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A note on forward contracts in leader-follower games

Monica Bonacina
IEFE, Bocconi University

Anna Creti
IEFE, Bocconi University and EconomiX, Université Paris Ouest

Abstract

This note shows that the pro-competitive effect of pre-commitments is robust to Stackelberg-like market structures. Although our results are in line with Allaz and Vila (1993), the two equilibria differ substantially. Sequential interactions foster a monopolization of the contract market and a redistribution of market shares - and hence of profits - towards the follower. Offsetting strategies in the sense of Bain (1949a) can then occur. The use of forward sales to exclude the rival in the output market requires the leader to have a strategic advantage in the contract market, as well as some conditions on the technological structure of the industry.

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1 Introduction

To date, the effect of the forward market on an output market is controversial. By studying the strategic motive for precommitting, Allaz and Vila (1993) have demonstrated that a contract stage taking place before the output market, yields pro-competitive effects in Cournot setting. Once forward trading is allowed, profit maximizing producers pre-commit to obtain leadership advantages. As long as contracts are binding and observable by competitors, they are used to signal Stackelberg attitudes in the output market. However, although one-sided precommitments would effectively give a Stackelberg advantage, two-sided ones do not. Since everybody pre-commits, each producer becomes more aggressive in the product market, and no one succeeds in acquiring an effective leadership. Here stands the *prisoner's dilemma* effect. Contracts reduce mark-up, increase production thus leaving producers worse-off. These results are challenging, especially for strategic industries, as for instance electricity and gas markets, where on one side, concentration is a main concern and, on the other, several forms of forward contracts exist (either physical or financial, exchanged in standardized marketplaces or over the counter).

From Allaz and Vila (1993, henceforth AV) on, the reliability of the setting and the robustness of related findings have been questioned to various extent. Models that endogenize capacity choice (Adilov, 2005), alter competition modes by using supply function (Green, 1999) or exclude observability of players' actions (Hughes and Kao, 1997) have shown that market players may be reluctant in trading forward when the participation is voluntary. In these frameworks, the pro-competitive effect of contracts does not realize. Green (2003) has proved that risk-averse retailers soften the *prisoner's dilemma* type of effect and limit competition in the output market. Finally, Mahenc and Salanie (2004) have argued that the use of pre-commitments by Bertrand producers favours the upsurge of market power and forward trading becomes an anti-competitive device. Despite the progress made,[1] several aspects of spot-forward interactions remain to be investigated. This note concerns the effectiveness of forward contracts as mitigating devices in industries where one firm has a first-mover advantage over its competitors in the output market, an issue that has not been addressed so far by the literature. Our analysis is of interest as long as Stackelberg-like market structures may exists for several reasons. For instance, Etro (2008) notices that exogeneity of the leadership "can be a realistic description for markets with established dominant firms or where entry at an earlier stage was not possible for technological or legal reasons, for liberalized markets that were once considered natural monopolies or those where intellectual property rights play an important role". To take into account pre-existing strategic advantage of the dominant firm, we slightly alter AV setting, by assuming that the follower has to recover some exogenous sunk cost. This hypothesis proves useful to understand whether the leader has incentives to engage in predatory practices.(i.e. to expand its production up to the point where the follower does not recover fixed costs).

We show that forward markets are exposed to monopolization of a unique active market player, an innovative result neglected by existing theoretical models but for example claimed by competition authorities monitoring forward trades in energy markets.[2] The

[1] Some experimental and empirical support to AV's predictions is in Wolak (2002), Le Coq & Orzen (2006), Brandts *et al.* (2008). For a detailed description of the literature from AV on, see Bonacina *et al.* (2008).

[2] See the analysis on gas and electricity markets in EC-DG Competition (2007).

asymmetric timing in the output market corresponds to an asymmetric behavior in the forward stage. Despite this monopolization, Stackelberg competition with contracts leads to a higher consumer surplus and under some assumption on demand and costs, it may be Pareto superior to the same situation without forward trading. Contracts cause a redistribution of profits from the leader to the follower such that the first-mover advantage vanishes. To counteract the pro-competitive effect of forward contracts, the leader can intervene in the contract market to exclude the rival from the product market. In this context, limit pricing - in the sense of Bain (1949a,b) - can occur. However, there is an essential - non trivial - prerequisite to this strategy: the Stackelberg producer has to strengthen its strategic advantage and extends its leadership position to the contract market. If this condition is met, the leader might monopolize both the spot and the contract markets, depending on the technological structure of the industry. Interestingly, we prove that even in this scenario, forward contracts improve consumer surplus with respect to the standard Stackelberg game.

Although de facto forward contract might become a barrier to entry, our results differ from Aghion and Bolton (1987) for two main reasons. First, both players can freely contract forward and if they don't, this is due to profit maximizing rules and strategic interactions. Second, as long as one player is active in the forward market, no matter whether the leader or the follower, consumers surplus always increases with respect to the standard game without contracts.

This note is organized as follows. Section 2 sets up the model and derives Stackelberg equilibria with and without forward markets. Section 3 discusses the conditions for (and limits to) predatory conducts and investigates the related effects. Final remarks are in Section 4.

2 Stackelberg leadership with simultaneous forward contracting game

We consider a duopolistic industry (i.e. $i = 1, 2$) supplying a homogeneous commodity (q_i) in a sequential mode. Competition is in quantity and one of the firms move first by choosing its production level before the competitor. We use the downscript l to denote the Stackelberg leader and the downscript f for the follower.

Agents are risk neutral and perfectly informed; demand is linear ($p = a - q_f - q_l$ where $a > \max\{c_i\}$). Production cost functions are heterogeneous and linear in their argument ($C_i(q_i) = c_i q_i + F_i^2$ where $i = l,\ f,\ c_i > 0,\ F_l = 0$ and $F_f \geq 0$). Notice that we slightly alter the AV setting by assuming asymmetric marginal cost and introducing a sunk cost paid by the follower to enter the market.

Given profits $\Pi_i = pq_i - C_i(q_i)$, it is straightforward to demonstrate that the Stackelberg outcome in the output market (without forward contracts) is characterized as follows:

$$q_l^s = \tfrac{a-c_l-\Delta}{2} \quad , \quad q_f^s = \tfrac{a+2\Delta-c_f}{4} \tag{1}$$

$$\text{and} \qquad p^s = \tfrac{a+2\Delta+3c_f}{4}. \tag{2}$$

We assume that sunk costs F_f are such that the Stackelberg equilibrium realizes (*i.e.* it is strictly preferred to standard limit pricing and gives non-negative payoffs):

$$\Pi_f(q_l^s, q_f^s) > 0 \Leftrightarrow F_f < \tfrac{a-c_f}{4} + \tfrac{\Delta}{2} \ , \tag{3}$$

where $\Delta = c_l - c_f$ measures the efficiency gap. Results are obtained for generalized production efficiencies (i.e. Δ may be both positive or negative).

The Stackelberg game whose outcome is given by (1), under the condition (3), serves as a benchmark to assess whether contracts modify production by the leader and the follower, as well as the commodity price. To this end, we add a forward stage as in AV. The sequential structure of the production stage does not extend to the contract market where duopolists interact simultaneously: the follower has the same right to contract as the leader.

The full game consists of the following sequence of moves:

1. in the first stage, each duopolist chooses its trading position, f_l and f_f;
2. in the second stage, the leader sets q_l;
3. in the last period, the follower chooses q_f.

The game is solved by backward induction and results are obtained for the physical delivery of the underlying commodity.

Proposition 1. *Sequential interaction in the output market leads to monopolization of the forward market by the follower.*

Proof. Players set their optimal trading position (i.e. f_i^*) by anticipating the profit maximizing - sequentially selected[3] - output levels. Therefore in the production stage, where forward variables (i.e. the contract price, P, and the trading positions f_i) are fixed and profits are $\Pi_i = pq_i - C_i(q_i) - (p-P)f_i$ $(i = l, f)$, players' maximization problems are

$$\max_{q_f}\{\Pi_f(f_f, q_l, q_f)\} \quad \text{and} \quad \max_{q_l}\{\Pi_l(f_l, q_l, q_f(f_f, q_l))\} \tag{4}$$

which give

$$\tilde{q}_f(f_f, f_l) = \left\{q_f^s + \tfrac{3f_f - f_l}{4} \text{ if } \tfrac{\mu}{4} \geq F_f;\ 0 \text{ oth.}\right\} \quad \text{and} \quad \tilde{q}_l(f_l, f_f) = q_l^s + \tfrac{f_l - f_f}{2}. \tag{5}$$

where $\mu = q_f^s - f_f - f_l$. Equation (5) gives the equilibrium quantities in the second stage game as a function of contracts coverage, and q_f^s, q_l^s are defined by (1). Moving backward to the contract market, excluding arbitrage profits (i.e. $p = P$) and resolving for the profit maximizing contract coverage, we obtain the forward quantities at equilibrium (f_l^* and f_f^*) and, by substitution in (5), the related production levels' (q_l^* and q_f^*). Formally the symmetric maximization problem is

$$f_i = \arg\max_{f_i}\{\Pi_i(\tilde{q}_f, \tilde{q}_l)\} \qquad i = l, f \ ; \tag{6}$$

and resolving the system of FOCs we get

$$f_l^* = 0 \quad , \quad f_f^* = \tfrac{a - c_f + 2\Delta}{3} \quad , \quad q_l^* = \tfrac{a - c_l - \Delta}{3} \quad \text{and} \quad q_f^* = \tfrac{a - c_f + 2\Delta}{2} \tag{7}$$

if sunk costs are moderate (i.e. if $f_f^* \geq 2F_f$), and

$$f_l^* = 0 \quad , \quad f_f^* = a - c_f + 2\Delta - 4F_f \quad , \quad q_f^* = 4q_f^s - 3F_f \quad \text{and} \quad q_l^* = 2(F_f - \Delta) \tag{8}$$

[3] Stackelberg competition realizes in the spot market.

if they are high (i.e. if $f_f^* < 2F_f$). ■

Consistently with AV, once the forward game is set up, strategic motives explain the participation to forward markets. The follower commits to recover some market share and to obtain a Stackelberg-like advantage in the output market. The leader's behavior, instead, differs from what AV would have predicted: no contract coverage, thus yielding asymmetric commitments and monopolization of forward markets. Given the sequential structure of the game, the first-mover anticipates the pro-competitive potential of trading (i.e. $\partial Q/\partial f_i > 0 \ \forall i$) and sustains output market prices by giving up forward transactions. This result is challenging to the extent that although everybody can commit, the second-mover only does so, becoming more aggressive in the product market and thus counterbalancing the leadership of the competitor.

Notice that high fixed costs decrease follower's contracts and production but in any case the follower is the only participant to the trading game ($f_l^* = 0$, $f_f^* > 0$). The monopolization of the contract market is a new issue in the literature on forward-spot interactions but it does not exclude positive effects: contracts increase consumer surplus and lower mark-ups. The issue is formalized in Corollary (1).

Corollary 1. *Stackelberg competition with contracts always yields a higher consumer surplus and may be Pareto superior to the same without forward trading.*

Proof. Recalling the results in Propostion (1), industry's payoffs (Π) without and with contracts, respectively, are:

$$\Pi_l^s + \Pi_f^s \quad \text{and} \quad \Pi_l^* + \Pi_f^* = \Pi_l^s + \Pi_f^s - f_f^* \tfrac{\Theta}{8}, \tag{9}$$

where $f_f^* = \{(a - c_f + 2\Delta)/3$ if $(a - c_f + 2\Delta) \geq 6F_f$; $a - c_f + 2\Delta - 4F_f$ oth.$\}$, $f_f^* \geq 0$ and $\Theta = 5f_f^*/2 - 4\Delta$. Similarly, consumers' surplus (CS) under Stackelberg competition without and with forward trading are respectively as follows:

$$CS^s = \tfrac{Q^s \times Q^s}{2} \quad \text{and} \quad CS^* = \tfrac{Q^* \times Q^*}{2} = CS^s + \tfrac{f_f^*}{8}\Lambda \ , \tag{10}$$

where $Q = q_l + q_f$ and $\Lambda = 2Q^s + f_f^*/4$.

The effect of pre-commitments on consumer surplus is unambiguous ($f_f^* \geq 0$ is sufficient to have $\Lambda > 0$, by which $CS^* > CS^s$). Producers are better-off or worse-off depending on Θ. A necessary condition for the economy to gain from the set up of a forward stage is:

$$\Pi_l^* + \Pi_f^* + CS^* > \Pi_l^s + \Pi_f^s + CS^s \implies \Lambda - \Theta > 0 \ . \tag{11}$$

If Θ is low enough, contracting increases total welfare. ■

Despite the monopolization of forward markets and the success of the second-mover in acquiring some leadership at the production stage, we find an overall pro-competitive effect: contracts leave consumers better-off. This result is robust to the technological structure of the industry. A quite intuitive result follows: Stackelberg competition in quantities with commitments is Pareto superior to the same without forward trading as long as contracts redistribute outputs to the most efficient producer. Notice that a sufficient but non necessary condition for eq. (11) to hold is:

$$2Q^s + \tfrac{f_f^*}{4} - \tfrac{5}{2}f_f^* + 4\Delta \geq \tfrac{3}{4}(a - c_l + 3\Delta) > 0 \ \Rightarrow \ \Delta \geq 0 \ , \tag{12}$$

which indicates a higher technological efficiency of the follower.

As for individual profits, the following Corollary (2) applies.

Corollary 2. *Contracts decrease leader's profit but leave the second-mover better-off.*
Proof. Proof is straightforward. We compute the payoffs of the leader without (Π_l^s) and with contracts (Π_l^*) respectively:

$$\Pi_l^s = (p^s - c_l) \times q_l^s \quad \text{and} \quad \Pi_l^* = (p^* - c_l) \times q_l^* \ . \tag{13}$$

Rearranging equation (5), we get:

$$q_l^* = q_l^s - \tfrac{f_f^*}{2} < q_l^s \quad \text{and} \quad p^* = p^s - \tfrac{f_f^*}{4} < p^s \quad \text{by which} \quad \Pi_l^s > \Pi_l^* \ . \tag{14}$$

Moving to the follower, we have:

$$\Pi_f^s = (p^s - c_f)\, q_f^s - F_f^2 \quad \text{and} \quad \Pi_f^* = (p^* - c_f)\, q_f^* - F_f^2 \tag{15}$$

where $p^* < p^s$ but $q_f^s < q_f^s + 3f_f^*/4 = q_f^*$. The second-mover benefits from the set up of a contract market if

$$f_f^* \leq \tfrac{2}{3}\left(a - c_f + 2\Delta\right). \tag{16}$$

Given that

$$f_f^* = \left\{ \tfrac{a-c_f+2\Delta}{3} \text{ if } \tfrac{a-c_f+2\Delta}{3} \geq 2F_f;\ a - c_f + 2\Delta - 4F_f \text{ oth.} \right\}, \tag{17}$$

condition (16) always holds. Therefore, whatever the actual contract coverage of the competitor, $\Pi_f^* > \Pi_f^s$. ■

Interestingly, the monopolization of the contract market by the follower causes a redistribution of profits which advantages the second-mover and hurts the Stackelberg leader. This outcome realizes as the first-mover, anticipating rival's behavior, is forced to sustain the output price by moving away from the contract market and this costs him its leadership. This result is robust to several degree of cost heterogeneity.

The uneven distribution of profits may favour predatory conducts that attempt to exclude the follower from the output market, as we discuss in the next Section.

3 Stackelberg leadership with sequential forward contracting game

We have formalized above that the Stackelberg game in quantity with contracts leave the first-mover worse off. The leader may counteract this effect by adopting predatory practices - as it is usually claimed by competition authorities - to exclude its competitor from the production process. This Section discusses pre-conditions to these strategies and related outcomes.

As a preliminary remark, we notice that the setting in Section 2 rules out exclusionary practices, as long as limit pricing does not hold. Production decisions depend on forward contracts; hence to be successful in excluding the rival at the spot stage, the leader must intervene the contract market, but a problem arises. At the forward stage there is no leadership advantage. Therefore simultaneity in forward choices is sufficient to hinder predatory practices. Since the leader cannot control the follower's contract coverage, exclusion is unfeasible.

An essential and tricky prerequisite to predatory practices is the extension of the leadership advantage of the Stackelberg producer to each market. Therefore, in this

Section the full-game's sequence of moves modifies as follows. In the contract stage, the Stackelberg leader chooses its trading positions, f_l, which is observed by the follower before setting f_f. Similarly, in the production game, the leader sets q_l before the follower chooses q_f.

Under such hypothesis, the question we ask now is whether forward contracts may be used to exclude the rival from the production process. Predatory practices in the full game are formalized in Proposition (2); profitability considerations follow (Corollary 3).

Proposition 2. *Exclusion of the follower in the output market requires monopolization of the forward market by the leader.*

Proof. Resolution is by backward induction. The reaction functions at the spot stage equal those in (5). Therefore, turning back to the contract market and recalling that the leader anticipates the follower's best-reply (i.e. $f_f(f_l) = (a + 2\Delta - c_f - f_l)/3$), we obtain the following - finite and non negative - contract coverage

$$f_l^p = a - c_f + 2\Delta - 2\sqrt{3}F_f \quad \text{and} \quad f_f^p = 0 \tag{18}$$

where the superscript '^{p}' is used for equilibrium variables and, by substitution in (5), the related production levels

$$q_l^p = a - c_f - \sqrt{3}F_f \quad \text{and} \quad q_f^p = 0 \ . \tag{19}$$

Therefore to blockade entry, the Stackelberg leader must participate to the forward stage and monopolize this market. ■

Proposition (2) states that exclusion of the rival might be obtained throughout contracts' monopolization. Depending on demand and cost parameters, either the dominant producer may take f_l^p and monopolizes both the output and the contract market or accommodate the rival getting Π_l^*, as the following Corollary points out.

Corollary 3. *(Sufficient) If $\Delta < 0$, the leader participates and monopolizes the forward market.*

Proof. Participation to the contract stage is strictly preferred by the first-mover if it gives a higher payoff. Formally:

$$\Pi_l^p > \Pi_l^* \quad \text{if} \quad \varepsilon_p = \tfrac{q_l^p - q_l^*}{q_l^*} \tfrac{p^*}{p^* - p^p} > \tfrac{q_l^p}{q_l^*} \tag{20}$$

where ε_p is the elasticity of output market demand along the relevant interval. After some rearrangements we obtain the following sufficient condition on sunk costs,

$$F_f > \Delta \tfrac{2+\sqrt{3}}{4\sqrt{3}-3}, \tag{21}$$

which holds when $\Delta < 0$. ■

Corollary (3) confirms an intuitive result: if the leader is more efficient than the follower (that is $\Delta < 0$) predatory practices are likely. Although strategic motives lead to monopolization of forward trading, the operation of contract markets improves consumers surplus, as Corollary (4) shows.

Corollary 4. *Despite predatory practices, Stackelberg competition in quantities with contracts yields a higher consumer surplus than the same without forward trading.*

Proof. Proof is straightforward given the following condition

$$CS^p = \tfrac{1}{2}\left(q_l^p\right)^2 > CS^s = \tfrac{1}{2}\left(Q^s\right)^2 \quad \text{if} \quad \sqrt{3}F < \tfrac{a - c_f + 2\Delta}{4} \ , \tag{22}$$

which always holds by Proposition (2). ■

4 Final remarks

Our analysis proves that the pro-competitive effect of precommitments is robust to Stackelberg-like market structures. Contracts mitigate market power even when one of the duopolist has a strategic advantage in the output market, increasing consumers' surplus. However, this comes at the cost of having a monopolization of the forward market and increasing the profit of the follower. The use of forward sales to exclude the rival in the output market requires the leader to have a strategic advantage in the contract market and possibly to be the most efficient firm. Both these result show that beside the pro-competitive effect, the operation of the contract market is strongly affected by firms' asymmetries, as also pointed out by Lisky and Montero (2008).

Future research in exploring the role of contracts in leader-follower games could include the analysis of price competition with differentiated product or the extension to financial contracts that allow the dominant firm to strategically buy forward to preserve its market power.

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