Extended Games Played by Managerial Firms[1]

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Abstract

The issue of timing is addressed in a game between managerial ¯rms. The choice over timing can be taken either by managers or by entrepreneurs. It is shown that (i) delegation drastically modi¯es the owners' preferences concerning the distribution of roles, as compared to the setting where ¯rms act as pure pro¯t-maximizers; and (ii) the ability of moving ¯rst in the market game entails that, at least observationally, the owner of the leading ¯rm prefers not to delegate. I show that the choice of the timing by managers entails the same pro¯t owners would achieve by specifying the timing in the delegation contract.

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1 Introduction

The earliest literature in oligopoly theory treated the choice between simultaneous and sequential moves as exogenous (Stackelberg, 1934; Fellner, 1949). Later contributions investigated the preferences of pro¯t-maximizing ¯rms over the distribution of roles (Gal-Or, 1985; Dowrick, 1986; Boyer and Moreaux, 1987a,b). The preference for leadership (respectively, followership) in quantity (price) games can be established on the basis of the slope of ¯rms' reaction functions or, likewise, resorting to the concepts of strategic substitutability or complementarity between products (Bulow et al., 1985).[1]

Recent literature explicitly models the strategic choice of timing. Hamilton and Slutsky (1990) endogenize the choice of roles in noncooperative two-person games, by analyzing an extended game where players (say, ¯rms) are required to set both the actual moves or actions and the time at which such actions are to be implemented. When ¯rms choose to act at di®erent times, sequential equilibria obtain, while if they decide to move at the same time, simultaneous Nash equilibria are observed. The choice of timing occurs in a preplay stage which does not take place in real time, so that there is no discounting associated with waiting. Matsumura (1995) analyses endogenous timing in a two-stage strategic commitment game where the decision upon a cost-reducing investment is followed by Cournot competition at the market stage (as in Brander and Spencer, 1983). Matsumura shows that the extended game has a unique equilibrium involving both ¯rms setting output levels at the earliest occasion. Another application of HS's box of tools is in Lambertini (1996), where a market is considered where at least one ¯rm is labor-managed (LM). It is shown that, when an LM ¯rm competes against a pro¯t-maximizing counterpart in a Cournot fashion, the pro¯t seeker takes the lead.

As to the interplay between market competition and the internal organization of the ¯rm, several contributions show that, in order to acquire the Stackelberg leader's position in the product market, ¯rms' stockholders delegate the control over their assets to managers who end up maximizing an objective function consisting in a weighted sum of pro¯ts and sales (Vickers, 1985; Fershtman and Judd, 1987; Sklivas, 1987; Fershtman et al., 1991; Polo and Tedeschi, 1992; Barcena-Ruiz and Paz Espinoza, 1996). In a Cournot setting, the equilibrium indeed involves all ¯rms delegating control in order to try and achieve a dominant position. Each ¯rm would prefer the rivals not to delegate, the equilibrium being a®ected by a prisoner's dilemma. Basu (1995) extends the basic model to explicitly describe the owner's decision to hire a manager in a Cournot duopoly.[2] He shows that a Stackelberg equilibrium may arise, with just one ¯rm delegating,

[1] On the role of cost asymmetry, see Ono (1982).

[2] Another incentive to hire managers not necessarily aligned with the owners' objectives may derive from the owners' attempt at colluding (Lambertini and Trombetta, 1997).

even though the cost of hiring an agent is the same across owners. However, no attention has been devoted so far to the question whether the endogenous choice of roles by managerial firms may actually lead to situations where these firms move sequentially in the market game. Moreover, a question mark arises as to whether the separation between ownership and control may affect owners' preferences over the distribution of roles in price or quantity games.[3]

These issues are tackled here in a model where firms supply substitute goods (Singh and Vives, 1984). I assume that principals delegate to agents the price or output decisions and instruct them to move early or delay as long as possible, on the basis of the profit ranking associated with the mutually exclusive roles of Stackelberg leader, Stackelberg follower or Nash competitor. First, the managerial preferences over timing are analysed. I show that they coincide with the preferences characterizing pure profit-maximizing agents. This is due to the fact that delegation is observationally equivalent to a parallel shift of the demand function which does not affect the sequence of payoffs arising under simultaneous and sequential play. When the owners' preferences over the distribution of roles are examined, two main results emerge. Under Cournot competition, the Nash equilibrium breaks as usual the sequence of the payoffs associated with the Stackelberg equilibrium, though the latter are reversed as compared to the setting where no delegation takes place. The leader cannot do any better than she is already doing, in that delegation does not add anything to the position acquired by moving first, given that the two decision are observationally equivalent. On the other hand, the follower can profitably shift outwards her reaction function by hiring a manager. This entails that delegation becomes a free-riding device allowing the follower to produce more and gain higher profits than the leader. In the case of Bertrand competition, from the owners' viewpoint leadership is preferred to followership, and both are better than being a Nash competitor. Thus, once again, the payoffs emerging from sequential play are reversed as compared to the usual sequence, while still being both higher than the profit associated with simultaneous play.

The remainder of the paper is organized as follows. Section 2 introduces the basic setting. Section 3 deals with the game of timing between managers. The owners' preferences are discussed in section 4. Section 5 concludes.

2 The model

I adopt a simplified version of the linear duopoly model introduced by Dixit (1979) and then used by Singh and Vives (1984) and many others. Two symmetric firms compete on a market for differentiated products, supplying one good each. The

[3] The picture could be enriched by considering a fully-fledged decision problem involving the choice of internal organization of the firm, timing, strategic market variable, and finally the actual competition at the market stage. This is done in Lambertini (1997).

inverse demand function faced by firm i is

$$p_i = 1 - q_i - \gamma q_j; \qquad (1)$$

where $j \neq i$ denotes i's rival, and $|\gamma| \leq 1$. When $\gamma \in [-1, 0[$ the two goods are complements, while in the range where $\gamma \in]0, 1]$ they are substitutes. In the remainder of the paper, I shall confine to the latter case, since once one avails of the results pertaining to substitute goods, a simple reversion gives those pertaining to the case of complements. From (1), the direct demand function for firm i can be easily obtained:

$$q_i = \frac{1}{1+\gamma} - \frac{1}{1-\gamma^2} p_i + \frac{\gamma}{1-\gamma^2} p_j. \qquad (2)$$

I assume firms operate with the same technology, characterized by a constant marginal production cost. Without loss of generality, I normalize it to zero. Consequently, profits coincide with revenues,[4] $\pi_i = p_i q_i$.

Firms can choose whether to move at the same time or scatter their respective decisions. If they decide to move simultaneously, no matter whether early or late, a Nash equilibrium in prices or quantities (or mixed) obtains. If, conversely, they move sequentially, then a Stackelberg equilibrium is observed. This is what Hamilton and Slutsky (1990) define as an extended game with observable delay.[5] In order to illustrate this concept, consider the simplest extended game where firms can set a single strategic variable (e.g., price or quantity) and must choose between moving first or second. I shall adopt here a symbology which largely replicates that in HS (1990, p. 32). Define $\Gamma^1 = (N; \Sigma^1; \Omega^1)$ the extended game with observable delay. The set of players (or firms) is $N = \{A, B\}$, and α and β are the compact and convex intervals of R^1 representing the actions available to A and B in the basic game. Ω^1 is the payoff function. Payoffs depend on the actions undertaken in the basic (market) game, according to the following functions, $a : \alpha \times \beta \to R^1$ and $b : \alpha \times \beta \to R^1$. The set of times at which firms can choose to move is $T = \{F, S\}$, i.e., first or second. The set of strategies for player i is $\Sigma^1_i = \{F, S\} \times R^1 \times \Psi_i$, where Ψ_i is the set of functions that map $T \times \beta$ (or α) into α (or β). Let $k = (n; l; f)$ define the role (Nash competitor, leader and follower, respectively) that firm i plays as a result of the combined choice of timing taken by the two firms. If both firms choose to move at the same time, they obtain the payoffs associated with the simultaneous Nash equilibrium, $(a^n; b^n)$, otherwise they get the payoffs associated with the Stackelberg equilibrium, e.g.,

[4] A more general formulation of the profit function would be $\pi_i = (A - q_i - \gamma q_j - c) q_i$. Observe that, as long as a constant marginal cost c is assumed, $A - c$ simply exerts a scale effect, so that its normalization has no qualitative bearings on the results.

[5] They also consider an extended game with action commitment, where an agent can play early only by selecting an action to which he is then committed. The undominated equilibria of such a game always involve sequential moves. This game is close in spirit to Robson (1990).

$(a^l; b^f)$ if A moves ¯rst and B moves second, or vice versa. The game can be described in normal form as in matrix 1 (cfr. HS, 1990, p. 33).

		B	
		F	S
A	F	$a^n; b^n$	$a^l; b^f$
	S	$a^f; b^l$	$a^n; b^n$

Matrix 1

Moreover, ¯rms' stockholders may decide whether to delegate control to managers who are not interested in pro¯t maximization as such, as they own no share, but rather in sales, so that in case of managerialization ¯rm i's maximand modi¯es as follows:[6]

$$M_i = ¼_i + µ_i q_i; \quad (3)$$

where parameter $µ_i$ identi¯es the weight attached to the volume of sales, and is optimally set by the stockholder in the employment contract, in order to maximize pro¯ts (Vickers, 1985). As to $µ_i$; one might believe that it should be natural to think of it as being positive. For reasons that will become clear in the remainder of the paper, I assume $µ_i$ 2 R . Managerial remuneration is a two-part wage, where a component is exogenously ¯xed and the other is increasing in output (see Fershtman and Judd, 1987; and Basu, 1995).

3 The game of timing between managers

The game where managers are delegated both the choice of the output level and the choice of timing can be quickly dealt with. The objective function of the managers at the market stage can be rewritten as follows:

$$M_i = (p_i + µ_i) q_i: \quad (4)$$

This entails that delegation mimics a shift in the demand function.[7] It is trivial to verify that the payo®s M_i^k; where k indicates the role, are ordered according to the same ranking as pro¯ts would be if the game of timing where played by entrepreneurs, without delegation, as in HS. This holds independently of the strategic variable being ¯xed by each ¯rm, so that we have

$$M_i^l(C) > M_i^n(C) > M_i^f(C); \quad (5)$$

[6]Considering a linear contract only is restrictive, but this assumption is adopted for the sake of comparability with most of the existing literature.

[7]If unit production cost were not normalized to zero, delegation could as well be interpreted as a shift of the cost function. The two interpretations are indeed qualitatively equivalent. The direction of such shifts depends on the sign of µ, which is discussed below.

$$M_i^f(B) > M_i^l(B) > M_i^n(B); \tag{6}$$

where the letter in parenthesis indicates whether firms are Cournot or Bertrand agents. As a result, managerial preferences concerning the distribution of roles are $l(C) \succ n(C) \succ f(C)$ and $f(B) \succ l(B) \succ n(B)$: The outcome can be summarized as follows. When managers are being delegated both the output and the timing decision, the extended game with observable delay has (i) a unique subgame perfect equilibrium in pure strategies, if both firms act as quantity-setters; (ii) a unique subgame perfect equilibrium in pure strategies, up to a permutation, plus a correlated equilibrium and a mixed-strategy equilibrium, if both firms act as price-setters.[8] Now the following question arises: if, say, the owner of firm i anticipates that the manager of his firm will move early (or will delay, respectively), then will he indeed allow any modification of the output level through θ_i on the part of his manager, as compared to what would be required by strict profit maximization? This issue is tackled in the following section.

4 The stockholders' perspective

In order to answer the question raised above, consider what happens in the two possible epiphanies of the Cournot setting. To start with, take the case in which managers play the Cournot-Nash equilibrium due to the fact that they delay the output decision as long as possible. The first order condition (FOC) for firm i is

$$\frac{\partial M_i(C)}{\partial q_i} = 1 - 2q_i - \gamma q_j + \theta_i = 0; \tag{7}$$

where $(q; q)$ reveals that both firms are quantity-setters. This yields

$$q_i^n(C) = \frac{2 + 2\theta_i - \gamma - \gamma\theta_j}{4 - \gamma^2}; \tag{8}$$

when $\gamma = 1$, i.e., goods are perfect substitutes, (9) obviously coincides with Vickers' finding (see Vickers, 1985, p. 142). The profit function simplifies as follows:

$$\pi_i(\theta_i; \theta_j) = \frac{(2 - 2\theta_i - \gamma - \gamma\theta_j + \gamma^2\theta_i)(2 + 2\theta_i - \gamma - \gamma\theta_j)}{4 - \gamma^2}: \tag{9}$$

The stockholder's FOC w.r.t. θ_i is

$$\frac{\partial \pi_i(\theta_i; \theta_j)}{\partial \theta_i} = \frac{(\gamma^2 - 2)(2 + 2\theta_i - \gamma - \gamma\theta_j) + 2(2 - 2\theta_i - \gamma - \gamma\theta_j + \gamma^2\theta_i)}{4 - \gamma^2} = 0; \tag{10}$$

[8] It can be easily shown that the mixed case where one firm is a quantity-setter, while the other acts as a price-setter yields a unique equilibrium, with the quantity-setter leading.

yielding

$$\theta_i^n(C) = \frac{\gamma^2(2-\gamma)}{\gamma^3-4\gamma^2+8} \tag{11}$$

as the optimal output weight for profit maximization if simultaneous play is expected to occur between managers fixing the level of production in the ensuing market stage. Equilibrium profit turns out as

$$\pi_i^n(C) = \frac{2(2-\gamma^2)}{(\gamma^2-2\gamma-4)^2}. \tag{12}$$

Let me now turn to the Stackelberg game. By symmetry, I confine to the case where the manager of firm j takes the lead, while that of firm i follows. Hence, the leader's problem consists in maximizing $M_j(C)$ subject to the constraint $\partial M_i(q;q)/\partial q_i = 0$, as in (8). The leader's FOC is

$$\frac{\partial M_j(C)}{\partial q_j} = 1 - 2q_j + \gamma^2 q_j - \frac{\gamma}{2}(1+\theta_i) + \theta_j = 0, \tag{13}$$

yielding

$$q_j^l(C) = \frac{2-\gamma(1+\theta_i)+2\theta_j}{2(2-\gamma^2)} \tag{14}$$

as the optimal output for the leader. The profit function at the first stage simplify as follows:

$$\pi_i^f = \frac{(4-2\gamma-\gamma^2-4\theta_i+3\gamma^2\theta_i-2\gamma\theta_j)(4-2\gamma-\gamma^2+4\theta_i-\gamma^2\theta_i-2\gamma\theta_j)}{16(2-\gamma^2)^2};$$

$$\pi_j^l = \frac{(2-\gamma-\gamma\theta_i+2\theta_j)(2-\gamma-\gamma\theta_i-2\theta_j)}{8(2-\gamma^2)}. \tag{15}$$

At this stage, stockholders simultaneously fix their respective θ. The FOCs are

$$\frac{\partial \pi_i^f}{\partial \theta_i} = \frac{4\gamma^2-2\gamma^3-\gamma^4-16\theta_i(1-\gamma^2+3\gamma^4)-2\gamma^3\theta_j}{8(2-\gamma^2)^2} = 0; \tag{16}$$

$$\frac{\partial \pi_j^l}{\partial \theta_j} = \frac{\theta_j}{\gamma^2-2} = 0. \tag{17}$$

As a consequence of (18), $\theta_j^l(C) = 0$, i.e., the stockholder of the firm which is going to take the lead in the ensuing market stage decides that it is optimal not to allow for any output expansion, while

$$\theta_i^f(C) = \frac{\gamma^2(4-2\gamma-\gamma^2)}{16-16\gamma^2+3\gamma^4} \in [0, 1/3] \quad \text{as } \gamma \in [0,1]. \tag{18}$$

Equilibrium profits are

$$\pi_i^f(C) = \frac{(4 - 2\gamma - \gamma^2)^2}{4(16 - 16\gamma^2 + 3\gamma^4)}; \quad \pi_j^l(C) = \frac{(2 - \gamma^2)(8 - 4\gamma - 4\gamma^2 + \gamma^3)^2}{2(16 - 16\gamma^2 + 3\gamma^4)^2}. \quad (19)$$

Evaluating (13) and (20) it can be quickly established that

$$\pi_i^f(C) > \pi_i^n(C) > \pi_i^l(C) \quad \forall \; \gamma \in [0; 1]. \quad (20)$$

The inequalities in (21) reveal that the relevant payoff sequence emerging from the quantity game where both firms are managerial is reversed as compared to the ranking observed when firms strictly behave as profit-seeking units. This implies that, from the owners' viewpoint, the preferences over the distribution of roles turn out to be reversed as well, so that the delegation contract should contain the clause that the manager must move at the latest available occasion, in order to avoid being the leader. This is confirmed by inspection of matrix 2, describing the reduced form of the extended quantity-setting game from the owners' standpoint.

		j: F	j: S
i	F	$\pi_i^n(q;q); \pi_j^n(q;q)$	$\pi_i^l(q;q); \pi_j^f(q;q)$
	S	$\pi_i^f(q;q); \pi_j^l(q;q)$	$\pi_i^n(q;q); \pi_j^n(q;q)$

Matrix 2

The obligation to move late being absent, both managers' decision would be to move first, as we already know from the previous section, with unfortunate consequences for a principal if the manager of the rival firm is indeed compelled to move late by the terms of her hiring contract. Obviously, in equilibrium, the profit accruing to stockholders is the same as long as firms move simultaneously, but to ensure that this is indeed the equilibrium outcome, both managers have to be obliged to behave against their own nature.

The setting where both firms are price-setters can now be briefly depicted. The Bertrand-Nash equilibrium is characterized by:

$$\pi_i^n(B) = \frac{2(1 - \gamma)(2 - \gamma^2)}{(1 + \gamma)(\gamma^2 + 2\gamma - 4)^2}; \quad \theta_i^n(B) = \frac{\gamma^2(\gamma - 1)}{4 - 2\gamma - \gamma^2}. \quad (21)$$

Observe that $\theta_i^n(B) < 0 \; \forall \gamma \in [0; 1[$; while it is nil in the case of perfect substitutability. Hence, price competition leads the owners to design the optimal delegation contract so as to generate output restriction rather than expansion.[9] When, say, firm j takes the lead in the market stage, the relevant equilibrium magnitudes are

$$\pi_i^f(B) = \frac{(1-\gamma)(\gamma^2-2\gamma-4)^2}{4(4-\gamma^2)(1+\gamma)(3\gamma^2-4)^2}; \quad \theta_i^f(B) = \frac{\gamma^2(\gamma-1)(4+2\gamma-\gamma^2)}{16-16\gamma^2+3\gamma^4}; \tag{22}$$

$$\pi_j^l(B) = \frac{(1-\gamma)(2-\gamma^2)(\gamma^3+4\gamma^2-4\gamma-8)^2}{2(\gamma-2)^2(2+\gamma)^2(1+\gamma)(3\gamma^2-4)^2}; \quad \theta_j^l(B) = 0. \tag{23}$$

Again, notice that moving first involve, at least from the observational point of view, no delegation; and $\theta_i^f(B) < 0 \ \forall \gamma \in]0,1[$. Profits can be ordered according to the following ranking:

$$\pi_i^l(B) \geq \pi_i^f(B) \geq \pi_i^n(B) \quad \forall \gamma \in [0,1], \tag{24}$$

so that, contrarily to what is observed under strictly profit-seeking behaviour, leading is at least weakly preferred to following. Nevertheless, obviously, the extended game with observable delay, as seen with the owners' eyes, still has two subgame perfect equilibria in pure strategies, namely, (F,S) and (S,F), together with a correlated equilibrium and a mixed-strategy equilibrium. The explanation of the reversal of fortune between leader and follower under Bertrand competition is largely analogous to the one underlying Cournot competition. The above findings concerning the timing game between owners can be summarized in the following:

Proposition 1 When managers are being delegated only the market decision, while the choice of timing remains in the stockholders' hands, the extended game with observable delay observationally exhibits the same subgame perfect equilibria arising if both decisions were delegated to managers.

It can be shown that the same also holds in the mixed setting where one firm is a quantity-setter while the other is a price-setter. Irrespectively of the market variable, delegation and the ability to move first are observationally equivalent, or, in the jargon of demand theory, perfect substitutes. This implies that these instruments can be used only alternatively. Hence, if the owner, say, of firm j, anticipates that his manager is going to move first in the market subgame, he also knows that there is no reason to use delegation to achieve the very same goal. The latter consideration can be interpreted in two ways, namely, that $\theta_j^l = 0$ means either that the delegation contract allows for no output expansion at all, forcing the manager to maximize profit only, or that there is no delegation at

[9] It is usually assumed that managers have a preference for output expansion. The above result may hold if one thinks of the population of consumers as consisting of two type of individuals, one having a taste for output expansion, the other for output restrictions.

all and the firm is entrepreneurial. Consider now the follower's behaviour. In the Cournot setting, if the owner of firm i knows that his manager is going to move late in the market stage, he finds profitable to use the delegation device so as to shift his own reaction function outwards. Delegation works thus as a free-riding tool in the hands of the follower. Hence, both owners must oblige their respective managers to move as late as possible, in that moving late is a strictly dominant strategy as far as stockholders are concerned, as in Vickers (1985). In the Bertrand setting, delegation is used by the owner of the firm moving late, to obtain an output restriction. This drives the price of the follower upwards and the follower's profit below the leader's. As long as both firms obtain higher profits under sequential than under simultaneous play, it follows that delegation is irrelevant as far as the choice of timing is concerned.

5 Concluding remarks

The preferences over the distribution of roles when an extended duopoly game is played by managerial firms have been discussed. The main findings are that (i) managers' and stockholders' preferences do not coincide, and yet (ii) it is wise to leave the explicit timing decision out of the delegation contract intentionally, given that the result of strategic interaction between managers is observationally equivalent to the outcome that would emerge at equilibrium if the owners' preferences were literally adhered to. As a final remark, consider the possibility that firms choose the strategic variable for the market subgame. A straightforward implication of the foregoing analysis is that adding a stage to model the choice of the market variable would lead to the same conclusion reached by Singh and Vives (1984), namely, that firms choose to play a simultaneous Cournot-Nash game since quantity-setting is a strictly dominant strategy.

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