ARE LABOR-MANAGED FIRMS REALLY ABLE TO SURVIVE COMPETITION WITH PROFIT-MAXIMIZING FIRMS?

Luca Lambertini - Gianpaolo Rossini

Dipartimento di Scienze Economiche
Università degli studi di Bologna
Strada Maggiore 45
40125 Bologna
Italy
tel 39-51-6402600
fax 39-51-6402664
e-mail Lamberti@boph01.cineca.it
e-mail Rossini@boph01.cineca.it

July 1995

JEL classification: D92, L13, L20

Keywords: capital commitment, labor managed firm

Running Title: *Capital Commitment with Cooperative Firms*

Abstract

The behaviour of labor managed and profit seeking firms in a Cournot duopoly with capital strategic interaction is analysed. When a pure labor managed duopoly is considered, firms choose their capital commitments according to the level of the interest rate, unlike what usually happens when only profit maximizing firms operate in the market. If we consider a mixed duopoly, the profit maximizing firm underinvests as a reaction to the strategic asymmetry characterizing competition in the quantity stage regardless of the rental cost of capital, while the investment decision taken by the labor managed firm is again affected by the cost of capital. The nature of competition between a PM and an LM firm is such that the LM firm is induced to set her own capital in such a way that she does not enter the market.

Acknowledgements

We would like to thank Guido Candela for helpful comments and discussion on an earlier draft. The usual disclaimer applies.

1. Introduction

When two firms compete over a two period horizon they may end up with a non optimal choice of the stock of capital as compared to what required by cost minimization. There results an excess of investment owing to strategic interaction in capital expenditure when an increase in capital lowers marginal costs. Under Cournot competition there is usually a monotonic relationship between the output and the profit of each firm. As a consequence, a spillover effect is going to determine a capital commitment which is beyond the efficient level. This result appears when profit maximizer firms (PM) compete over quantities in a Cournot two stage game (Brander and Spencer, 1983), due to the strategic substitutability characterizing competition in quantities in the market stage.

Our purpose is to see whether the same result extends to firms with a different objective function due to a particular ownership structure. First of all our extension entails the analysis of a duopoly made up by two Labor Managed firms (LM). Then, we focus on the strategic interaction between a PM firm and an LM firm. It is known (see Cremer and Crémer, 1992; Delbono and Rossini, 1992; Rossini and Scarpa, 1993) that competition with or between LM firms gives rise to a strategic behaviour that largely differs from that observed when only profit seeking firms operate in the market. Relying on this feature, we will show that in a pure duopoly made up by LM firms, the investment decisions made by LM firms is conditional upon the level of the cost of capital. This feature may rescue the LM firm from some of the inefficiencies for which she is usually blamed. However, this "prudential" behaviour of the LM firm is augmented in the case of competition with a PM firm. We show, in a mixed duopoly setting, that a profit seeking firm underinvests respect to what would be required to minimize total costs, when she competes with a cooperative firm. This is the opposite of what happens when the rival is a PM firm. Despite the increased plausibility of the behaviour of the PM firm, the corresponding attitute of the LM firm leads to a radical result as far as the optimal level of capital is concerned.

For a reasonable set of parameters, the LM firm is going not to enter the market, when facing competition with a PM firm in quantities and capital expenditure.

The paper is structured as follows. Section 2 is devoted to the analysis of a duopoly made up by cooperative firms. The competition between a PM and an LM firm is described in Section 3. Section 4 provides the result of numerical simulations pointing to the disappearance of the LM firm. Section 5 contains final comments.

2. The two stage Cournot game between LM firms

We consider two LM firms with the usual objective function represented by profit per worker

$$V_i = \frac{p q_i - r k_i}{L_i}, \quad i = 1, 2, \tag{1}$$

where q_i is the quantity sold by the ith firm, p is the market price , r is the price of capital, k_i is the amount of capital used in the production process and L_i is the quantity of labor utilized.

We assume that the size of the market is represented by a linear demand function

$$p = a - Q, \tag{2}$$

where $Q=q_1+q_2$ and $a>Q$.

We then assume a Cobb-Douglas technology with constant returns to scale

$$q_i = \sqrt{k_i L_i} \tag{3}$$

from which we obtain

$$L_i = \frac{q_i^2}{k_i} \tag{4}$$

We can then write the objective function of the LM firm as

$$V_i = \frac{[(a - q_i - q_j)q_i - r k_i]k_i}{q_i^2} \tag{5}$$

Now we consider a duopoly made up by two LM firms that are identical in all respects. Competition takes place in two stages following a Cournot scheme. The two firms set the level of their physical capital in the first stage and in the second stage they decide their output levels.

The solution concept is two-stage subgame perfect equilibrium solved via backward induction, leading to the following proposition:

PROPOSITION 1. *In a pure LM duopoly, firms treat quantities as strategic complements in the market stage. As far as capital expenditure is concerned, they show a sensitiveness to the rental cost of capital, by underinvesting when it is above a critical threshold and overinvesting otherwise.*

PROOF. We firstly find the optimal quantity by solving the first order condition (FOC) for the market stage:

$$\frac{\partial V_i}{\partial q_i} = \frac{[(a - 2q_i - q_j)q_i^2] - 2q_i[(a - q_i - q_j)q_i - r k_i]}{q_i^4} = 0, \tag{6}$$

from which we can get the best response function for firm i

$$q_i = \frac{2rk_i}{a - q_j} \tag{7}$$

This means that LM firms treat quantities as strategic complements, while in case of profit maximizing behaviour, quantities are strategic substitutes (cfr. Brander and Spencer, 1983, pp.227-8).[1] The equilibrium quantity for firm i is

$$q_i^* = \frac{1}{2a}\left[a^2 + 2r(k_i - k_j) - \sqrt{(2r(k_i - k_j) - a^2)^2 - 8rk_j}\right] \tag{8}$$

provided that

$$(2r(k_i - k_j) - a^2)^2 - 8a^2 k_i r > 0. \tag{9}$$

We are now in a position to proceed to some comparative statics on quantities. From (8) the following conditions emerge:

$$\frac{\partial q_i}{\partial k_i} > 0; \quad \frac{\partial q_i}{\partial k_j} > 0; \tag{10}$$

notice that the sign of the cross derivative $\partial q_i/\partial k_j$ is opposite to that observed when quantity competition occurs between profit maximizing firms (cfr. Brander and Spencer, 1983, pp.227-8).

1. The concept of strategic complementarity/substitutability is due to Bulow et al. (1985).

Provided that quantities are strategic complements, an increase in firm *j*'s investment shifts out her reaction function in the quantity space, yielding thus an increase in firm *i*'s output.

Going backwards we can get the optimal level of k_i by maximizing V_i with respect to capital. The FOC relative to the first stage of the game is

$$\frac{\partial V_i}{\partial k_i} = -2rk_i + pq_i^2 + k\frac{\partial q_i}{\partial k_i}\left[2rk_i - pq_i + q_i^2\frac{\partial p}{\partial q_i}\right] + k_i q_i^2 \frac{\partial p}{\partial q_j}\frac{\partial q_j}{\partial k_i} = 0. \qquad (11$$

The expression in square brackets is nil since it corresponds to $\partial V_i/\partial q_i$. Hence, condition (11) can be solved to obtain the optimal level of firm *i*'s capital:

$$k_i^* = \frac{pq_i}{2r - q_i \frac{\partial p}{\partial q_j}\frac{\partial q_j}{\partial k_i}}. \qquad (12$$

Going back to the cost function and assuming that the labor wage is normalised to one, we get

$$C_i = \frac{q_i^2}{k_i} + rk_i \qquad (13$$

and then

$$\frac{\partial C_i}{\partial k_i}\bigg|_{k_i^*} = rp^2 - \left(2r + q_i\frac{\partial q_j}{\partial k_i}\right)^2 + 2p\left(2r + q_i\frac{\partial q_j}{\partial k_i}\right)\frac{\partial q_i}{\partial k_i}\frac{\partial k_i}{\partial k_j} \qquad (14$$

The above derivative is strictly positive if

$$r \in \left] \frac{1}{8}\left(p^2 + 4p\frac{\partial q_i}{\partial k_i}\frac{\partial k_i}{\partial k_j} - 4q_i\frac{\partial q_j}{\partial k_i} \pm p\sqrt{p^2 + 8p\frac{\partial q_i}{\partial k_i}\frac{\partial k_i}{\partial k_j} + 16\left(\frac{\partial q_i}{\partial k_i}\frac{\partial k_i}{\partial k_j}\right)^2 - 8q_i\frac{\partial q_j}{\partial k_i}} \right) \right[, \qquad (15$$

while it is negative when the interest rate lies outside the roots interval. Since the smaller root defined in (15) is negative, the implication of the above condition is that LM firms initially overinvest in phisycal capital when its cost is sufficiently low, while they underinvest when the cost of capital grows beyond the threshold defined above. *Q.E.D.*

These results sharply contrast with the conclusions reached by Brander and Spencer (1983), where profit seeking behaviour and Cournot competition lead firms to overinvest regardless of the cost of capital.[2]

3. The mixed duopoly case

Now we wish to analyse the strategic interaction between a PM and an LM firm, as far as capital expenditure is concerned. A case of simple strategic interaction between PM and LM firms has already been investigated by Cremer and Crémer (1992); Delbono and Rossini (1992). Moving from a pure LM duopoly to a mixed PM-LM duopoly has a beneficial impact on equilibrium values as far as social welfare is concerned (see Rossini and Scarpa, 1993, p.202). However, we do not know whether the extension of interaction to capital commitment leads to

---

2. The adoption of Betrand competition between profit maximizing firms in the market stage would lead to the opposite result, i.e., underinvestment (see Dixon, 1985).

results which mimic the previous ones.

We label the LM and the PM firm as 1 and 2, respectively. We specify only the objective function of the PM firm, since that of the LM firm has already been defined in (1):

$$\pi_2 = (a - q_1 - q_2)q_2 - \frac{q_2^2}{k_2} - rk_2 \qquad (16$$

The equilibrium concept is defined as above. The outcome of the two-stage competition between the Lm and the PM firm is summarized by the following proposition:

PROPOSITION 2. *In the mixed duopoly regime, the LM firm has an increasing reaction function while the PM firm has a decreasing reaction function in the market stage. When facing the capital commitment decision, the LM firm takes into account the cost of capital, while the PM firm underinvests irrespectively of the cost of capital.*

PROOF. From the FOCs we derive the following reaction functions in quantities:

$$q_1 = \frac{2rk_1}{a - q_2} \quad (LM) \qquad (17$$

$$q_2 = \frac{k_2(a - q_1)}{2(1 + k_2)} \quad (PM) \qquad (18$$

INSERT FIGURE 1

As we can see from Figure 1, the reaction function of the PM firm is downward sloping, while that of the LM firm is upward sloping. By looking at (17-18), we see that the effect of a change in capital expenditure for the LM firm leads to a new reaction function shifted to the right, giving rise to another equilibrium in which the quantity produced by the LM firm increases, while the quantity produced by the PM firm decreases. We are then able to claim that

$$\frac{\partial q_2}{\partial k_1}\Big|_{\bar{k}_2} < 0. \tag{19}$$

On the other hand, if we consider an increase in the capital commitment of the PM firm, the effect on the equilibrium output will be definitely an increase in the quantities produced by both firms,[3] so that

$$\frac{\partial q_1}{\partial k_2}\Big|_{\bar{k}_1} > 0. \tag{20}$$

Now we have to go back to the first stage and solve for the optimal levels of capital commitments. The FOCs are:

---

3. The same would obtain through the delegation of control to a manager characterized by a utility function partially dependent on the output level. See Vickers (1985); and Stewart (1992) for the strategic use of delegation with LM firms.

$$\frac{\partial V_1}{\partial k_1} = \frac{(fc_1 - pq_1)\left(\frac{\partial vc_1}{\partial k_1} + \frac{\partial vc_1}{\partial q_1}\frac{\partial q_1}{\partial k_1}\right)}{vc_1^2} + \frac{\left(p\frac{\partial q_1}{\partial k_1} - \frac{\partial fc_1}{\partial k_1} + q_1\left(\frac{\partial p}{\partial q_1}\frac{\partial q_1}{\partial k_1} + \frac{\partial p}{\partial q_2}\frac{\partial q_2}{\partial k_1}\right)\right)}{vc_1} = 0; \quad (21$$

$$\frac{\partial \pi_2}{\partial k_2} = p\frac{\partial q_2}{\partial k_2} + q_2\left(\frac{\partial p}{\partial q_2}\frac{\partial q_2}{\partial k_2} + \frac{\partial q_1}{\partial k_2}\frac{\partial p}{\partial q_1}\right) - \frac{\partial vc_2}{\partial k_2} - \frac{\partial q_2}{\partial k_2}\frac{\partial vc_2}{\partial q_2} - \frac{\partial fc_2}{\partial k_2} = 0, \quad (22$$

where fc_i and vc_i represent firm i's fixed and variable costs, respectively. In order to assess the sign of (21) and (22) we use the two FOCs obtained in the quantity stage which now appear as

$$\frac{\partial V_1}{\partial q_1} = vc_1\left(p + q_1\frac{\partial p}{\partial q_1}\right) - pq_1\frac{\partial vc_1}{\partial q_1} + fc_1\frac{\partial vc_1}{\partial q_1} = 0 \quad (23$$

$$\frac{\partial \pi_2}{\partial q_2} = p + q_2\frac{\partial p}{\partial q_2} - \frac{\partial vc_2}{\partial q_2} = 0 \quad (24$$

Therefore (21) and (22) become:

$$\frac{\partial V_1}{\partial k_1} = fc_1\frac{\partial vc_1}{\partial k_1} - pq_1\frac{\partial vc_1}{\partial k_1} - vc_1\frac{\partial fc_1}{\partial k_1} + vc_1 q_1\frac{\partial p}{\partial q_2}\frac{\partial q_2}{\partial k_1} = 0 \quad (21'$$

$$\frac{\partial \pi_2}{\partial k_2} = q_2\frac{\partial q_1}{\partial k_2}\frac{\partial p}{\partial q_1} - \frac{\partial vc_2}{\partial k_2} - \frac{\partial fc_2}{\partial k_2} = 0 \quad (22'$$

We now need to evaluate the sign of the reaction of total costs to the change of the capital expenditure in order to see whether each firm behaves efficiently or not, i.e., whether she over or underinvests in capital to reduce marginal costs. The sign of (21') is ambiguous; though, provided that the cost function C_i has the form specified in (13), the FOC relative to the LM firm can be rewritten as follows:

$$\frac{\partial V_1}{\partial k_1} = r\left(k_1 \frac{\partial vc_1}{\partial k_1} - vc_1\right) - pq_1 \frac{\partial cv_1}{\partial k_1} + cv_1 q_1 \frac{\partial p}{\partial q_2}\frac{\partial q_2}{\partial k_1} \tag{21"}$$

which is positive if

$$0 < r < \frac{pq_1 \frac{\partial vc_1}{\partial k_1} - vc_1 q_1 \frac{\partial p}{\partial q_2}\frac{\partial q_2}{\partial k_1}}{k_1 \frac{\partial vc_1}{\partial k_1} - vc_1} \qquad (25$$

Hence, in the interval specified by (25), i.e., when the cost of capital is sufficiently low, the LM firm overinvests, otherwise she underinvests.

As for the PM firm, from (22’) we can get

$$\frac{\partial C_2}{\partial k_2} = \frac{\partial vc_2}{\partial k_2} + \frac{\partial fc_2}{\partial k_2} = q_2 \frac{\partial q_1}{\partial k_2}\frac{\partial p}{\partial q_1} < 0, \tag{22"}$$

which implies that the PM firm underinvests irrespectively of the cost of capital. *Q.E.D.*

Hence, competition against an LM firm induces a reversal in the investment policy adopted by the PM firm, due to the opposite slopes of the reaction functions in the quantity stage. Underinvestment by the PM firm reveals a scarcely aggressive strategy by the same firm. Is there any economic justification beyond the analytical fundamentals? The reason is quite simple, and comes from the behaviour of the LM firm, which is trapped in its radical underinvestment that dramatically reduces her size and therefore her ability to represent a fierce competitor for the PM firm. In the next Section, we shall see that the LM firm is actually going to become much less of a competitor.

4. Entry/exit decision by the LM firm

The effect of competition upon the behaviour of a LM firm is different according to whether the rival is either a PM or a LM firm. Specifically, when we consider a one-stage competiton in quantities between an LM and a PM firm, the LM firm benefits since she increases her level of activity as compared with the level of production activated when competing against a similar firm in a pure LM duopoly (see Delbono and Rossini, 1992). However, when competition stretches over two stages, the outcome changes drastically, because output levels are largely predetermined by the strategic commitments emerged in the previous stage. Since there exists a positive relationship between capital and output, and the LM firm correctly anticipates that she will compete with a larger rival in the market stage, her own likely underinvestment may yield extreme consequences as far as her ability to survive is concerned. How dramatic is the reduction in capital commitment undertaken by the LM in a mixed duopoly? We try and answer this question since the result may go far beyond the simple behaviour we have described before. Indeed, the competition extended to the capital commitment uncovers a surprising behaviour of the LM firm. By simulating numerically the competitive behaviour of the LM for a plausible range of the cost of capital, given the size of the market, we find that the LM firm reacts to the capital choice of the PM by disinvesting sharply, reaching negative levels of capital. This means that the LM firm is not able to survive competition with a PM firm, when starting from scratch. The LM firm is so much "prudential" that it doesn’t enter the market. In table 1 below we provide the most significant results of the numerical simulations we have undertaken.

INSERT TABLE 1

The contents of Table 1 suggest a few considerations.

The level of capital becomes negative for the LM firm as a result of strategic competition with the PM firm. This is due to the very low quantity chosen by the LM firm. When this firm produces a low quantity she is compelled to sell some of her capital to maximize the individual value. However, the negativity of the LM capital prompts for some qualifications of the above statements about the relationship between the cost of capital and the investment behaviour of the LM firm. There is an inverse relationship between the cost of capital and the absolute value of capital. The firm must compensate an increase in the cost of capital by reducing the amount of capital she sells, i.e. there is an increase in the capital committment. In section 3, we observed a direct relationship between quantity of the LM and the cost of capital: the increase of the cost of capital boosts the revenue of the LM firm reducing furtherly the sale of capital needed to maximize individual value added. As it emerges from the numerical results, the total capital expenditure born by the LM firm, rk_1, remains constant. Since revenue increases, individual profits go the same way. The ultimate upshot is the euthanasia of the LM firm originated by the too low level of strategic production. We then state the following:

CLAIM 1. *The strategic interaction in capital and quantity between a PM and an LM firm leads the LM to choose a negative level of capital, i.e., the LM firm does not enter the market.*

5. Conclusions

The introduction of LM firms into a two-stage model of strategic interaction gives rise to a set of new insights. We show that the change of the objective function of the firm from PM to LM makes the cost of capital a relevant determinant of the degree of inefficiency as far as the dimension of the firm is concerned: there are levels of the rental price of capital which are compatible with efficient capital commitment, when a pure LM duopoly is considered.

If we turn to a mixed duopoly made up by an LM and a PM firm, the LM firm still exhibits a sensitiveness to the cost of capital, while the PM firm underinvests all over the range of capital rental prices. The force driving this outcome is the existence of a strategic asymmetry between the PM and the LM firm in the quantity space. Since the reaction function of the LM firm in the market stage is upward sloping, the PM firm correctly anticipates that an increase in her own quantity causes an increase in the rival's quantity as well. The astonishing follow-up of this strategic reaction is the sharp shrinking of the LM capital commitment beyond the level ensuring her survival. This opens the way either to the internal reorganization of the LM firm, or the her complete dismissal, leaving the PM firm free to operate as a monopolist. This perspective could also be analysed in a dynamic framework, in order to investigate the characteriscitcs of the disinvestment process by the LM firm, ultimately leading the LM firm to disappear.

References

Brander, James, and Barbara Spencer, 1983, Strategic Commitment with R&D: The Symmetric Case, *Bell Journal of Economics*, 14, 225-35.

Bulow, Jeremy, John Geanakoplos and Paul Klemperer, 1985, Multimarket Oligopoly: Strategic Substitutes and Complements, *Journal of Political Economy*, 93, 488-511.

Cremer, Helmut, and Jacques Crémer, 1992, Duopoly with Employee-Controlled and Profit-Maximizing Firms: Bertrand vs Cournot Competition, *Journal of Comparative Economics*, 16, 241-58.

Delbono, Flavio, and Gianpaolo Rossini, 1992, Competition Policy vs Horizontal Merger with Public, Entrepreneurial and Cooperative Firms, *Journal of Comparative Economics*, 16, 216-40.

Dixon, Huw, 1985, Strategic Investment in a Competitive Industry, *Journal of Industrial Economics*, 33, 205-12.

Rossini, Gianpaolo, and Carlo Scarpa, 1993, The Transformation of an LM Monopoly: Competition Policy vs Mixed Firms, *Journal of International and Comparative Economics*, 2, 191-206.

Stewart, Geoff, 1992, Management Objectives and Strategic Interactions among Capitalist and Labor-Managed Firms, *Journal of Economic Behavior and Organization*, 17, 423-31.

Vickers, John, 1985, Delegation and the Theory of the Firm, *Economic Journal*, 95 (Conference Papers), 138-47.

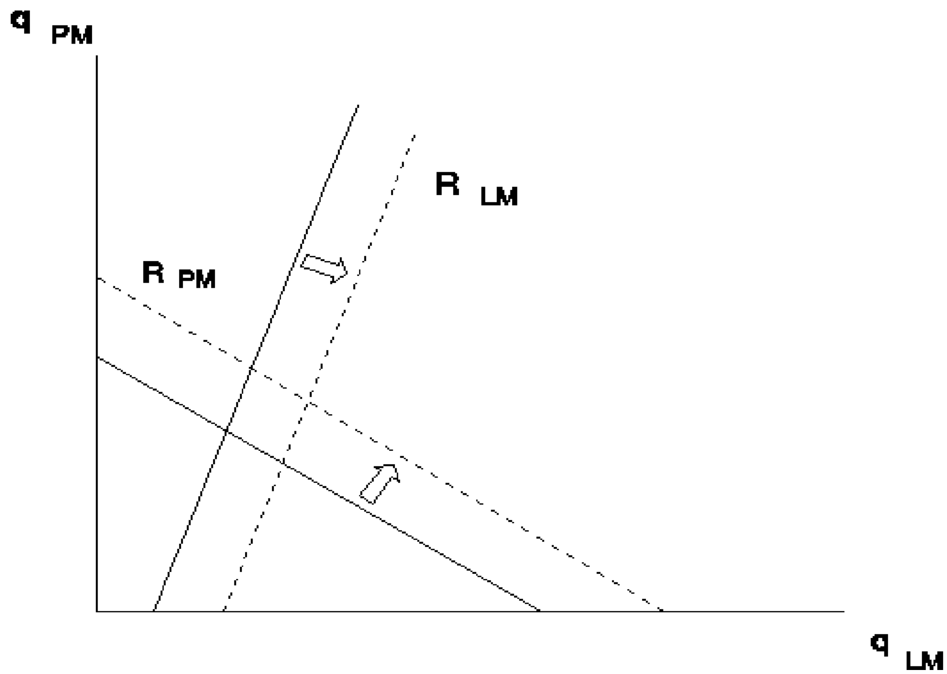

Figure 1. Reaction functions in the quantity space

a=10	r=0.1	r=0.2	r=0.5	r=0.8
k_2=4	-105.47	-52.73	-21.09	-13.18
k_2=9.9	-74.94	-37.47	-14.99	-9.37

Table 1. Simulation on capital commitment.

The entries give the optimal capital by the LM firm.