reinganum, 1983). For the same costs, it also holds if firms compete Bertrand with differentiated products and a linear demand system.

[8]If firms had the option of backing out of their contracts altogether (receiving back the fixed fees), the monopolist would be deterred from offering the deviation. As noted in the introduction, however, there are

Anticipating this, firm n indeed accepts the deviation. Thus, a symmetric equilibrium contract (r_O, f_O) must be pairwise proof. With two or more firms active (as required to attain G*, by assumption) pairwise proofness of a vector r implies that r does not attain G*. This is simply the flip side of the logic used in Proposition 1 to argue that the Commitment solution is not pairwise-proof with respect to the last mover.[9]

Proposition 2 contrasts with the findings of DeGraba and Postlewaite (1987), who show that a commitment not to discriminate restores the monopolist's optimum when the monopolist charges only fixed fees.[10] There is a basic difference between using nondiscrimination clauses for two-part tariffs and using

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problems (not modelled explicitly) with this resolution: on the one hand, firms may be locked in by other relation specific investments (plant, promotion expenses); on the other hand, with unrestricted "back out" firms might extort the monopolist whenever it wished to change other contracts even for legitimate reasons.

[9]With an additional, natural assumption on firms' beliefs, pairwise-proofness must also hold in a symmetric equilibrium to an alternative game in which recontracting is *simultaneous*: after initial sequential contract choices, all firms choose simultaneously (rather than sequentially) from the new menu. Suppose that the menu inherited from Stage 1 consists of two contracts, the proposed symmetric-equilibrium contract and a deviation contract, and that in any equilibrium to the recontracting subgame only one firm chooses the deviation. There will be indeterminacy about which firm *ends up* with the deviation contract, and this indeterminacy in turn may deter a firm in Stage 1 from accepting a deviation. Assume, however, that firms hold No-Bumping Beliefs: if firm j accepts a contract (r_1, f_1) in stage 1 and others accept (r_O, f_O) and if in the equilibrium to the ensuing recontracting subgame any firm selects (r_1, f_1), then all believe that firm j will. (This assumption does not say that other firms will necessarily stay at (r_O, f_O). It simply rules out a situation where only one firm can profitably accept (r_1, f_1), and firm i switches to this contract believing that simultaneously firm j is switching away from it.) Given such beliefs, firm n (last mover) will accept a bilaterally-profitable deviation in stage 1, hence any proposed symmetric equilibrium to the overall game again must be pairwise proof and therefore $V < G^*$.

In this alternative game with simultaneous recontracting, the result that $V < G^*$ can be proved under a weaker assumption than 2 above. We need only assume that in the Commitment Game at least two active firms are needed to attain G*, possibly with $r_i \neq r_j$. If different contracts are accepted in equilibrium, then a firm receiving a lower price (and paying a higher fee) earns greater profit than a higher-price one, and therefore earns positive profit, implying that the monopolist earns $V < G \leq G^*$. To see this, consider two firms, 1 and 2, that in equilibrium accept $r_1 < r_2$, $f_1 > f_2$, and for simplicity suppress the input prices of other firms. Then equilibrium requires $\pi(r_1, r_2) - f_1 \geq \pi(r_2, r_2) - f_2 > \pi(r_2, r_1) - f_2 \geq 0$, where the first inequality follows since firm 1 could switch to 2's contract in the simultaneous recontracting stage without disturbing any other choices, the second follows since a firm's profit increases with the rival's cost (and $r_2 > r_1$ by hypothesis), and the third by individual rationality of firm 2. Intuitively, if a lower-price firm switched to the contract of a higher-price firm, it would have the same costs as the latter but would face a higher-cost rival than the high-price firm faces in the hypothesized equilibrium. Since the high-price firm's equilibrium profit is nonnegative, any lower-price firm's profit must be strictly positive.

[10]DeGraba and Postlewaite consider an input monopolist facing potential buyers each of whom would require one unit of the input. By assumption, downstream industry profit would be maximized with a single firm, hence if the monopolist could commit itself it would sell only one unit of the input at a price equal to the downstream monopoly profit (denote it R). However, in the unique subgame-perfect equilibrium to the game the monopolist sells the input at price equal to marginal cost and brings in a correspondingly large number of firms. Introducing nondiscrimination clauses would enable the monopolist to collect R from a rational buyer, because to sell a second unit the monopolist would have to cut price (since per-firm profit falls with the number of downstream firms) but the price cut would then be demanded also by the first buyer rendering such a cut unprofitable.

them for either linear prices or only fixed fees. Typically, a linear price or fixed fee that is preferred by one firm is unequivocally preferred by all; generally, the lower the better. Nondiscrimination clauses thus ensure that any price cut to later customers will be demanded by all previous customers, and this cools the monopolist's urge to offer selective future price cuts. This is generally not true of two-part tariffs, or of any contract that entails a fixed-fee component (e.g. agreeing to buy a minimum level of inputs at a certain price). How much a firm is willing to pay for a decrease in its marginal cost generally increases in the marginal costs of rivals. Consequently, nondiscrimination clauses may have no bite—because only one firm will accept a deviation contract that offers a low marginal cost, provided the average cost is sufficiently high; other firms would elect not to exercise the option of exchanging their contracts for this new contract.

Note that we interpret nondiscrimination as allowing the seller to offer several contracts, as long as the same menu is offered to all. If the law against price discrimination meant instead that a seller simply could not charge different marginal prices to competing buyers (regardless of offsetting terms) and if such a law were vigorously enforced, then the entire issue of private commitment against opportunism would be moot. At least in the U.S., however, this has not been the case.[11]

The legal status in the U.S. of "nondiscrimination" is ambiguous (see ABA, 1980 and 1991, on which the ensuing discussion draws). The Robinson-Patman Act—the chief federal statute governing price discrimination—contains two sections, 2(d) and 2(e), that allow a seller of "commodities" (services are not covered by the Act) to selectively pay for or directly provide to a buyer promotional services related to the resale of the commodities, provided the concessions were *made available* to all buyers on "proportionally equal terms." Section 2(a) of the Act, pertaining to price concessions related to the initial sale of the goods, does not contain such an availability defense and an important 1960 Supreme Court decision (*FTC v. Anheuser Busch, Inc.*) described price discrimination as "merely a difference in price." Since then, however, the courts and the enforcement agencies (primarily the Federal Trade Commission) have generally been willing to consider the availability defense, especially in secondary line cases as in our context (cases involving injury to competing buyers).

[11] As argued below, nondiscrimination has not been interpreted so rigidly. Moreover, the law applies to commodities of "like grade and quality" and to sales that are reasonably contemporaneous, caveats that could permit sellers to disguise some discriminatory price cuts from outsiders.

Interestingly, courts are aware that a menu of contracts can be designed to induce self selection when buyers are heterogeneous; thus, a quantity discount schedule was struck down by the Supreme Court in a 1948 landmark case (*FTC v. Morton Salt Co.*) on the grounds that only the large chain buyers could qualify for the top discounts. Correspondingly, courts have conditioned the availability defense on the offer being "functionally" (i.e. practically) available to all. In practice this test seems directed at preventing sellers from stringing conditions contrived to exploit inherent asymmetries among customers. Price discounts have been upheld when tied to "reasonable" conditions, e.g. to stocking inventory or purchasing minimum quantities.

Enforcement agencies have been increasingly sympathetic to a "practical availability" defense. In 1977 the U.S Department of Justice proposed amending the Robinson-Patman Act to explicitly incorporate such a defense. More recently, the Canadian Bureau of Competition (1991) issued draft enforcement guidelines stressing the role of practical availability as a defense. Going beyond the scope of this paper, our analysis suggests that the meaning of "practical availability" and "nondiscrimination" in input markets is rather subtle. Even with symmetric buyers, offering the same menu of contracts to all can entail discrimination—in that a second firm may rationally choose to reject an offer once a competitor has accepted.

III. Secret Offers

A. Unobservability and Ex Post Observability

The Sequential Game in Section I illustrates the opportunism incentive, but is somewhat artificial. Firms take as given the monopolist's contracts with earlier movers, and fear only its dealings with later movers; for example, the last mover has nothing to fear. More plausibly, all firms will be leery that the monopolist might recontract with their rivals. The Sequential Game therefore is likely to understate the harm to the monopolist from fears of opportunistic recontracting. For example, since the last mover is not concerned about any opportunism, in the Sequential Game the monopolist can—by offering prohibitive prices to all earlier movers—guarantee itself the maximum profit attainable conditional on having only one active firm downstream. This profit can be close to the commitment profit G^*, or even equal to it if there is natural monopoly downstream (i.e. if one firm suffices to attain G^* in the Commitment Game).

Alternatively, the Sequential Game might overstate the harm to the monopolist from fears of recontracting. If at least two active firms are needed to attain G^* under commitment, then in the Sequential Game the monopolist earns less than G^* (Proposition 1), since firms rationally fear that the last mover will accept a deviation. However, in an alternative game in which the last mover also is concerned that once it accepts a contract the monopolist will go back and recontract with others, the last mover might reject any deviation from the commitment solution. Such fears could support the commitment solution as an equilibrium, thereby allowing the monopolist to earn G^* even absent commitment.

To shed light on these issues, we consider other representations of contracting without commitment. The key feature of the Commitment Game is that, when accepting its contract, a firm is confident about rivals' future costs. This occurs because offers are public and the monopolist does not move again once initial offers are accepted. Under no commitment, rather than modelling recontracting explicitly, we incorporate the key idea that all firms are uncertain about rivals' future costs by assuming that offers are made simultaneously and *secretly*.

We consider two simple games. The *Ex Post Observability Game* is identical to the Commitment Game, except that in Stage 1 offers are secret (each firm knows only the offer it has received). Thus, firms learn rivals' contracts after paying their fixed fees but before they compete downstream. The *Unobservability Game* also has secret offers, but firms never observe others' contracts (stage 3 of the Commitment Game, learning, is absent). The strategies are as follows. In both games, the monopolist simply makes a set of n offers, one to each firm. A given firm chooses: (i) to accept or reject knowing only the offer it receives; and (ii) its input order and the level of its downstream variable (price or output) knowing its own costs under Unobservability, and all costs under Ex Post Observability.

These games are intended to capture different reasons discussed in the introduction for why commitment may be difficult. Unobservability reflects the possibility that, due to secret discounts, it is difficult for firms ever to learn others' costs. (In pure-strategy equilibrium, however, each firm holds correct beliefs about others' costs, and downstream competition is the unique outcome for these beliefs.) Ex Post Observability reflects the possibility that, even if firms can observe others' contracts, it can be costly for the monopolist to sign efficient contracts that are conditional on the terms to be offered to others, due to costs of specifying all

relevant contingencies and problems of third-party verification (of the state, or of the values of different contracts). To retain flexibility, the monopolist therefore tells each firm only what its terms will be and preserves the option of recontracting with others. Thus initial offers, even if they were public, would convey little assurance about what rivals' costs will be ultimately. We represent this by assuming that contracts are secret when the firm has to sign but become known before downstream competition occurs.[12]

Throughout, we look only for *pure-strategy, Perfect Bayesian-Nash equilibria.* In both games there are many such equilibria, because each firm must accept or reject the monopolist's offer without knowing the offers made to rivals. There is considerable latitude in how a firm might revise its beliefs about offers made to others when it receives an off-equilibrium offer and this latitude can support many outcomes as equilibria. To focus on beliefs, we continue to assume (as in the Nondiscrimination Game) symmetric firms, and that under commitment G^* can be attained in a symmetric equilibrium with all firms facing the same price r^*.

We study each game, Unobservability and Ex Post Observability, under three sets of beliefs: Symmetry, Passive, and Wary. As noted in the introduction, Symmetry Beliefs and Passive Beliefs can be rationalized if firms interpret unexpected offers from the monopolist as mistakes, or trembles (perfectly correlated and uncorrelated, respectively). A firm expects a given equilibrium offer, and if it receives a different offer it concludes that the deviation is a tremble to it alone (Passive Beliefs) or to all firms (Symmetry Beliefs). Narrowing the set of Perfect-Bayesian equilibria then proceeds by postulating a candidate equilibrium and asking if, given the assumed beliefs, the monopolist would profitably deviate from that equilibrium. These

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[12]Taken literally, this game suppresses an obvious solution to the opportunism problem: to contract with each firm regarding the prices its rivals will face, and collect the fixed fees ex post only if the observed input prices conform with what was promised. Making the promises efficiently contingent on all relevant variables (both the state, and rivals' prices), however, amounts to complete contracts. We have already noted the difficulties with complete contracts, although we do not incorporate the sources of these difficulties explicitly into the model. An alternative to complete contracts is to adopt short-term contracts, whereby a firm pays a (small) fixed fee for the right to buy the input during the given period, and recontract when new information emerges. This is similar to Coase's (1972) suggestion that the durable-good monopolist can reduce its gain from opportunism by renting rather than selling.

There are difficulties with this approach in our context. For example, if the input is storable a firm could buy large quantities and "stock up" while paying only the one-period fee. If the input is intangible, such as know-how in a franchising or licensing arrangement, the monopolist may rationally fear that its customer will terminate the relation having obtained the know-how. Therefore, a substantial fixed fee may be required up front. And having collected such fees, the monopolist could change prices to rivals when the (short-term) contracts expire. In practice, substantial up-front fixed fees are used in franchise contracts while ongoing fixed fees (those independent of franchisee revenues) are rare. Lafontaine (1992) finds that only 4 out of 125 franchisors in her survey use ongoing fixed fees.

beliefs are studied in the next two subsections. Wary Beliefs have a different flavor; firms interpret any offer as a deliberate choice by the monopolist. Wary Beliefs are examined in Section IV. In order to help keep track of the six cases under secret offers, we present in Table 1 an overview of the various outcomes.

--INSERT TABLE 1 ABOUT HERE--

B. Symmetry Beliefs

Under *Symmetry Beliefs* each firm believes that all others receive the same offer as it. When offered a price r_o, a firm therefore is willing to pay a fixed fee of at most $\pi(r_o)$ where r_o is an n-tuple of r_o's.

REMARK 1: *Given Symmetry Beliefs, the equilibrium outcome to both the Unobservability Game and Ex Post Observability Game is V = G*.*

This is easily seen. Given such beliefs, under Unobservability the monopolist maximizes

$$V(r) = \sum_{i=1}^{n} (r_i - z)q(r_i, ..., r_i) + \pi(r_i, ..., r_i).$$

Under Ex Post Observability, input demands q are based on rivals' observed prices rivals, r_{-i}. The monopolist therefore maximizes

$$V(r) = \sum_{i=1}^{n} (r_i - z)q(r_i, r_{-i}) + \pi(r_i, ..., r_i).$$

Since a solution of the Commitment Game is, by assumption, symmetric, by offering $r = r^*$ to all firms the monopolist achieves $V(r^*) = G^*$ also under Unobservability and Ex Post Observability.

Intuitively, with Symmetry Beliefs (and identical firms), the highest fixed fee the monopolist can extract from a firm equals 1/n of the profit that the industry would earn if all firms accepted the same price offered to that firm. The monopolist thus has no incentive to offer a price below r^*, because a firm receiving such an offer would believe that all others also did and hence would not be willing to pay as high a fixed fee as it would if it thought the discount was offered to it alone (as the last mover knows in the Sequential Game).

Symmetry Beliefs illustrate that the optimum might be attainable even without commitment. However,

Table 1. Outcomes Under Secret Offers

Rivals' Acceptances Observable?	*Beliefs About Rivals' Offers (rationale)*		
	Symmetry (correlated trembles)	Passive (uncorrelated trembles)	Wary (deliberate choice)
Unobservable	No opportunism ($V = G^*$)	Opportunism ($V < G^*$): monopolist charges all price equals marginal cost	Opportunism ($V < G^*$): monopolist charges all price equals marginal cost
Ex Post Observable	No opportunism ($V = G^*$)	Opportunism ($V < G^*$): frequent nonexistence of equilibrium with Cournot downstream	Opportunism ($V < G^*$): existence of equilibrium with Cournot downstream

such beliefs are not very compelling: if a firm accepts a given contract, the monopolist's preferred contract with another firm generally will differ from the first firm's contract. One rationale for Symmetry Beliefs is that firms interpret any offer that is different from what was expected as a tremble by the monopolist and believe the monopolist's trembles to be perfectly correlated (e.g. because the monopolist has miscalculated r^* or because z changed). A natural alternative assumption based on the idea of trembles is Passive Beliefs.

C. *Passive Beliefs*

Under *Passive Beliefs*, when a firm receives an offer different from what it expects in the candidate equilibrium, it does not change its beliefs about the offers made to others. Here each firm interprets an unexpected deviation by the monopolist as a tremble and assume that trembles are uncorrelated (e.g. because the monopolist appoints different agents to deal with different firms). Passive beliefs have been invoked, explicitly or implicitly, by other authors dealing with a single-principal-and-multiple-agents framework, such as Jacques Cremer and Michael Riordan (1987), Henrick Horn and Asher Wolinsky (1988), Hart and Tirole (1990), and O'Brien and Shaffer (1991).[13]

Given Passive Beliefs, if an equilibrium exists (under Unobservability or Ex Post Observability) it must be pairwise-proof with respect to each of the n firms: $u_i(r_i, r_{-i}) \geq u_i(r_i', r_{-i})$ for any r_i', $i = 1,...,n$. That is, taking all other contracts as given, the monopolist and any downstream firm cannot profitably deviate (at the offers stage) from their equilibrium contract.[14] Arguably, pairwise-proofness is a property that one

[13]Cremer and Riordan (1987) do not discuss beliefs explicitly, but define a contract equilibrium as a set of contracts between the single supplier and its (noncompeting) customers such that holding all other contracts fixed, there is no incentive for the supplier and any customer to change their contract (thus, a contract equilibrium is pairwise proof in our terminology). O'Brien and Shaffer (forthcoming) adopt the same contract equilibrium concept (but customers compete). Horn and Wolinsky (1988) also do not discuss beliefs explicitly. They consider a supplier selling to duopolists that compete after learning all costs (as in our Ex Post Observability Game), with each input price determined by Nash bargaining bilaterally assuming the other price is fixed ("simultaneous bargaining") and recognizing how input prices affect downstream competition. In all these approaches (as in McAfee and Schwartz, 1990), the equilibrium must be immune to bilateral deviations, but deviations that the monopolist can offer to two or more firms are not considered. Hart and Tirole (1990) invoke Passive Beliefs explicitly (Appendix 2, "market by market bargaining"), in a game with an information structure similar to our Unobservability Game.

[14]A remark on notation: in the Ex Post Observability Game, $u_i(r_i', r_{-i})$ is evaluated assuming that all firms observe the input prices (r_i', r_{-i}) before making downstream choices. In the Unobservability Game, $u_i(r_i', r_{-i})$ is evaluated assuming that firm i continues to believe that others accept their candidate

might expect of an equilibrium. It captures the intuitive idea that, when commitment is absent, equilibrium contracts should be immune to the simplest and most natural deviations: bilateral recontracting.[15] We show, however, that under Ex Post Observability pairwise proofness is an overly strong requirement.[16]

Passive Beliefs: Unobservability

PROPOSITION 3: *Given Passive Beliefs, in the Unobservability Game the equilibrium outcome is for the monopolist to charge all firms price equal to its marginal cost:* $r_i = z$, $i = 1,....n$. *All firms are active and the monopolist earns* $V = n\pi(z)$.

The underlying intuition is simple. Since firms' decisions (input purchases or choice of downstream price or output) are unaffected by the unobserved changes in input prices to rivals, in its dealings with any firm the monopolist acts as if the two are integrated and face a given residual downstream demand. Pairwise maximization then involves setting input price equal to the monopolist's marginal cost. Note that this result is quite general—it does not hinge on the nature of downstream production (fixed versus variable proportions) or of downstream competition (strategic substitutes or strategic complements). Moreover, as Hart and Tirole (1990) show in a restricted environment, the "pairwise maximization" logic implies that the same downstream outcome would emerge even if the monopolist could employ more general contracts than two-part tariffs (the instruments would no longer be the marginal prices, but the targets would be set at the

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equilibrium offers r_{-i} (by Passive Beliefs); firms $j \neq i$, that do not observe the deviation offer to firm i, continue believing (r_i, r_{-i}). With this slight abuse of notation, we use the same expression to describe the pairwise-proof conditions in both games.

[15]Given Passive Beliefs, this pairwise-proof property would also hold if, instead of the monopolist setting the contract, fixed fees were determined by efficient bargaining between the monopolist and downstream firms. (The input price to any firm would still be chosen to maximize the combined profit of that firm and the monopolist.)

[16]In both Cremer and Riordan's setup, where customers' demands are independent, and in our Unobservability Game, the monopolist cannot benefit firm i by harming firm j. With competing firms and Ex Post Observability, the contract with firm i can be manipulated to increase bilateral profit through affecting firm j's downstream choices.

same levels hence profits would be the same).[17]

Observe that the monopolist's profit with Unobservability will be less than the commitment level G*, since input prices above marginal cost would be required to attain G*—in order to counteract the negative competitive externality present whenever there are two or more firms downstream. Indeed, with Unobservability the monopolist's profit can be driven to zero. Since it prices inputs at (constant) marginal cost, the monopolist's profit accrues entirely from the fixed fees that collect downstream profits. Given sufficient competition downstream (e.g. many homogeneous-product Cournot firms or two Bertrand firms offering close substitutes), downstream profit will be small and with it the monopolist's profit.[18]

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[17]Note that the "pairwise maximization" logic relies on the assumption that firms order their inputs before learning their sales (production to inventory rather than to order). If firms order inputs only after learning their sales (this makes sense only if the downstream competition is in prices), giving a secret discount might backfire on the monopolist. When given a lower input price, a firm cuts its output price; this reduces demand for others' outputs, hence reduces their input orders from the monopolist. Therefore, the price-equals-marginal-cost result will not hold generally when inputs are purchased after sales.

McAfee and Schwartz (1990, Proposition 2) consider such timing and show that if each downstream firm uses a unit of the monopolist's input per unit output, and competition is Bertrand with imperfect substitutes satisfying $\partial D_i/\partial p_i + \Sigma_{k\neq i}\, \partial D_k/\partial p_i < 0$ for all firms, then in symmetric equilibrium the monopolist still charges $r_i = z$ to all. (The equilibrium must be symmetric, and thus have input prices equal to marginal cost, for example in the case of two firms even if their demands are not symmetric.) O'Brien and Shaffer (forthcoming) establish this result under the same assumptions about timing and downstream production technologies, but more general assumptions about demands and pricing schemes. They consider Bertrand competition downstream with differentiated-products (possibly asymmetric) and allow the monopolist to charge general fee schedules as a function of a firm's realized level of sales. (This is similar to inputs being purchased after sales, since granting a discount to one firm will affect the monopolist's revenue from another.) They show that in "contract equilibrium" (equivalent to imposing our Passive Beliefs) the marginal charges to all firms are equal to the monopolist's marginal cost.

[18]Thus, under Unobservability and Passive Beliefs, the monopolist's profit with two-part tariffs can easily be less than it would earn if firms knew that it was constrained somehow (e.g., due to input arbitrage) to charge only marginal prices ($f = 0$). In the latter, firms would correctly anticipate that the monopolist would set prices above marginal cost to rivals and would base their input purchases on this. The monopolist's profit would therefore always be strictly positive. The ability to charge two-part tariffs therefore can harm the monopolist under Unobservability and Passive Beliefs. In the Commitment Game, where offers are public, the ability to charge two-part tariffs cannot be disadvantageous.

Note that even if fixed fees are precluded (e.g. due to input arbitrage), the monopolist's profit under Unobservability and Passive Beliefs would still be less than the profit it could earn in the Commitment Game conditional on no fixed fees. For instance, under Commitment and no fixed fees the monopolist can come arbitrarily close to G* if there is strong competition downstream (many Cournot firms, say), because the distortion from double marginalization is then small hence the monopolist's optimum is to set a price well above marginal cost. With Unobservability and Passive Beliefs, however, firms will recognize the monopolist's incentive to cut input prices below this level, since such cuts would not lead others to reduce their input purchases. Recognition of this reduces a firm's input demand at any given price that exceeds the monopolist's marginal cost. Therefore, under Unobservability and Passive Beliefs the monopolist would suffer from expectations of opportunism even if fixed fees were not feasible.

Passive Beliefs: Ex Post Observability

Turn now to the game in which each firm does learn others' costs after it signs its own contract but before the downstream competition. In contrast to the Unobservability Game, the nature of downstream competition (whether downstream choice variables are strategic substitutes or strategic complements) will now matter. The input price offered to any firm i, if accepted, becomes a parameter that affects the subsequent downstream competition. By manipulating r_i appropriately, the monopolist can now change downstream choices of other firms to benefit firm i (by inducing softer behavior by others) and collect through a higher fixed fee the expected increase in firm i's profit. Such incentives to undertake an observable prior action in order to influence subsequent competition are familiar from the oligopoly literature. (For a complete discussion of strategic substitutes and complements, and incentives in two-stage games see Tirole (1988, 323-328), or Carl Shapiro (1989, 389-397).) The wrinkle here, which proves significant, is that the monopolist is selling to all the competing parties downstream.

To see how the monopolist's incentives differ under Ex Post Observability, suppose n = 2 and consider as a candidate equilibrium $r = z$. Then the change in the joint profit of the monopolist and firm i from a small change in r_i comes entirely from the strategic effect that this observed change has on the choice of firm k:

$$(3) \qquad \left.\frac{\partial u_i}{\partial r_i}\right|_{r=z} = \left(\frac{\partial \pi_i}{\partial x_k}\right) R_k'(x_i^e)\left(\frac{\partial x_i^e}{\partial r_i}\right)$$

where x_i^e is firm i's equilibrium choice (of its downstream variable, price or output) given $r = z$, and R_k is firm k's "reaction function." Thus, the first term on the right denotes the effect on firm i's profit of firm k's downstream choice, the second denotes the change in k's choice with respect to the (expected) change in i's equilibrium choice, and the third the change in i's choice, which is expected by firm k given the observed change in firm i's input price. For price competition with differentiated products, the typical pattern is

$$\frac{\partial \pi_i}{\partial x_k} > 0, \quad R_k' > 0, \quad \frac{\partial x_i^e}{\partial r_i} > 0, \quad \text{hence} \quad \left.\frac{\partial u_i}{\partial r_i}\right|_{r=z} > 0.$$

For quantity competition with homogeneous products, the typical pattern is

$$\frac{\partial \pi_j}{\partial x_k} < 0, \quad R_k' < 0, \quad \frac{\partial x_j^e}{\partial r_i} < 0, \text{ hence } \left.\frac{\partial u_j}{\partial r_i}\right|_{r=z} < 0.$$

Therefore, with price competition the monopolist's incentive is to increase price above marginal cost, and with quantity competition to lower it.[19]

Following this logic, Passive Beliefs and price competition imply that in symmetric equilibrium $r^e > z$. However, r^e will still differ from the joint-maximizing level r^* (typically $r^e < r^*$). This occurs because, as shown in equation (2), when contracting secretly with a firm and maximizing pairwise profit, the monopolist ignores the direct profit reduction to rivals from cutting price to the immediate firm (even under Ex Post Observability, it cares only about rivals' response to that firm's change in cost, not about the reduction in their profits per se). Thus, provided an equilibrium exists, the monopolist's profit will be less than G^* when downstream there is differentiated-products price competition.[20]

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[19]For example, with Cournot competition, $\partial u_i(z)/\partial r_i = q_i p'(Q) \partial Q_{-i}/\partial r_i$, where Q_{-i} denotes the Cournot-equilibrium output of all firms other than i. Thus, $\partial Q_{-i}/\partial r_i$ is typically positive: rivals reduce outputs in response to an observed reduction in a firm's marginal cost, as they anticipate expansion by that firm. The first order increase in firm i's profit equals the resulting increase in downstream price multiplied by firm i's output. Thus, $\partial u_i(z)/\partial r_i < 0$.

More generally, the monopolist's incentive hinges on whether demand and cost parameters make downstream choice variables strategic substitutes ($R_k' < 0$) or strategic complements ($R_k' > 0$) not whether x is quantity or price. To see this, assume as in the text that the downstream equilibrium is stable, so that "normal" comparative statics hold when shifting a reaction function: $\partial x_i^e/\partial r_i < 0$ if x is quantity and > 0 if x is price. Observe that $\partial \pi_j/\partial x_k < 0$ if x is quantity and > 0 if x is price. Therefore, $R_k' < 0$ implies $\partial u_j/\partial r_i < 0$ and $R_k' > 0$ implies $\partial u_j/\partial r_i > 0$. (That is, if x is price instead of quantity, both $\partial x_i^e/\partial r_i$ and $\partial \pi_j/\partial x_k$ change signs, hence the key is the sign of R_k'.)

[20]Bertrand competition with constant costs and *homogeneous* products is a special case: in any downstream equilibrium with two or more firms active (including the Commitment solution G^*), all firms must receive the same input price and earn zero profit. Cutting price to one firm therefore does not reduce profits to others and, as shown in equation (2), it is this "externality term" (now zero) that creates the incentive to cut price to any firm starting from the optimum r^*. In this perfect-substitutes Bertrand case, under Passive Beliefs there are multiple equilibria to both the Unobservability and Ex Post Observability Games, with the monopolist's profit V ranging from 0 to G^* (here $G^* = \pi^m(z)$, the downstream monopoly profit for cost z).

Under Ex Post Observability, $V = G^*$ is attained e.g. by offering to all but one firm $r = \infty$, $f = 0$ and to the designated firm $r = z$, $f = \pi^m(z)$. The monopolist gains nothing by bringing in another firm, since doing so requires offering it $r = z$, $f = 0$. Alternatively, G^* can be attained by offering to two or more firms $r = p^m(z)$, $f = 0$ (where p^m is the downstream monopoly price for input cost z). There are also equilibria (still under Passive Beliefs) with $V < G^*$. Suppose downstream inverse demand is such that the revenue function p(Q)Q is concave. Then it is an equilibrium for two or more firms to accept any $r' \in [z, p^m(z)]$, $f = 0$; and for $r' < p^m(z)$ the monopolist collects less than $\pi^m(z)$.

There are multiple equilibria also in the Unobservability Game. One is the equilibrium identified in Proposition 3, $r_i = z$, $f_i = \pi_i(z)$, $i = 1,....,n$ (here $\pi_i(z) = 0$). But it is also a equilibrium to offer to one firm $r = z$, $f = \pi^m(z)$ and to all others $r = \infty$, $f = 0$. (Expecting these contracts, an idle firm would reject any deviation contract that has $r \geq z$, $f > 0$.)

The outcome under quantity competition warrants closer scrutiny. Now the incentive is to set $r < z$. Other authors have noted similar incentives for oligopolist manufacturers to signal toughness when output market competition is Cournot. For instance, John Vickers (1985) shows that manufacturers that collect franchise fees from exclusive dealers would set wholesale prices below the marginal cost of manufacturing, in order to reduce sales of the rivals' dealers. Chaim Fershtman and Kenneth Judd (1987) suggest that firms' owners might write observable contracts that reward managers partly as a function of market share, thereby signalling that they will compete more aggressively. In those models, the oligopolists are generally made worse off by all committing to toughness (but might still do so because of a prisoner's-dilemma payoff structure). However, an equilibrium typically exists. The situation is different here.

Suppose downstream competition is Cournot with homogeneous-products, and the n identical firms have cost functions $C_i(q_i) = rq_i$. Thus, firms have constant marginal costs equal to the monopolist's input price. Aggregate output is denoted $Q = \Sigma q_i$ and inverse demand $p(Q)$ is such that industry marginal revenue is decreasing in output: for all Q, $2p'(Q) + Qp''(Q) < 0$. Proposition 4 below characterizes how far below the monopolist's marginal cost (z) input prices must be in order to be pairwise proof. The monopolist would never offer negative input prices, since if it did a firm would demand an infinite quantity of the input and the monopolist would lose money for any fixed fee; we therefore assume that z is "sufficiently high" that the pairwise-proof input prices characterized below are nonnegative (though below z).

PROPOSITION 4: *For z sufficiently high, in the Ex Post Observability Game with Passive Beliefs, all firms are active in equilibrium and produce equal outputs Q/n satisfying*

$$p(Q) - z = \frac{Q}{n}\left[p'(Q)(n-2) + p''(Q)\frac{n-1}{n}Q\right].$$

This implies that output price would be below integrated cost, $p(Q) < z$, if

(i) $n \geq 2$ *and* $p''(Q) < 0$, *or*

(ii) $n \geq 3$ *and* $p'(Q) + Qp''(Q) < 0$, *or*

(iii) $n \geq 4$.

In each case, the monopolist's profit would be negative, so there exists no pure strategy equilibrium.

The argument is as follows. Under Passive Beliefs, equilibrium prices must be pairwise proof. Given $2p'(Q) + p''(Q)Q < 0$, pairwise proofness implies that in equilibrium all firms must get equal input prices hence produce equal outputs, and that the monopolist would cut price to any idle firm until it became active. The condition $2p'(Q) + p''(Q)Q < 0$ also implies that starting from a symmetric equilibrium $\partial q_k/\partial r_i > 0$ and $\partial Q/\partial r_i < 0$. Thus, equilibrium price must be below the monopolist's marginal cost: starting at $r = z$, by equation (3), cutting price to any firm would be bilaterally profitable due to the strategic effect of shifting profit towards that firm by inducing contraction of rivals (since $\partial q_k/\partial r_i > 0$); starting at $r > z$, cutting price to any firm would increase the monopolist's profit both due to this strategic effect and from increased input sales (since $\partial Q/\partial r_i < 0$).

Given that all face $r < z$, consider reducing r_i. There are three effects on the combined profit of the monopolist and firm i: (i) the loss to the "integrated structure" from expanding sales once input price is below cost; (ii) the increase in firm i's revenue due to the contraction of rivals' outputs; and (iii) the resulting contraction of rivals' input purchases, which benefits the monopolist given that $r < z$. Depending on the number of downstream firms and the shape of final demand, this crucial third effect can be strong enough to induce the monopolist to cut r_i even if *output* price p is below combined costs. Conversely, once $p < z$, raising price to any one firm can increase the monopolist's losses due to increased input purchases by the other firms, whose contracts are held fixed when testing for the profitability of a *bilateral* deviation. (We discuss multilateral deviations shortly.)

Proposition 4 implies nonexistence of equilibrium in "normal" environments, for example, Cournot duopoly with (strictly) concave inverse demand.[21] (In the Unobservability Game, by contrast, Proposition

[21]This nonexistence problem would arise also in the model of Horn and Wolinsky (1988) if bargaining included not only linear prices but also fixed fees. They consider an input monopolist selling to downstream Cournot duopolists and assume that input prices are determined through simultaneous Nash bargaining between the supplier and each duopolist, incorporating how input prices affect the subsequent output-market interaction. They show that the duopolists would be worse off if they merged because doing so would weaken their bargaining power with the supplier sufficiently to offset the gain from monopolizing the output market. Allowing the bargaining to include also fixed fees would mean that the Nash-bargaining price in each transaction must be the one that maximizes the joint surplus of the monopolist and that firm. Thus, equilibrium marginal prices would have to be pairwise proof as in our case (where the monopolist sets the contract), with the associated nonexistence feature.

1 tells us that $r = z$, hence the monopolist's profit remains positive for any number of Cournot firms downstream.) Actually, the nonexistence problem is even worse than suggested by Proposition 4. The above characterization of input prices relies only on pairwise-proofness, that is, only on bilateral deviations. But an equilibrium must also be immune to *multilateral* deviations: offers which the monopolist can profitably make to several downstream firms and which the latter would accept (under Passive Beliefs). Given Ex Post Observability, any contract $(r, 0)$ is acceptable, since a firm pays no fixed fee and orders its inputs only after learning rivals' costs. Therefore, the monopolist's equilibrium profit not only must be nonnegative (to satisfy individual rationality), it also must exceed what the monopolist could earn if charging no fixed fees. To illustrate, with linear demand and $n = 2$, the expression in Proposition 4 implies $r < z$ such that $p = z$, so that an equilibrium is not ruled out. However, by offering $f = 0$ and $r > z$ the monopolist could guarantee itself positive profits, so there is no equilibrium in that case either.

Aside from its intrinsic curiosity, the frequent nonexistence of pure-strategy equilibrium under Passive Beliefs and Cournot competition shows that here too the monopolist generally earns less than G^*, even if a mixed strategy equilibrium exists. Moreover, modifying the Ex Post Observability Game to add nondiscrimination clauses generally would still not enable the monopolist to attain G^*.[22]

Finally, we should say a word about more general contracts than two-part tariffs. As discussed earlier,

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[22]Consider a modified game in which firms learn all contracts and can then recontract simultaneously from the new menu before the downstream competition. A symmetric equilibrium to this modified game must be pairwise proof, for the same reason as in Section II: if it were not, the monopolist could offer a deviation initially that only one firm would find profitable to accept (even though others are eligible to take it in the recontracting stage). Therefore, even with nondiscrimination clauses the monopolist's profit will be less than G^* if two or more firms are needed to attain G^*.

With identical constant costs downstream and Cournot competition (hence G^* attainable with one firm), we show elsewhere (McAfee and Schwartz, 1990, Proposition 4) that with nondiscrimination clauses: a) if z is sufficiently low, the monopolist can indirectly "commit" to $m = 1$ and $V = G^*$, but b) if z is sufficiently high (and inverse demand is concave) then $V < G^*$. Briefly, the reasoning is this. G^* can be achieved if a single firm accepts $r^* = z$ and $f^* = \pi^m(z)$, the monopoly profit for cost z. To induce entry by a second firm, the monopolist would need to offer $f < f^*$. We show that any deviation contract that features $r \geq z$, $f = \pi(r, z) < f^*$ cannot be profitably offered because it would be taken also by the initial firm (in the recontracting stage). So would a contract with r slightly below z. Thus, if z is sufficiently low, then any deviation that will be taken only by the second firm requires $r < 0$, which cannot be profitable to the monopolist (a firm would order an infinite quantity of the input). Therefore, the monopolist cannot profitably add a second firm, and foreseeing this, the first firm would initially accept the efficient contract. However, if z is sufficiently high (and $p''(Q) \leq 0$), then there exists a profitable deviation from (z, f^*) which only the second firm would find profitable to accept; recognizing this, the first firm would reject (z, f^*). To attain G^*, the monopolist would therefore need two or more firms active, but then $V < G^*$ (by pairwise proofness).

such contracts make no difference under Unobservability, since each firm still assumes that the monopolist will reach the "integrated solution" with any one of them. Under Ex Post Observability with Cournot competition downstream, more general contracts do help the monopolist; for example, they allow the monopolist to attain the solution that would obtain under Unobservability. To see why, suppose the monopolist calculates the (symmetric) Unobservability solution outputs q_u and offers to all firms a marginal price schedule of r up to q_u and infinite thereafter, with a fixed fee equal to the implied downstream profit if all produce q_u. For r sufficiently low (possibly negative), it is optimal for a firm to remain at q_u for a wide range of outputs by others. By setting r sufficiently low the monopolist thus removes its incentive to induce output contraction of one firm by recontracting with others. Thus, it is an equilibrium for each firm to accept such contracts and produce q_u.[23]

While more general contracts might help the monopolist we conjecture, but have been unable to prove, that they will not allow the monopolist to attain G* under Ex Post Observability. The difficulty is in checking all discontinuous pricing schedules. Using such discontinuous contracts, however, amounts to fixing the downstream outputs. The problem with this is that there will be future changes in downstream conditions that will be observable to the firms but not the input monopolist. Fixing outputs directly or through the nonlinear contracts above therefore can be quite inefficient (Fershtman and Judd, 1987).

IV. Secret Offers: Wary Beliefs

Recall that Symmetry Beliefs and Passive Beliefs are based on the notion that firms view unexpected offers from the monopolist as trembles. This section takes a somewhat different approach to firms' beliefs and equilibrium selection. We view firms as somewhat suspicious, and assume that firms interpret any offer

[23]Let q_O be such that $p(q_u + q_O) = z$; if firm i adheres to q_u and others produce q_O then output price equals integrated cost. Suppose the monopolist offers to firm i, $r_u = p(q_u + q_O) + p'(q_u + q_O)q_u$ for $q_i \leq q_u$ and ∞ for $q_i > q_u$. Then expecting any $Q_{-i} \leq q_O$, firm i chooses q_u. To induce firm i to shrink below q_u, so as to benefit some firm j with which the monopolist is contemplating a deviation, would require expanding industry output beyond $q_u + q_O$ (since firm i and others would contract by less than firm j's expected expansion). But this would yield $p < z$, which cannot be profitable for the monopolist. Thus, any $r \leq r_u$ would support the Unobservability equilibrium outputs q_u.

as a deliberate choice by the monopolist. In particular, each firm believes that other firms received offers which are the monopolist's best responses to the offer the firm was made, even if this offer was unexpected. We call such beliefs Wary Beliefs.

We illustrate these beliefs for the simple case of two symmetric downstream firms. Let $\pi(r, s)$ and $q(r, s)$ denote a firm's profit and input demand, respectively, when the firm gets input price r and the rival gets s. We retain the standard assumptions that parameters and downstream competition are such that

$$\frac{\partial \pi(r, s)}{\partial r} < 0, \quad \frac{\partial q(r, s)}{\partial r} < 0, \quad \frac{\partial \pi(r, s)}{\partial s} > 0, \quad \frac{\partial q(r, s)}{\partial s} > 0.$$

A firm's equilibrium strategy will be summarized by a set A that denotes all contract offers that a firm will accept. This strategy is optimal given the firm's equilibrium belief function R(r) about the price that the monopolist offers the rival if it is offered r.[24] The function R is optimal for the monopolist given the acceptance set A (for any r, not just the equilibrium value). Thus, the equilibrium set A and the equilibrium belief function R are determined jointly.

If offered a contract $(r, f) \in A$ firm i believes that:

a) The monopolist expected it to accept the offer.

b) The monopolist offers firm k the contract $(R(r), F(r))$, that is best for the monopolist given that firm i accepts (r, f), from among all contracts acceptable to firm k.

c) Firm k reasons the same way.

If offered a contract not in A, the firm believes that the monopolist offers to the rival the optimal contract conditional on only the rival being in the market. Without loss of generality we can confine attention to contracts that are acceptable (since instead of a contract that will be rejected, the monopolist could offer $(\infty, 0)$ which is trivially accepted).

Given these beliefs, a firm accepts a contract only from the set $A = \{ (r, f): f \leq \pi(r, R(r)) \}$. Note that this strategy is optimal given beliefs: if the rival is offered R(r) and accepts, then the firm's own profit is $\pi(r, R(r))$ hence a fixed fee higher than this should be rejected.

Consistency of the firm's beliefs with the rival's strategy requires

[24] We consider point beliefs because they are simple, and because we focus on pure strategies.

(4) $$(R(r), F(r)) \in A,$$

otherwise the rival would reject its offer, contradicting the postulated beliefs. Consistency of beliefs with the monopolist's strategy requires

(5) $$(R(r), F(r)) = \arg\max_{(s, g) \in A} V(r, f, s, g)$$

where V denotes the monopolist's profit function. (The function V is different in the Unobservability Game and the Ex Post Observability Game, but we use the same symbol to simplify notation.) Therefore

$$F(r) = \pi(s, R(s))$$

and so

(6) $$R(r) = \arg\max_{s} (r - z)q(r, s') + (s - z)q(s, r') + f + \pi(s, R(s))$$

where:

(7) $s' = R(r), \quad r' = R(s)$ in the Unobservability Game

(8) $s' = s, \quad r' = r$ in the Ex Post Observability Game.

Equation (6) represents the imposition of Wary Beliefs: the monopolist offers a best response R(r) to the other firm, given the observed offer r. The monopolist's equilibrium strategy is to choose from the set A its two profit-maximizing contracts, one for each firm. In a symmetric equilibrium firms get the same contract (r^e, f^e), $f^e = \pi(r^e, r^e)$ with $R(r^e) = r^e$.[25]

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[25] In an asymmetric equilibrium, input prices are t and R(t) with $R(R(t)) = t$; fixed fees are $f = \pi(t, R(t))$, $g = \pi(R(t), R(R(t)))$.

A. *Unobservability*

Substituting (9) into (8) shows that in the Unobservability Game

$$(9) \qquad R(r) = \arg\max_{s} \; [(r - z)q(r, R(r)) + f] + (s - z)q(s, R(s)) + \pi(s, R(s)).$$

Since s is absent from the term in square brackets (the profit obtained from the first firm), R(r) is independent of r. Similarly R(s) is independent of s. Thus, R(r) is the value of s that maximizes an expression of the form $A + [(s - z)q(s, x) + \pi(s, x)]$ where A and x are independent of s. This implies that $R(r) = z$:

PROPOSITION 5: *In the Unobservability Game, the equilibrium outcome under Wary Beliefs is the same as under Passive Beliefs: the monopolist charge all firms price equal to its marginal cost.*

The intuition is that with Unobservability, changing the contract to one firm does not affect how much the monopolist will collect from another. Wary Beliefs then dictate that each firm must expect the monopolist to behave as though integrated with the other firm, and therefore expects marginal-cost pricing to the rival regardless of the offer it receives.

B. *Ex Post Observability*

With Ex Post Observability, the monopolist's preferred contract is not independent across transactions. Granting a lower price to firm i will reduce the input quantity bought firm k, and such a reduction is less harmful to the monopolist the lower is the price to k. Therefore, the monopolist's preferred price to one firm will depend on the price charged to the other, and firms' beliefs should incorporate this. Substituting (8) into (6) gives

$$(10) \qquad R(r) = \arg\max_{s} \; (r - z)q(r, s) + (s - z)q(s, r) + f + \pi(s, R(s)).$$

In contrast to expression (11), now R(r) depends on r, via the effect of r on the rival's input orders. The

analysis of equilibrium is therefore more complicated.

Our main interest is whether the monopolist can attain G^* under Wary Beliefs.[26] Recall from Remark 1 that G^* is attainable (in either game) if firms hold Symmetry Beliefs.

REMARK 2: *Symmetry Beliefs are not Wary Beliefs.*

To see this, note that under Symmetry Beliefs, the monopolist solves

$$\max_{r,s} \; V(r, s) = [(r - z)q(r, s) + (s - z)q(s, r)] + \pi(r, r) + \pi(s, s)$$

and $s = r$ generally is *not* best given r (although it will be when $r = r^*$).

We have worked out a Cournot duopoly example with inverse demand $p(Q) = 1 - Q$ and constant marginal costs r_1 and r_2. For these assumptions, recall that there is no equilibrium to the Ex Post Observability Game under Passive Beliefs (see the discussion of Proposition 4). Under Wary Beliefs, we look for a linear belief function, $R(r) = ar + b$. Tedious derivations (available on request) show that, for $z = 0$, there exists a symmetric equilibrium characterized by

$$a = (5 - \sqrt{13})/2 \approx 0.69$$

$$b = (2a - 1)/[2(a + 1)(a - 4)] \approx 0.035$$

$$r^e = b/(1 - a) \approx 0.116.$$

For $z = 0$, the commitment solution would be $r^* = 0.25$. Thus, $z < r^e < r^*$. This outcome therefore

[26] If fixed fees were not feasible, under Ex Post Observability the monopolist could attain the same profit under Wary Beliefs as in the Commitment Game (with no fixed fees). Under Wary Beliefs

$$R(r) = \arg\max_{s} \; (r - z)q(r, s) + (s - z)q(s, r).$$

Thus, letting subscripts denote partial derivatives,

$$0 = (r - z)q_2(r, R(r)) + q(R(r), r) + (R(r) - z)q_1(R(r), r)$$

or, in a symmetric equilibrium

$$0 = (r - z)(q_1(r, r) + q_2(r, r)) + q(r, r).$$

This is the same as the maximizer of $(r - z)q(r, r)$, and the solution coincides with the optimum.

displays the effects of anticipated opportunism: the monopolist charges a lower marginal price than under commitment and collects less than G^*.

We have been unable to prove or disprove that there is no other (possibly discontinuous) belief schedule R which will support G^* as an equilibrium. However, we saw that a natural candidate for supporting G^*, Symmetry Beliefs, are not Wary Beliefs. Moreover, we can show that the above equilibrium is unique in the class supported by polynomial R(r) functions. Also, provided $\partial Q/\partial r < 0$ (where Q is total input demand), in equilibrium both firms are active for any R function. These findings, though incomplete, lead us to think that if G^* can be supported as an equilibrium under Wary Beliefs, it requires rather unnatural belief functions.

V. Conclusion

We began by illustrating the opportunism problem in a game with sequential contracting. Noting that such a set-up artificially presumes a last mover, we examined the problem when all firms receive simultaneous and secret offers. We considered three different assumptions describing firms' beliefs about others' offers, and distinguished between two cases—Unobservability and Ex Post Observability—according to whether firms never learn others' contracts or do so after accepting their own contracts. The results for these secret-offers cases are summarized in Table 1. Only in the case of symmetric beliefs, where firms believe that the same deviation from equilibrium is offered to all, does the commitment solution arise.

Our analysis differs from the existing literature in three major respects. First, we have shown that nondiscrimination, or most-favored-customer, clauses do not generally yield the commitment solution, even in symmetric environments. Nondiscrimination is obviously of even less help in asymmetric environments.

Second, we identified a nonexistence problem for Passive Beliefs, whereby firms receiving off-equilibrium offers do not change their beliefs about offers made to others. Passive Beliefs would arise, for example, when firms believe that a monopolist's disequilibrium offers arise from independently distributed trembles. The nonexistence of equilibrium (for Cournot competition downstream under Ex Post Observability) under Passive Beliefs calls for a reexamination of the literature that employs such beliefs.

Finally, we introduced a new restriction on beliefs, which we called Wary Beliefs. Wary Beliefs produce

the same outcome as Passive Beliefs in the Unobservability Game, and this outcome seems natural to us for that environment: the monopolist acts with each firm as if it were vertically integrated with that firm alone. This outcome exemplifies the desire of the monopolist to renegotiate with each firm individually, undercutting the commitment solution. We feel that the assumptions underlying Wary Beliefs, that the monopolist is conjectured to offer its best response to other firms, given any observed offer, are also natural. Unfortunately, the analysis of such equilibria in the Ex Post Observability Game appears extremely difficult, and we have only managed to offer an example with Cournot competition. Contrary to the case of Passive Beliefs, under Wary Beliefs an equilibrium exists in our example; and it displays opportunism. Existence, uniqueness and characterization of Wary-Belief equilibria in more general settings provide an interesting research problem for recontracting.

The general thrust of our analysis is that fears of opportunistic recontracting harm the monopolist if it fails to commit. One resolution, also noted by DeGraba and Postlewaite (1987), Hart and Tirole (1990), and O'Brien and Shaffer (forthcoming), is vertical integration.[27] Integration, however, can entail its own inefficiencies; thus, the issue remains of how to assure independent firms against opportunism. We noted in the introduction that commitment to multilateral contracts is costly, because of the difficulties of writing and verifying efficient state-contingent contracts. The prospective losses from opportunism, however, suggest that some commitment will be undertaken despite its attendant inefficiencies, in order to reassure customers against opportunism. We now discuss some vertical practices that may play this role. The most available data is on franchise contracts, from which our evidence below is primarily drawn.[28]

An approach that we find informationally plausible is for the monopolist to deal with only one firm in a

[27]O'Brien and Shaffer also suggest another solution: eliminating downstream margins through maximum resale price maintenance (RPM), thus leaving no downstream profit vulnerable to opportunism. However, when there is moral hazard downstream, it is important to preserve marginal profit incentives. Also, RPM is *per se* illegal in the U.S.

[28]Hadfield (1990) reports U.S. Department of Commerce estimates that in 1987 franchise sales accounted for $591 billion, or about one third of all retail sales in the U.S. The Department distinguishes between "Traditional Franchising" or product franchising, involving franchised dealers as in automobile and gasoline retailing, and "Business Format Franchising," as in fast foods. The latter accounted for about 32% (or $191 billion) of all franchise sales. Lafontaine (1991) notes that franchisors in traditional franchising derive their revenue primarily from input mark-ups that are unobservable to outsiders, while the Business Format Franchising exhibit royalties and franchise fees for which data is more readily available (e.g. from disclosure statements). Consequently, most empirical work has concentrated on Business Format Franchising.

given market. True, a commitment is required, and the widespread litigation alleging violations of territorial franchise arrangements suggests this commitment problem is nontrivial. Nevertheless, it is easier for a firm to convince a court that the monopolist has brought in a significant new downstream competitor than to delve into the details of whether and why a price cut was offered to an existing competitor.[29] Our analysis therefore may explain the use of practices such as exclusive territories even when there is no problem of free riding on downstream services, and even when efficiency would dictate against a downstream monopoly (e.g. because downstream firms face increasing costs or offer differentiated products). In fact, exclusive territories are widely used. Entrepreneur Magazine's (1987) survey, the latest that offers data about exclusive territories, reveals that of the 139 top franchisors in various businesses, 93 granted exclusive territory franchises.

Exclusive territories are not a panacea. Granting long-term exclusivity can be inefficient, especially if demand is expected to grow. Moreover, as demonstrated by numerous suits charging violation of exclusive territories, the protection territories offer is far from ironclad. Restricting competition through territories can be tricky; it is not always easy to determine who is a competitor, when customers are mobile and when the franchisor can offer products slightly differentiated from the franchisee's or the same product through different types of outlets (ABA, 1990). Thus, a franchisor may be reluctant to grant exclusivity or unable to completely reassure a franchise against encroachment of its territory by a second firm. Another way to reassure franchisees is to follow a policy of making contracts uniform across franchisees and rigid over time.

Uniformity is helpful because it can be difficult for the manufacturer to convince all firms what are appropriate differentials as opposed to opportunistic discounts. Since it is easier to agree on uniformity, to prevent opportunism there might be a bias towards uniformity—even if uniformity would be inefficient under full information. Changes in contracts should be relatively infrequent, as all parties must be convinced that their positions are not undermined. This is similar to the difficulties facing a cartel in changing conditions. Note that uniformity and rigidity need not be a substitute for reputation as a method of

[29]Patrick Rey and Tirole (1986) suggest a similar observability advantage of uniform two-part tariffs over more sophisticated contracts. It is easier to convince a court that a distributor is carrying a manufacturer's product, beyond some minimum threshold to be labelled a "dealer", than to monitor the exact sales of the dealer. Thus, a manufacturer might be able to extract a uniform franchise fee from all dealers but not to implement more sophisticated pricing schemes.

commitment; rather, they can be complements. For a reputation mechanism to work, outsiders must be able to discern when a change was efficient and when opportunistic. This will be more difficult when terms are highly volatile than when a policy of uniform and stable terms is followed.

In fact, the uniformity of franchise contracts is striking. Across franchisors, there is considerable variation in contract terms.[30] For a given franchisor, however, terms are remarkably uniform across franchisees. Lafontaine's (1992) survey finds that all 126 franchisors responding to this question said they offered the same franchise contract to all potential franchisees at a given point in time. Moreover, 104 of them said either that the offer was "take-it-or-leave-it" or that they might negotiate only on nonmonetary clauses. Significantly, variation in royalty rates was particularly low. Of the 55 firms in Lafontaine's survey that also submitted franchise disclosure statements, 45 said that they employed a constant royalty rate at all levels of sales. In contrast, only 22 used a single franchise fee.[31] This difference conforms with our theory, since a rival's franchise fee is a fixed cost whereas the royalty rate acts as a marginal tax on revenue and therefore affects the rival's aggressiveness as a competitor. Consequently a firm will be more concerned about the rival's royalty rate than about the fixed fee.[32]

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[30]For example, in a sample of fast-food firms Banerji and Simon (1992) find that the franchise fees (in thousands of $1980) ranges between 4 and 37 with a mean of 22.15 and a standard deviation of 8.32. Royalty rates range from 0 to 6% of sales (i.e. revenue), with a mean of 4% and a standard deviation of 1.22%. Presumably the variation would be greater still in a sample of firms from different industries.

[31]This information is not reported in Lafontaine (1992) but is provided in Sugato Bhattacharyya and Lafontaine (1992), who stress that royalty rates are less variable than franchise fees. Of the 10 firms that used variable royalties, 4 used a sliding scale, 3 used rebates during the first year of operation, 2 provided discounts for operating multiple outlets, and 1 used an increasing scale. Of the 33 that used multiple franchise fees, 12 provided discounts for multiple outlets in a given territory and 6 more for multiple outlets regardless of their location, 9 made the fixed fees depend on the territory's size, 3 on the outlet's size, and 3 on various options in the franchise contract. (As explained in Lafontaine (1991, pp. 4-5), this wide variability in franchise fees is consistent with the preponderance of franchisors to offer a uniform franchise "contract" to all, insofar as the contract specifies formulae for computing the franchise fee. Moreover, some of the variability in royalty rates also overstates the different treatment of different franchisees, as it reflects differences in the services being offered by the franchisor.)

Bhattacharyya and Lafontaine (1992) note also that input sales at markup can serve as a substitute for royalties, and that the requirements to buy such inputs from the franchisor of approved suppliers are completely uniform across all franchisees. This further supports the finding that a franchisor does not discriminate across franchisees with respect to fees that affect marginal cost or marginal revenue. They offer an alternative explanation to ours for the relative constancy of marginal charges as compared to fixed fees, based on double moral hazard with heterogeneity of preferences across franchisees and Cobb-Douglas production technology that uses franchisor and franchisee inputs and varies across locations only with respect to a scale parameter.

[32]The fixed fee could matter insofar as a lower fee could allow the franchisor to bring in additional franchisees. This danger, however, may be more easily addressed by the exclusive territory provisions.

Such uniformity in contract terms seems inefficient given the likely heterogeneity of potential franchisees and market circumstances. As Lafontaine (forthcoming) observes, various agency theories would predict that the franchisor should offer a menu of contracts featuring different royalty rates. For instance, with franchisee moral hazard and risk aversion, the chosen royalty rate should vary according to the degree of risk aversion and the importance of franchisee effort; with double moral hazard, according to the importance of both parties' efforts; and with asymmetric information about the franchisee's type, a menu should be offered to induce better types to self select by choosing the lower-royalty-cum-higher-fixed-fee contract. Indeed, in Lafontaine's (1992) survey, of 88 respondents to the question of what might be the disadvantages of using the same contract to all franchisees, only 23 claimed no disadvantage; the remainder primarily cited loss of flexibility (35 to cope with special economic or geographic conditions and 28 to prevent losing potential franchisees).

This uniformity in franchise contracts does not seem entirely or even primarily attributable to legal constraints. When asked to identify the advantages of using the same contract to all franchisees, of the 120 respondents in Lafontaine's (1992) survey only 29 cited compliance with legal, FTC and disclosure requirements, with an additional 48 citing transaction costs (such as negotiation and ease of administration).[33] Uniformity and consistency in methods of dealing were cited by 62, and a desire for fairness and equity by an additional 33 (multiple responses were allowed). These replies can be interpreted as attempts to assure franchisees against opportunism.[34]

The rigidity of franchise terms over time also is striking. Banerji and Simon (1992) find that out of 31 fast food franchisors observed over a minimum of three years (and an average of over six), 17 never changed

[33]The Robinson-Patman Act does not apply to services and courts have consistently held that grants of trademark and franchise licenses do not constitute sale of commodities (Zeidman, 1991); only eight states have price discrimination laws that do cover services (ABA, 1991). State statutes governing franchising specifically apply only to automobile and gasoline dealers (Zeidman, 1991). Some states have "little FTC Acts" and administrative policies governing franchising, and conceivably these may account for uniformity in those states. However, state treatments differ widely and are probably insufficient to explain the widespread uniformity observed. The administrative convenience of having a single disclosure statement may also play a role; but replies to Lafontaine's survey suggest this was not paramount.

[34]According to practicing attorneys, suppliers are highly sensitive to how customers might react to perceived discrimination and customers themselves are acutely concerned with terms offered to rivals (conversations with Harvey Appelbaum and Richard Whiting, partners respectively at Covington & Burling and Steptoe & Johnson, Washington DC). These practitioners confirm that federal and state antitrust laws do not account for the uniformity in franchise contracts.

their royalty rate and 13 changed it only once. Interestingly, the franchise fee—which does not affect marginal incentives—was changed more frequently (measured in real $1980, the fee was changed at least once by 20 respondents). Lafontaine (1992) finds that 59 out of 125 respondents never changed the royalty rate while only 26 out of 98 never changed the franchise fee (although this understates the rigidity since the fees here are in nominal $). Finally, Lafontaine (1991) reports for a different sample of 125 franchisors, each observed at two points at least five years apart, that both the average royalty rate and franchise fee changed insignificantly (average royalty declining from 7.04% and average franchise fee increasing from 14.24 to 16.21 in thousands of $1980). This rigidity in contract terms over time seems even less likely to be explained by legal constraints.

To conclude, our discussion may provide clues as to how the number of trading partners is chosen. There can be a tradeoff between static efficiency and the need to reduce opportunistic renegotiation incentives: dealing with several firms might be statically more efficient, but could increase scope for opportunism. The choice might depend on how important it is to preserve contracting flexibility. If the environment is relatively stable, long-term contracts become more feasible, so opportunism might be curbed while admitting multiple downstream firms. If the environment is changing rapidly and unpredictably, requiring ongoing adjustments in contract terms, exclusivity becomes more attractive.

In order to make serious headway on these contracting problems it will be necessary to introduce asymmetric information explicitly and specify more fully the particular environment. We hope, however, that the basic perspective of opportunistic recontracting incentives with multiple parties will prove fruitful to understanding a wide range of business practices.

Appendix

PROOF OF PROPOSITION 1 :

Consider the last firm that the monopolist intends to be active, firm $k \leq n$. Suppose that in the Commitment Game G^* is attainable by offering firms 1 through k, the vector r^* and that in the Sequential Game the monopolist has offered to each firm $i < k$ its price from r^* (otherwise necessarily $V < G^*$). When contracting with firm k the monopolist, having collected fixed fees from other firms, maximizes not overall profit G but rather $u_k = G - \Sigma_{i \neq k} \pi_i$. Observe that

$$\frac{\partial u_k(r^*)}{\partial r_k} = \frac{\partial G(r^*)}{\partial r_k} - \sum_{i \neq k} \frac{\partial \pi_i(r^*)}{\partial r_k} < 0,$$

since $\partial G(r^*)/\partial r_k = 0$ by definition of r^* and since $\partial \pi_i(r^*)/\partial r_k > 0$ for at least some firm i (as at least one firm must be active in addition to k to attain G^*, by hypothesis). So if the monopolist has offered to all firms $i < k$ their prices from r^*, to firm k it will offer $r_k < r_k^*$, implying $G < G^*$. In equilibrium the monopolist's behavior is foreseen, hence the monopolist earns $V = G < G^*$.

PROOF OF PROPOSITION 2:

Let (r_0, f_0) be a symmetric equilibrium contract with $n \geq 2$ firms active, where $f_0 = \pi(r_0)$, and suppose $\partial u_i(r_0)/\partial r_i \neq 0$. Thus, there exists a deviation price $r_1 \neq r_0$ which would increase the joint profit of the monopolist and any one firm if that firm accepts and all others stay at (r_0, f_0) after the recontracting stage. Let $f_1 = \pi(r_1, r_0)$ denote a firm's profit if it gets price r_1 and all n-1 others get r_0. Suppose that in stage 1 the monopolist offered to firm n the contract (r_1, f_1). Firm n will accept this deviation offer if it expects all others not to switch with r_0 after the recontracting stage.

To see if others would switch, consider any other active firm $k < n$. Firm k knows that firm n has accepted r_1. Suppose no additional firm has switched to r_1 and firm k expects all others to remain with r_0; we relax this assumption below. Let v_1 denote firm k's expected profit if it switches to (r_1, f_1) and v_0 if it stays with (r_0, f_0). Suppressing input prices to firms $j \neq k, n$ we have

$$v_1 = [\pi(r_1, r_1) - f_1] = [\pi(r_1, r_1) - \pi(r_1, r_o)]$$

$$v_o = [\pi(r_o, r_1) - f_o] = [\pi(r_o, r_1) - \pi(r_o, r_o)]$$

$$\Rightarrow v_1 - v_o = [\pi(r_1, r_1) - \pi(r_o, r_1)] - [\pi(r_1, r_o) - \pi(r_o, r_o)]$$

$$= \int_{r_o}^{r_1} \int_{r_o}^{r_1} \frac{\partial 2\pi_k}{\partial r_n \partial r_k}(r_k, r_n)\, dr_n\, dr_k < 0.$$

Thus, firm k would stay with (r_o, f_o). If firm k expected others to switch to (r_1, f_1) then, by the same argument, its loss from switching would be even greater. Foreseeing that no other firm would follow its deviation contract, firm n accepts such a contract in stage 1. Therefore, it is not an equilibrium for all firms to receive r_o in stage 1. It also is not an equilibrium for all to receive r_o in the recontracting stage, because if firms n through 2 did, the monopolist could profitably induce a deviation by firm 1 (the last mover in the recontracting stage). Therefore, a symmetric equilibrium must be pairwise proof.

Pairwise proofness implies $\partial u_k(r_o)/\partial r_k = 0$. Thus, $\partial G(r_o)/\partial r_k = \partial u_k(r_o)/\partial r_k + \Sigma_{i \neq k} \partial \pi_i(r_o)/\partial r_k > 0$, since $\partial \pi_i(r)/\partial r_k > 0$ for any r and any active firms $i \neq k$. Therefore, the monopolist earns $V \leq G < G^*$.

PROOF OF PROPOSITION 3:

When considering a deviation from equilibrium with an active firm i, the monopolist maximizes

$$u_i = (r_i - z)q_i + \pi_i + \sum_{j \neq i} (r_j - z)q_j.$$

By assumption, firms $j \neq i$ cannot observe changes in r_i hence the last term is invariant to r_i. By Passive Beliefs, firm i assumes that prices r_j remain constant, hence we need consider only the effect of r_i on the first two terms on the right. The first-order effect on π_i from changing firm i's own downstream variable (price or quantity) in response to r_i is zero by the Envelope Theorem; the direct effect of raising r_i, namely q_i, is a pure transfer hence cancels. Therefore, equilibrium prices r^e must satisfy, for each active firm i,

$$\frac{\partial u_i(r^e)}{\partial r_i} = (r_i^e - z)\frac{\partial q_i(r^e)}{\partial r_i} = 0.$$

Here $\partial q_i(r^e)/\partial r_i$ denotes the change in firm i's optimal input purchases assuming (by Passive Beliefs)

that other firms' choices are fixed (at the candidate equilibrium levels). As $\partial q_j/\partial r_i < 0$, $r_i^c = z$ for each active firm i. With symmetric firms, each would enter if offered price z and assuming its active rivals also will be charged z. Since bringing in another firm lets the monopolist capture its profit and leaves unchanged the profit collected from other firms, the monopolist brings all in and earns $n\pi(z)$.

PROOF OF PROPOSITION 4:

We assume industry marginal revenue is decreasing in output,

(A1) $$\forall\, Q: \quad 2p'(Q) + Qp''(Q) < 0.$$

An active firm chooses an equilibrium quantity q_i satisfying

(A2) $$0 = q_i\, p'(Q) + p(Q) - r_i.$$

If firms 1,..., m are active, $m \leq n$, then:

(A3) $$0 = Qp'(Q) + mp(Q) - \sum_{i=1}^{m} r_i.$$

The right-hand side of (A3) is monotonically decreasing in Q, showing that for any number of active firms the Cournot equilibrium is unique.

Differentiating (A3) with respect to r_i yields

(A4) $$\frac{\partial Q}{\partial r_i} = \left[(m+1)p'(Q) + Qp''(Q)\right]^{-1} < 0,$$

the inequality following from (A1). Differentiating (A2) with respect to r_i and substituting from (A4) gives

(A5) $$\frac{\partial q_j}{\partial r_i} = \begin{cases} \left[m + \dfrac{p''(Q)}{p'(Q)}(Q - q_i)\right]\dfrac{\partial Q}{\partial r_i} < 0, & i = j \leq m \\ -\left[1 + \dfrac{p''(Q)}{p'(Q)} q_j\right]\dfrac{\partial Q}{\partial r_i}, & i \neq j,\ i, j \leq m \end{cases}$$

where the inequalities follow from (A1) and (A4).

The monopolist chooses the level r_i to maximize

(A6) $$u_i = \sum_{j \neq i} (r_j - z)\, q_j + \left(p(Q) - z\right) q_i.$$

Expression (A6) is not generally concave in r_i, although it is for linear demand. Nevertheless, if p is twice continuously differentiable, u_i will be continuously differentiable in r_i and first order conditions will hold.

Suppose the first m firms are active. Then for $i \le m$,

(A7)
$$\frac{\partial u_i}{\partial r_i} = \sum_{j=i}^{m} (r_j - z)\frac{\partial q_j}{\partial r_i} + q_i\, p'(Q)\frac{\partial Q}{\partial r_i} + (p(Q) - z)\frac{\partial q_i}{\partial r_i}$$

$$= \sum_{j=i} (r_j - z)\frac{\partial q_j}{\partial r_i} + q_i\, p'(Q)\frac{\partial Q}{\partial r_i} + (p(Q) - z)\left[\frac{\partial Q}{\partial r_i} - \sum_{j=i}\frac{\partial q_j}{\partial r_i}\right]$$

$$= \sum_{j=i} \left[r_j - p(Q)\right]\frac{\partial q_j}{\partial r_i} + \left[p(Q) + q_i\, p'(Q) - z\right]\frac{\partial Q}{\partial r_i}$$

$$= \sum_{j=i} q_j\, p'(Q)\frac{\partial q_j}{\partial r_i} + \left[p(Q) + q_i\, p'(Q) - z\right]\frac{\partial Q}{\partial r_i}$$

$$= \frac{\partial Q}{\partial r_i}\left[- p'(Q)\sum_{j=i} q_j\left[1 + \frac{p''(Q)}{p'(Q)}q_j\right] + p(Q) + q_i\, p'(Q) - z\right]$$

$$= \frac{\partial Q}{\partial r_i}\left[- p'(Q)\,[Q - q_i] - p''(Q)\sum_{j=i} q_j^2 + p(Q) + q_i\, p'(Q) - z\right]$$

$$= \frac{\partial Q}{\partial r_i}\left[\, p(Q) - z - p'(Q)\,[Q - 2q_i] - p''(Q)\sum_{j=i} q_j^2\,\right].$$

For the monopolist to be in equilibrium we have, necessarily, that

(A8)
$$\frac{\partial u_i}{\partial r_i} = 0 \quad \text{if} \quad q_i > 0$$

(A9)
$$\frac{\partial u_i}{\partial r_i} \ge 0 \quad \text{if} \quad q_i = 0,$$

where (A9) follows since increasing the output of an idle firm i requires reducing r_i. Consider two firms that are active in equilibrium: $q_i > 0$, $q_j > 0$. Then

$$0 = \frac{\partial u_i}{\partial r_i} - \frac{\partial u_j}{\partial r_j}$$

$$= \frac{\partial Q}{\partial r_i}\left[2p'(Q)\,[\,q_i - q_j\,] - p''(Q)\,[\,q_i^2 - q_j^2\,]\right]$$

$$= \frac{\partial Q}{\partial r_i}\,(q_i - q_j)\left[2p'(Q) + p''(Q)\,(q_j + q_i)\right].$$

By (A1), the term in square brackets is negative, so $q_i = q_j$, proving that, in any equilibrium, production of active firms is equal. Thus, by (A7),

(A10) $$p(Q) - z = \frac{Q}{m}\left[\,p'(Q)\,(m-2) + p''(Q)\,\frac{m-1}{m}\,Q\,\right].$$

Now consider a firm i producing $q_i = 0$. Decreasing r_i to the point where (A2) holds with $q_i = 0$ (that is, $p(Q) - r_i = 0$) has no effect on u_i. Thus, (A9) yields

$$0 \le \left.\frac{\partial u_i}{\partial r_i}\right|_{p(Q)-r_i=0} = \frac{\partial Q}{\partial r_i}\left[\,p(Q) - z - p'(Q)\,Q - p''(Q)\,\frac{Q^2}{m}\,\right];$$

hence, by (A4),

(A11) $$p(Q) - z - p'(Q)\,Q - p''(Q)\,\frac{Q^2}{m} \le 0.$$

Combining (A10) and (A11) gives:

$$-\frac{Q}{m}\left[\,2p'(Q) + \frac{Q}{m}\,p''(Q)\,\right] \le 0,$$

which contradicts (A1). Thus, all firms are active.

Substituting $m = n$ in (A10) shows that in equilibrium firms produce equal outputs Q/n satisfying

(A12) $$p(Q) - z = \frac{Q}{n}\left[\,p'(Q)(n-2) + p''(Q)\,\frac{n-1}{n}\,Q\,\right].$$

Case (i) in the Theorem follows immediately from (A12).

Case (ii) follows by noting, for $n \ge 3$, $(n - 1)/[n(n - 2)] \le 1$, and thus, for $p'' \ge 0$,

$$p'(Q)(n-2) + p''(Q)\,\frac{n-1}{n}\,Q \le (n-2)\left[\,p'(Q) + Qp''(Q)\,\right].$$

Finally, (iii) follows from noting, for $n \ge 4$, $(n - 1)/[n(n - 2)] < 1/2$, and using (A1).

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