Staggered Contracts, Market Power, and Welfare

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Abstract. I show that exclusive, staggered supply contracts can decrease industry competition when there are economies of scale: buyers pay a higher price to the incumbent seller and the discounted expected value received by an entrant seller is lower when contracts are staggered. Moreover, under staggered contracts there may exist equilibria where an inefficient firm forecloses a more efficient one. Finally, I show that, given that contracts are staggered, contract length further increases market power. However, increasing contract length may also eliminate the inefficient foreclosure equilibrium.

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1. Introduction

In some industries, firms maintain a position of monopoly or market dominance by securing exclusive, long-term contracts with key suppliers or customers. In this paper, I consider the case when a supplier sells to multiple buyers and ask whether it makes a difference whether contracts are synchronous or staggered.

As a motivating example, consider the case of Nielsen. During the 1980s, Nielsen maintained a monopoly over the provision of market-tracking services for grocery store produce sales in Canada.[1] In this industry, the key inputs are raw scanner data provided by the major grocery chains. When Information Resources Incorporated (IRI) threatened to enter the market, Nielsen responded by signing exclusive, long-term contracts (three years or longer) with Canada's grocery chains. Moreover, by Nielsen's own admission, the contracts were staggered as a means to create an additional barrier to competition:

> After we did our retailer deals five years ago, we recognized that we were vulnerable because virtually all of these agreements expired around the same time. We set ourselves a goal then to pursue a practice that would result in our retailer and distributor contracts expiring at different times. This would make it much more difficult for any competitor to set up a service unless he was prepared to invest in significant payments before he had a revenue stream.[2]

A second example is given by television broadcast rights in the Portuguese Professional Soccer League (LPFP). These rights are currently wholly owned by one single firm, PPTV, which negotiates individually with each club. Despite PPTV's high profitability (average rate of return of about 30%), there is no sign of credible potential entry. This is likely due to the high entry barrier created by the contracts signed by the soccer clubs with PPTV: long in duration (5 to 10 years) and staggered in structure.

In this paper, I consider the economic effect of staggered contracts in an industry with market power. I develop an infinite period model with two sellers and two buyers. I look for stationary equilibria where sellers bid for contracts under two possible contract structures: synchronous contracts (all contracts are renewed at the same time); and staggered contracts (contracts are renewed at different times). I show that equilibrium price is higher under staggered contracts than under synchronous contracts. Moreover, under staggered contracts per period price is increasing in contract length, whereas under synchronous contracts it is invariant with respect to contract length. In other words, staggered contracts imply an increase in price and an increase in the derivative of price with respect to contract length.

Next I consider the case when one of the sellers is more efficient than the other and show that, if the efficiency difference is not too high, then there exists an equilibrium where the inefficient seller makes all of the sales. Moreover, a necessary condition for such an equilibrium to exist is that contract length not be too long.

Finally, I extend the model to include the possibility of product differentiation. In this context, I show that an entrant's value is lower under staggered contracts. In this sense, in addition to higher prices staggered contracts also increase the level of entry barriers.

These results are relevant for a series of cases where long-term input or output contracts can diminish the degree of competition. In addition to the examples mentioned earlier,

1. Jing and Winter (2012) discuss this case at length.
2. Page 66 in: Canada (Director of Investigation and Research) v. The D & B Companies of Canada Ltd. (1995), 64 C.P.R. (3d) 216 (Comp.Trib.).

there are two recent European cases where contracts played an important role. In 2007, the European Commission "expressed concerns under Article 82 of the EC Treaty that Distrigas' long-term gas supply contracts would prevent customers from switching." An agreement was reached whereby Distrigas, a Belgian gas supplier, committed to bring to market each year 70% of the contracts (by volume), as well as limit contract duration to less than five years.[3] More recently, a similar commitment was obtained from Electricité de France: "65% of the volumes contracted on the relevant market will be made available every year for recontracting;" and "EDF undertakes not to conclude new contracts with a duration exceeding five years."[4] In both cases, the idea is to make the market more "contestable" by insuring that a certain fraction is up for bids each period.

My results cast a word of caution regarding this type of policy. Consider two alternative scenarios: (a) 40% of the contracts are one-year long; the remaining 60% are two-years long and are all renewed at the same time (that is, every two years); (b) 40% of the contracts are one-year long; the remaining 60% are two-year long, 30% of each renewed each year. At some level, case (b) seems more "contestable:" every period 70% of the contracts are available to a potential entrant, as the Distrigas agreement indicates. However, as I will show in this paper, market power and entry barriers are greater in case (b) than in case (a), where the share of the market up for grabs alternates between 40 and 100% (thus violating the Distrigas agreement).

■ **Related literature.** Conceptually, the Coase theorem (Coase, 1960) provides an important reference point to judge the competitive effects of long-term contracts: if all parties enter into the contract; and if there are no significant externalities; then there is no reason to believe the market solution is inefficient, even if involves long-term exclusive contracts. This view — usually associated to the "Chicago school" — has been challenged by a series of scholars. In particular, as Aghion and Bolton (1990) point out, to the extent that there are externalities in contracting, it is quite possible that two parties agree on an exclusive contract that is socially inefficient: both parties gain from the contract but that gain is more than outweighed by the loss to the excluded party. In sum, long-term exclusive contracts may create an inefficient barrier to entry.

More closely related to my paper is the literature on "naked exclusion" (Rasmusen, Ramseyer and Wiley, 1991; Segal and Whinston, 1999; Fumagalli and Motta, 2005). This literature considers the case when an incumbent sells to a series of buyers and produces with a technology subject to increasing returns to scale. By securing contracts with a large enough number of buyers, an incumbent is able to exclude a potential entrant who, having only access to a small share of the market, is unable to cover its average cost. Differently from Aghion and Bolton (1990), an additional externality now exists between buyers who sign exclusive deals with the incumbent and buyers who do not. Similarly to Aghion and Bolton (1990), there may exist equilibria with inefficient exclusion.[5]

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3. Summary of Commission Decision of 11 October 2007 relating to a proceeding pursuant to Article 82 of the EC Treaty (Case COMP/B-1/37.966 — Distrigaz).
4. Summary of Commission Decision of 17 March 2010 relating to a proceeding under Article 102 of the Treaty on the Functioning of the European Union and Article 54 of the EEA Agreement (Case COMP/39.386 — Long Term Electricity Contracts France).
5. Similarly to economies of scale, the argument can also be made that contracts which link two markets with economies of scope may lead to effectively foreclose an entrant in one of those markets. See Bernheim and Whinston (1998), Carlton and Waldman (2002), for more on this.

My paper extends the idea of exclusive contracts that induce externalities, market power, and possibly inefficient exclusion. I do so by considering specifically the role played by staggered contracts as well as contract length. In addition to the different focus (on staggered contracts), one important difference with respect to the previous literature is that I assume both sellers are present in the market at all moments of an infinite period game. In other words, incumbency results from equilibrium play, not from a finite extensive form.

Jing and Winter (2012) is also very closely related to my paper. They discuss the Nielsen case (presented earlier) in great detail, and argue that exclusive contracts (in the particular setting they examine) have an anti-competitive effect. They also suggest that staggered contracts increase the size of that barrier, though they do not provide a formal argument for the latter.

From an oligopoly theory point of view, my paper is related to the work on Gilbert and Newbery (1982), who provide conditions for the persistence of monopoly dominance. My assumption regarding monopoly and duopoly profits is essentially identical to theirs. Their work does not consider the issue of contracts (either their length or synchronicity); and they do not consider an infinite period model as I do. In the latter sense, my model is closer to Cabral (2011), a paper that develops a general theory of dynamic competition with network effects. Again, the novelty of the present paper is to consider the role played by staggered contracts.

2. Model

Consider an industry with two sellers and a sequence of short-lived pairs of buyers.[6] Buyers have a valuation u for one unit of the industry product during one period, zero for any additional unit. Given this, buyers choose the seller who offers the lowest price. (In Section Section 5, I consider the possibility of seller and buyer heterogeneity.)

For accounting purposes, I will divide contract length into two periods. Throughout the paper, when I refer to "period" I mean one half of contract length; in other words, I will assume contracts last for two periods. Let δ be the discount factor corresponding to one period. It follows that the discount factor corresponding to the entire contract length is δ^2.

The cost of serving one customer during one period, c_k, depends on k, the number of customers served. I make the important assumption that

Assumption 1. $c_2 < c_1$

In words, I assume economies of scale in serving customers.

Throughout the paper, the equilibrium concept I use is that of Markov equilibria, that is, subgame-perfect Nash equilibria such that strategies depend only on the state of the game. The state of the game, in turn, is defined by the identity of the "incumbent" supplier, the supplier who holds the "old" contract in the case when contracts are staggered; if contracts are not staggered, then there is only one state. Either way, my assumption of Markov equilibria effectively excludes the possibility of history dependent strategies.

6. Alternatively, I could assume two long-lived buyers, but then I would also need to assume buyers are myopic.

3. Staggered contracts and market power

In this section I consider two possible cases: (a) synchronous contracts, that is, the situation whereby every 2 periods all contracts are auctioned off; and (b) staggered contracts, that is, the situation whereby every period one of the contracts is auctioned off. Suppose first that, every two periods, sellers set the price for two-period supply to one buyer. Buyers then simultaneous choose one of the sellers. Since sellers are indistinguishable in the buyers' eyes, the latter always pick the firm (or a firm) setting the lowest price. I next show that, in equilibrium, both sellers set $p = c_2$, where p is *per period* price, and one of the sellers wins both contracts. To see this, notice that it would not be an equilibrium for each seller to sell one contract for $p = c_2$, for then the price received is lower than cost (which would be c_1 for each seller). Likewise, it would not be an equilibrium for each seller to sell one contract for a price p strictly greater than c_2: a slightly lower price would secure both buyers for a higher seller value. We thus conclude that the equilibrium price is $p_s = c_2$ (s for short-term).

Consider now the case when every period one of the buyers comes to the market demanding a 2-period contract. Let v_i be the value of a seller who holds an old contract before the new one is assigned. Let v_e be the other seller's value. Let p_i and p_e be the *per period* prices set by incumbent and entrant seller, respectively. The process of deriving equilibrium prices is similar to what we considered before, with the difference that we now must explicitly account for continuation values. For example, if in a given period the incumbent seller has the winning price, p_i, then its discounted value is given by

$$\widetilde{p} + p_i - 2\,c_2 + \delta\, v_i$$

where $\widetilde{p}$ is the per period price of the preceding contract and v_i the continuation value for an incumbent seller.

My first result compares per-period price under the alternative regimes considered above. Specifically, let p^g be the per-period price under staggered contracts, whereas p^s denotes price under synchronous contracts.

Proposition 1. *In an anonymous equilibrium, prices are given by*

$$\begin{aligned} p^y &= c_2 \\ p^g &= c_2 + (1-\delta)\,(c_1 - c_2) \end{aligned}$$

In words, Proposition 1 states that equilibrium price under staggered contracts is higher than under synchronous contracts: staggered contracts increase seller monopoly power.

Corollary 1. $\frac{d\,p^y}{d\,\delta} = 0 > \frac{d\,p^g}{d\,\delta}$

In words, contract length has no effect on (per period) contract price under synchronous contracts. However, under staggered contracts contract length (further) increases monopoly power. In the limit as $\delta \to 1$, synchronous and staggered contracts perform equally in terms of equilibrium price. In the opposite limit as $\delta \to 0$, $p^g \to c_1$, which, by Assumption 1, is greater than $p^y = c_2$.

Note that there may be many good reasons whey market competitiveness decreases as contract length increases (including, for example, a combination of uncertainty and sunk entry costs). The point of Corollary 1 is that, under staggered contracts, contract length becomes an additional source of monopoly power.

At this point, I should mention that I am implicitly making the assumption that buyers cannot transfer contracts post sale. If resale is possible, then, starting from a subgame where each seller owns one contract, I would expect sellers to bargain over contract transfers. If bargaining is efficient, then I would expect sellers to come to an agreement whereby the seller holding the new contract would also secure the old one. Assuming that sellers split the gain from the agreement as in the Nash bargaining solution, this would increase payoffs for both sellers. In fact, an entrant now looks forward to a higher payoff in case it acquires a new contract: not only does it get the new contract but then it also obtains the other one from the incumbent. In other words, I would expect the existence of a secondary market to reduce the degree of monopoly power by the incumbent seller.

4. Staggered contracts and inefficient exclusion

Suppose that one of the sellers, say firm b, is more efficient than the other. Specifically, I assume that firm a must pay an additional cost d per period each time it is active (regardless of whether it sells one unit or two).

Under synchronous contracts, b systematically wins the auction for each new contract. It follows that the equilibrium is efficient: production costs are minimized and social welfare maximized.

Consider now the case of staggered contracts. As suggested by Proposition 1, incumbency creates a seller advantage. Can this advantage be so great that it outweighs firm a's cost disadvantage? The next result provides conditions for that to be the case.

Proposition 2. *If $d < 2\,(2\,\delta - 1)\,(c_1 - c_2)$, then there exists an equilibrium where firm a makes all sales.*

In other words, Proposition 2 states that if firm a is not too inefficient with respect to firm b, then it is able to exclude the more efficient entrant.

Notice that a necessary condition for Proposition 2 is that $\delta > \frac{1}{2}$, in other words, that contract length not be too long. The reason is that the less efficient firm must credibly "threaten" to make a sale if it finds itself in the position of being an entrant. Given firm b's price as an incumbent, making a sale as an entrant implies that firm a set a price below cost. If the value of δ is too small (specifically, less than 1/2), then firm a prefers not to make a sale. Intuitively, if different values of δ reflect different period lengths, a low δ implies a long period of pricing below cost, making is less attractive for firm a to enter (or re-enter) and breaking down the credibility of the equilibrium that excludes firm b.

Note that Proposition 2 provides a different story than Corollary 1 regarding the role played by contract length. Under a symmetric equilibrium, an increase in contract length increases equilibrium price under staggered contracts. Intuitively, longer contract length increases the asymmetry between incumbent and entrant. In fact, as we saw earlier, in the limit when $\delta \to 1$ there is no difference between synchronous and staggered contracts. According to Proposition 2, one effect of increasing δ is to allow for the inefficient exclusion equilibrium to exist. In that sense, increasing contract length may lead to higher social welfare by virtue of eliminating a bad equilibrium.

In the next section I further explore the implications of the incumbency commitment effect, namely in terms of creating a barrier to entry.

5. Staggered contracts as a barrier to entry

In the previous sections, I considered the case when there is complete information regarding payoffs. When this is the case, prices are set as under Bertrand competition with asymmetric costs. In asymmetric cost Bertrand model, the lower cost seller sets a price equal to the cost of the high-cost seller. This implies that the high-cost seller's equilibrium profit is zero. It also creates a bit of a puzzle: if the high-cost seller's payoff is zero, then why does it bother to be present in the market at all? The most common answer to this paradox is to consider the possibility of seller heterogeneity, in which case both sellers receive strictly positive expected payoffs.

In the present case, complete information implies that the entrant is always kept from winning any contract, thus receiving a zero payoff. This is true in any of the equilibria considered (except when the entrant has a large cost advantage with respect to the incumbent). In this section, I follow the same solution as in standard oligopoly models: I add some degree of agent heterogeneity so as to obtain strictly positive expected payoffs for all players and equilibrium outcomes that are continuous with respect to exogenous parameters (for example, a probability of entry that varies continuously with respect to costs and profits).

Specifically, I assume that, in each period and for each buyer, Nature generates a preference shock ξ which is the buyer's private information and corresponds to the buyer's preference for one of the sellers. Since in this section I return to symmetric anonymous equilibria, I assume that ξ measures the buyer's preference for the incumbent seller; that is, the buyer prefers to buy from i if and only if $\xi - p_i > -p_e$. In the case of synchronous contracts, I can arbitrarily designate one of the firms as incumbent.

I assume that ξ is distributed according to cdf $\Phi(\xi)$ which has the following properties:

Assumption 2. *(i) $\Phi(\xi)$ is twice continuously differentiable; (ii) $\phi(\xi) = \phi(-\xi)$; (iii) $\phi(\xi) > 0$, $\forall \xi$; (iv) $\Phi(\xi)/\phi(\xi)$ is strictly increasing.*

Part (i) is done for technical simplicity; part (ii) follows from the assumption of symmetry between sellers; part (iii) implies that the likelihood that a given seller makes a sale is always strictly positive, though possibly very small. Finally, part (iv) corresponds to a standard assumption in auction theory and other fields (monotone hazard rate). It is satisfied by most symmetric distribution functions (including the normal, uniform and t distributions).

It follows from part (ii) of Assumption 2 that the probability that i is selected by the buyer is given by

$$q = \mathcal{P}(\xi - p_i > -p_e) = 1 - \Phi(p_i - p_e) = \Phi(p_e - p_i) \tag{1}$$

If contracts are synchronous, I define by v the (common) discounted firm value at the the beginning of a period where contracts are up for bids. If contracts are staggered, then I define by v_i (reap. v_e) the discounted value for a seller who has (resp. does not have) a contract at the time it bids for the newly available contract. v_e thus measures the expected value of an entrant into a market where there is one seller only. The question at hand is whether this value is lower than the value expected by an entrant into a market where contracts are all bid at the same time, that is, are synchronous.

Let us begin with synchronous contracts. From the previous sections, we conclude that $v_e = 0$ both under synchronous and under staggered contracts. Is this also true when there is incomplete information? At this point, we are faced with a modeling problem: how exactly do synchronous contracts work when there is incomplete information? Under complete information, I assumed that buyers simultaneously choose a seller; and I shows that the winning bidder secures both contracts. In fact, this is the only Nash equilibrium. With incomplete information, if both contracts are auctioned simultaneously, then there is a positive probability (50%, to be more precise) that each seller gets one contract, an outcome that is likely to be inefficient (especially if c_2 is significantly lower than c_1). In a real-world situation, we would expect the selling protocol to account for the possibility of these coordination mistakes. I model this by assuming that, under the synchronous contracts regime, contracts are auctioned sequentially (though at the same calendar date). The value of an entrant is then the (symmetric) value of the two-stage game played between buyers.

I can now establish the main finding in this section:

Proposition 3. *If $c_1 - c_2$ is sufficiently large, then an entrant's expected value is lower under staggered contracts than under synchronous contracts.*

The intuition for this result is akin to the idea of persistence of monopoly in dynamic games. Gilbert and Newbery (1982) consider a model where an incumbent monopolist and a potential entrant bid for a patent that provides the entrant the means to compete against the monopolist. If duopoly profits are less than one half of monopoly profits, then in equilibrium the incumbent overbids the entrant, whereby the monopoly market structure persists. The idea is that what the monopolist has to lose from letting the entrant come in, $\pi_m - \pi_d$, is more than what the entrant has to gain from entering the market, π_d. In terms of my model's notation, this corresponds to the assumption $c_2 < c_1$. In other words, the fact that there are increasing returns to scale makes an incumbent more aggressive, which in turn makes entry more difficult. Under synchronous contracts, there is an element of "incumbent" pressure: the buyer who is able to secure the first contract becomes more aggressive in bidding for the second one. However, at the time of bidding for the first contract, both buyers are equally placed. As a result, the discounted payoff for a newcomer is greater than under staggered contracts (where a newcomer is always at a disadvantage with respect to an incumbent).

The above discussion also illustrates an important difference between my model of staggered contracts and the Rasmusen et al (1991) model of naked exclusion with sequential contracts. In fact, my version of synchronous contracts also features a sequential bidding process. Even so, staggered contracts imply an additional decrease in entrant's payoff, thus an additional barrier to entry.

6. Conclusion

I have shown that exclusive, long, staggered contracts create a barrier to entry over and above other possible barriers to entry. As a result, buyers pay a higher price under staggered contracts. Moreover, such price is increasing in contract length.

In order to stress the point that the barrier I identify is over and above other barriers previously identified, I considered an ideal world with no information asymmetries across sellers and where there exists a potential entrant who is always present, always bids simultaneously for new contracts against a rival buyer, and has infinite financing abilities. In this context, long-term contracts or staggered contracts do not constitute a barrier to entry per se. However, the *combination* of long-term contracts and staggered contracts does create a barrier to entry.

Appendix

Proof of Proposition 1: If the incumbent seller has the winning price, then its discounted value is given by

$$\widetilde{p} + p_i - 2\,c_2 + \delta\,v_i \tag{2}$$

where $\widetilde{p}$ is the per period price of the continuing contract (a contract which buyer and seller are locked in to). If the entrant makes the sale then the incumbent's value is

$$\widetilde{p} - c_1 + \delta\,v_e \tag{3}$$

Similarly, expected payoff for the entrant in case the entrant makes the sale is given by

$$p_e - c_1 + \delta\,v_i \tag{4}$$

whereas the entrant's expected payoff if the incumbent makes the sale is simply given by

$$\delta\,v_e \tag{5}$$

Equating (3) and (2) and solving for p_i I get the incumbent's minimum price:

$$p_i^\circ = 2\,c_2 - c_1 - \delta\,\big(v_i - v_e\big)$$

Similarly, the entrant's minimum price is given by

$$p_e^\circ = c_1 - \delta\,\big(v_i - v_e\big) \tag{6}$$

It can be shown that $p_i^\circ < p_e^\circ$ if and only if $c_2 < c_1$, which is true by Assumption 1. It follows that, in every period, the incumbent makes the sale. This implies that $v_e = 0$ and the equilibrium price is given by

$$p = p_i = p_e = c_1 - \delta\,\big(v_i - v_e\big) \tag{7}$$

Since the incumbent seller always makes a sale, we conclude that $\widetilde{p} = p_i$. Moreover, from (2) we have

$$v_i = 2\,\big(p_i - c_2\big) + \delta\,v_i \tag{8}$$

or simply

$$v_i = 2\,\frac{p_i - c_2}{1 - \delta}$$

Substituting (7) for p_i in (8) and simplifying, we get

$$v_i = c_1 - c_2 \tag{9}$$

Substituting 0 for v_e and (9) for v_i in (7), and simplifying, I get

$$p_i = c_1 - \delta\,(c_1 - c_2) = (1 - \delta)\,c_1 + \delta\,c_2$$

In the text I derived the values $p_S = p^y = c_2$. ■

Proof of Proposition 2: Suppose that firm b is currently the entrant. Firm b's expected payoff in case firm b makes the sale (an off-the-equilibrium event) is given by

$$p_e^b - c_1 + \delta\, v_i^b \tag{10}$$

whereas firm b's (the entrant) expected payoff if the incumbent (firm a) makes the sale is simply given by

$$\delta^{\frac{T}{2}}\, v_e^b \tag{11}$$

Given the equilibrium hypothesis that firm a makes all of the sales, we have

$$\begin{aligned} v_i^b &= p_e^b - c_1 \\ v_e^b &= 0 \end{aligned} \tag{12}$$

Substituting (12) for v_i^b in (10), equating (10) to (11) and solving for p_e^b, I obtain firm b's minimum price when it is an entrant:

$$p_e^{b\circ} = c_1$$

Consistently with the equilibrium hypothesis that firm a makes all sales, firm b sets its price at the minimum level consistent with its no-deviation constraint:

$$p_e^b = c_1 \tag{13}$$

Note that this implies that

$$v_i^b = 0$$

Even though I assume that, along the equilibrium path, firm a always makes a sale, I need to consider the off-the-equilibrium possibility of firm b being an incumbent. If that is the case, then firm b's discounted value in case firm b makes the current sale is given by

$$\widetilde{p} + p_i^b - 2\, c_2 + \delta\, v_i^b \tag{14}$$

where $\widetilde{p}$ is the per period price of the continuing contract (a contract to which buyer and seller are locked in). If the entrant (firm a) makes the sale then firm b's value is

$$\widetilde{p} - c_1 + \delta\, v_e^b \tag{15}$$

Substituting 0 for v_i^b in (14), 0 for v_e^b in (15), and solving the equality of the two expressions with respect to p_i^b, I obtain firm b's minimum price when it is an incumbent:

$$p_i^{b\circ} = 2\, c_2 - c_1$$

Consistently with the equilibrium hypothesis that firm a makes all sales, firm b sets its price at the minimum level consistent with its no-deviation constraint:

$$p_i^b = 2\, c_2 - c_1 \tag{16}$$

In equilibrium, firm a (the incumbent) matches firm b's price when firm b is an entrant, that is, p_e^b, which is given by (13), and makes a sale. This implies

$$v_i^a = \frac{2\,(c_1 - c_2) - d}{1 - \delta} \tag{17}$$

If firm a ever happens to be an entrant, it matches firm b's price when firm b is an incumbent, that is, p_i^b, which is given by (16), and makes a sale. This implies

$$v_e^a = (2\,c_2 - c_1) - c_1 - d + \delta\, v_i^a$$

Substituting (17) for v_i^a, I get

$$v_e^a = \frac{2\,(2\,\delta - 1)\,(c_1 - c_2) - d}{1 - \delta} \tag{18}$$

Note that $v_e^a > 0$ if and only if

$$d < 2\,(2\,\delta - 1)\,(c_1 - c_2)$$

which is true by assumption.

Ir order to show that the proposed equilibrium is indeed an equilibrium, I must show that firm a would not want to set a lower price, thus leaving the sale to firm b. Suppose that firm a is the entrant and prices above firm b, thus losing the sale to firm b. It follows that firm a's expected payoff is

$$\delta\, v_e^a$$

But since $v_e^a > 0$, this is strictly lower than v_e^a. When firm a is the incumbent, letting firm b make a sale would imply a payoff of

$$p_i^a - c_1 - d + \delta\, v_e^a = -d + \delta\, v_i^a < v_i^a$$

where the equality follows from $p_i^a = p_e^{b\circ}$ and (13). ■

Proof of Proposition 3: The proof proceeds in three steps. First I compute the equilibrium under staggered contracts. Second I compute the equilibrium under synchronous contracts. Finally, I compare the value of an entrant in each of the two cases.

Consider first the case of staggered contracts. For simplicity, I assume that the price for the entire contract is received at the beginning of the first period (of the two periods that the contract lasts for). Moreover, differently from the previous sections I let p_i and p_e denote the discounted price for the entire duration of a contract. (In other words, price per period is given by p_i and p_e divided by $1 + \delta$.) Let q be the probability that the incumbent seller is chosen by the buyer. The value of an incumbent and of an entrant are given by

$$\begin{aligned} v_i &= q\,\Big(p_i - 2\,c_2 + \delta\, v_i\Big) + (1 - q)\,\Big(-\,c_1 + \delta\, v_e\Big) \\ v_e &= (1 - q)\,\Big(p_e - c_1 + \delta\, v_i\Big) + q\,\delta\, v_e \end{aligned} \tag{19}$$

Define

$$P \equiv p_i - p_e$$

From (1), $q = 1 - \Phi(P)$. It follows that $\partial q / \partial p_i = -\phi(P)$, whereas $\partial q / \partial p_e = \phi(P)$. The first-order conditions for an incumbent and for an entrant's value maximization are given by

$$1 - \Phi(P) - \phi(P)\Big(p_i - 2\,c_2 + \delta\, v_i - (-c_1 + \delta\, v_e)\Big) = 0$$

$$\Phi(P) - \phi(P)\Big(p_e - c_1 + \delta\, v_i - \delta\, v_e\Big) = 0$$

or simply

$$
\begin{aligned}
p_i &= \frac{1-\Phi(P)}{\phi(P)} + (2\,c_2 - c_1) - \delta\,(v_i - v_e) \\
p_e &= \frac{\Phi(P)}{\phi(P)} + c_1 - \delta\,(v_i - v_e)
\end{aligned}
\tag{20}
$$

Subtracting these two first-order conditions and simplifying, I get

$$
P + \frac{2\,\Phi(P) - 1}{\phi(P)} = -2\,(c_1 - c_2) \tag{21}
$$

Assumption 2 implies that the left-hand side of (21) is strictly increasing in P ranging from $-\infty$ to $+\infty$ as P varies from $-\infty$ to $+\infty$. Moreover, the left-hand side of (21) is zero when P is zero. It follows that there exists a unique value of P satisfying (21). Moreover, since $P > 0$ if and only if the right-hand side of (21) is positive, Assumption 1 implies that $P < 0$.

Substituting the first-order condition (20) into the value functions (19) and simplifying, I get

$$
\begin{aligned}
v_i &= \frac{\big(1-\Phi(P)\big)^2}{\phi(P)} + \delta\,v_e \\
v_e &= \frac{\Phi(P)^2}{\phi(P)} + \delta\,v_e
\end{aligned}
\tag{22}
$$

or simply

$$
v_e = \frac{1}{1-\delta}\,\frac{\Phi(P)^2}{\phi(P)} \tag{23}
$$

where P is given by (21).

Consider now the case of synchronous contracts which are auctioned at every even period. Suppose that firm i has made the first sale. Seller continuation values before the second auction takes place are given by

$$
\begin{aligned}
v_i &= q\,\Big(p_i - 2\,(1+\delta)\,c_2\Big) + (1-q)\,\Big(-\,(1+\delta)\,c_1\Big) + \delta^2\,v^\circ \\
v_e &= (1-q)\,\Big(p_e - (1+\delta)\,c_1\Big) + \delta^2\,v
\end{aligned}
$$

where v° is the value before the first sale is made in a given even period. The first-order conditions for an incumbent and for an entrant are given by

$$
\begin{aligned}
1 - \Phi(P) - \phi(P)\,\Big(p_i - 2\,(1+\delta)\,c_2 + (1+\delta)\,c_1\Big) &= 0 \\
\Phi(P) - \phi(P)\,\Big(p_e - (1+\delta)\,c_1\Big) &= 0
\end{aligned}
$$

or simply

$$
\begin{aligned}
p_i &= \frac{1-\Phi(P)}{\phi(P)} + (1+\delta)\,(2\,c_2 - c_1) \\
p_e &= \frac{\Phi(P)}{\phi(P)} + (1+\delta)\,c_1
\end{aligned}
\tag{24}
$$

Subtracting these two first-order conditions, I get

$$P + \frac{2\,\Phi(P) - 1}{\phi(P)} = -2\,(1+\delta)\,(c_1 - c_2) \tag{25}$$

which determines the value of P uniquely. Substituting (24) back into the value functions, I get

$$\begin{aligned} v_i &= \frac{1 - \Phi(P)^2}{\phi(P)} + \delta^2\, v^\circ \\ v_e &= \frac{\Phi(P)^2}{\phi(P)} + \delta^2\, v^\circ \end{aligned}$$

Consider now the first auction in the sequence. Firm A's value functions is given by

$$v = \Big(1 - \Phi(P^\circ)\Big) \left(p_A^\circ + \frac{\big(1 - \Phi(P)\big)^2}{\phi(P)} \right) + \Phi(P^\circ)\, \frac{\Phi(P)^2}{\phi(P)} + \delta^2\, v^\circ$$

where p_A° is firm A's price and $P^\circ \equiv p_A^\circ - p_B^\circ$ is the price difference between firm A and firm B at the beginning of the period (when there is no differentiation between incumbent and entrant). Firm A's first-order condition for profit maximization is given by

$$1 - \Phi(P^\circ) - \phi(P^\circ) \left(p_A^\circ + \frac{\big(1 - \Phi(P)\big)^2}{\phi(P)} - \frac{\Phi(P)^2}{\phi(P)} \right) = 0$$

Since the equilibrium is symmetric, $P^\circ = 0$ and $p_A^\circ = p_B^\circ = p^\circ$, and hence

$$\begin{aligned} p^\circ &= \frac{1 - \Phi(0)}{\phi(0)} + \frac{\Phi(P)^2}{\phi(P)} - \frac{\big(1 - \Phi(P)\big)^2}{\phi(P)} && (26) \\ &= \frac{1 - \Phi(0)}{\phi(0)} - \frac{1 - 2\,\Phi(P)}{\phi(P)} && (27) \end{aligned}$$

Plugging (26) back into the value function, I get

$$v^\circ = \frac{1}{1 - \delta^2} \left(\frac{\Phi(0)^2}{\phi(0)} + \frac{\Phi(P)^2}{\phi(P)} \right)$$

Consider now a potential entrant that arrives at a random t. If t is even, then such entrant will receive v. If t is odd, then the entrant gets δ times v. In expected terms, the entrant gets

$$v = \frac{1}{2}\, v^\circ + \frac{1}{2}\, \delta\, v^\circ = \frac{1}{1 - \delta}\, \frac{1}{2} \left(\frac{\Phi(0)^2}{\phi(0)} + \frac{\Phi(P)^2}{\phi(P)} \right) \tag{28}$$

where P is given by (25).

Next, I compare the equilibria with staggered and with synchronous contracts. Let G stand for staggered contracts and Y for synchronous contracts. From (21) and (25), we see that

$$\begin{aligned} P^g + \frac{2\,\Phi(P^g) - 1}{\phi(P^g)} &= -(1+\delta)\,(c_1 - c_2) \\ P^y + \frac{2\,\Phi(P^y) - 1}{\phi(P^y)} &= -2\,(1+\delta)\,(c_1 - c_2) \end{aligned}$$

Assumption 2 implies that $0 > P^g > P^y$. Moreover, from (23) and (28), we see that

$$v_e^g = \frac{1}{1-\delta}\,\frac{\Phi(P^g)^2}{\phi(P^g)}$$

$$v_e^y = \frac{1}{1-\delta}\,\frac{1}{2}\left(\frac{\Phi(0)^2}{\phi(0)} + \frac{\Phi(P^y)^2}{\phi(P^y)}\right)$$

Notice that, as $c_1 - c_2 \to \infty$, both P^y and $P^g \to -\infty$, which in turn implies that $v_e^g \to 0$ whereas $v_e^y \to \frac{1}{8\,(1-\delta)\,\phi(0)} > 0$. ■

■ **Syncrhonous contracts with sequential sales.** Alternatively, I could consider an extensive form with sequential sales: Nature determines an ordering of buyers. Then both sellers simultaneously set prices to be paid by the first buyers. After the first buyer chooses one of the sellers, the sellers simultaneous set prices for the second buyers, who then picks one of the sellers.

Considered the subgame that begins with setting prices for the second buyers. Denote by incumbent (index i) the sellers who made the first sale and entrant (index e) the one who did not. If the incumbent seller makes the second sale, then its payoff is given by

$$\widetilde{p} + p_i - 2\,c_2$$

where $\widetilde{p}$ is the period price of the contract with the first buyer (a contract to which buyer and seller are locked in). If the entrant makes the second sale then the incumbent's payoff is

$$\widetilde{p} - c_1$$

Similarly, the entrant's payoff in case the entrant makes the second sale is given by

$$p_e - c_1 \tag{29}$$

whereas the entrant's payoff if the incumbent makes the second sale is zero. By equating payoff from making a sale and payoff from not making a sale, I obtain the sellers' minimum prices. They are given by

$$p_i^\circ = 2\,c_2 - c_1$$

$$p_e^\circ = c_1$$

Assumption 1 implies that $p_i^\circ < p_e^\circ$. It follows that the seller who makes the first sale also makes the second sale, specifically, sets a price c_1 for the second sale. This implies that, by making the first sale for a price p, a seller expects a continuation payoff of

$$p + c_1 - 2\,c_2$$

whereas missing the first sale means missing the second one as well, for a payoff of zero. It follows that (both) firms set a price of $2\,c_2 - c_1$ for the first sale. All in all, the average price in the sequential sales model is given by

$$\overline{p} = \frac{1}{2}\big(2\,c_2 - c_1\big) + \frac{1}{2}\,c_1 = c_2$$

In other words, from the point of view of average price it does not matter whether sales are simultaneous or sequential. Buyers do care: in particular, it's better to be the first buyer than to be the second buyer.

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