Innovation and Managerial Incentives: A Tale of Two Systems*

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Abstract

This paper describes R&D competition between a managerial firm and an entrepreneurial one, in a Cournot market. It is shown that a manager interested in output expansion exerts higher R&D efforts, yielding productive efficiency as compared to the performance of a strictly profit-seeking firm. This may ultimately yield monopoly power for the managerial firm, if technological spillovers in the industry are low enough.

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1 Introduction

Is it really dangerous for firms' shareholders to delegate control over their assets to managers who are interested in expanding sales or market shares, but not particularly (if at all) interested in maximising the market value of the capital stock? This issue has been the focus of the literature on agency relationships,[1] stressing the need for the shareholders to design incentive contracts so as to align as much as possible to the objective of profit maximisation the behaviour of potentially misbehaving managers, under asymmetric information. An alternative albeit related literature has stressed the potential advantages associated with the strategic delegation of control unde full information.[2] In such a case, hiring an aggressive manager may lead the firm to enjoy a dominant position replicating the performance of a Stackelberg leader, provided that rivals remain entrepreneurial, i.e., strictly profit-seeking units. It is worth noting that the two approaches rely upon very different presumptions and lead to strikingly different conclusions, although the object of their analyses is quite the same. According to agency theory, the problem consists in preventing managers' deviations from profit-maximising strategies, through incentives that are linked to profits themselves, as they are observable. By contrast, the theory of strategic delegation maintans that managerial contracts must specifically allow for some weight attached to dimensional variables like revenues or market share, as this enhances the firm's equilibrium profits. Hence, what is assumed to be a bad thing in the former theory, turns out to be a good one in the latter. Which one shall we believe to be more realistic? The purpose of the present paper is to propose a perspective by which to address this question.

On of the most relevant aspects of a firms' acitivities is investment; in particular, all those activities that can be labelled as R&D, either for process or for product innovation. Zhang and Zhang (1997) extend the strategic delegation model to the analysis of cost-reducing R&D with spillovers, (d'Aspremont and Jacquemin, 1988), comparing the performances of a duopoly where both firms are either managerial or entrepreneurial. They find that managerial firms invest more and earn lower profits than their managerial counterparts. However, they do not consider the mixed case where a manage-

[1]See Holmström (1979, 1999); Grossman and Hart (1983); and Mirrlees (1999), *inter alia*.

[2]To this regard, see Vickers (1985), Fershtman and Judd (1985), Sklivas (1987) and Reitman (1993), *inter alia*.

rial firm competes with an entrepreneurial one. My aim consists in showing that, under some relevant respects, this situation closely reflects the current state of the competition between firms located on the opposite sides of the Atlantic.

If one compares the compensation accruing to the CEOs of, say, Ford, Motorola and Boeing McDonnell Douglas with that of their counteparts at VW-Audi, Nokia and Airbus, there emerges that, taking into account both the regular wages and the stock options, the former receive several times as much as the latter (see, e.g., Hutton, 2002, chs. 4 and 8). By the same token, assessing the alleged mission of US vs European firms and how it translates into their effective behaviour, one very often verifies the following situation. On the west side of the Atlantic, strict profit maximisation and high divend distribution correspond to low R&D/revenues ratios, while the opposite holds on the east side. While the objective of VW-Audi and Michelin consists in keeping and possibly improving market shares and technological leadership, that of Goodyear and Ford is to maximise the stockholders' value. The new Airbus A380 has required the investment of profits that, alternatively, could have been distributed as dividends, which is indeed the route taken by the CEOs of Boeing McDonnell Douglas. As a result, the potential competitor of the A380, the Boeing 777, isn't yet there.

On these basis, one may think that two significantly different concepts of managerialisation currently prevail in Europe and in the US, respectively. More explicitly, there seems to be a correspondence between (i) the strategic motive for delegation and the European approach to managerialisation, and (ii) the incentive compatibility issue and the North American approach to the separation between ownership and control.

To deal with this issue, I will examine an extension of Vickers's (1985) model where managers control both sales and R&D efforts for process innovation, *à la* d'Aspremont and Jacquemin (1988). This idea has already been investigated by Zhang and Zhang (1997), confining however their attention to the symmetric cases where all firms are either entrepreneurial or managerial. Their conclusion is that delegating control to managers may indeed involve higher investment levels, but surely entails lower profits as compared to the situation where shareholders are directly in control of their firms, or equivalently, design delegation contracts so as to keep managers completely aligned with pure profit maximisation. Zhang and Zhang (1997) completely disregard the asymmetric case where a managerial firm and an entrepreneurial one interact. Perhaps, they do so because they are aware that managerialisation is a dominant strategy and therefore one should expect to observe separation between ownership and control by all the firms alike. While this is surely a sound conclusion in purely game-theoretical terms, it may nonetheless be unrealistic, as the former examples tend to confirm.

The analysis of the asymmetric case leads to some neat results in line with casual observation. First, the managerial firm's R&D effort and output are both larger than the entrepreneurial firm's. Consequently, the second result is that at equilibrium the managerial firms earns higher profits than the rival. An interesting ancillary conclusion is that, given that equilibrium marginal costs are asymmetric to the advantage of the managerial firm, then there exists an admissible parameter range wherein the entrepreneurial firm shuts down and the managerial firm becomes a monopolist. It is worth stressing that this is a direct consequence of the asymmetric R&D incentives. That is, the different rates of technical progress characterising the two firms determine their long run performances and, ultimately, their ability to survive.

The remainder of the paper is structured as follows. The model is laid out in section 2. Section 3 contains the analysis of the asymmetric case. Concluding remarks are in section 4.

2 The model

Consider a Cournot duopoly where firms 1 and 2 supply a homogeneous good. Market demand is:

$$p = a - q_1 - q_2 \tag{1}$$

Each firm bears production costs $C_i = c_i q_i$, and the marginal cost c_i cab be reduced by investing in R&D activity, according to the following technology (d'Aspremont and Jacquemin, 1988):[3]

$$c_i = \overline{c} - k_i - \beta k_j \,. \tag{2}$$

In (2), k_i is the R&D effort of firm i, while parameter $\beta \in [0, 1]$ measures the spillover that firm i receives from the rival. The cost of R&D activity is $\Gamma_i = bk_i^2$, $b > 0$, to indicate that R&D is characterised by decreasing returns. The resulting profit function is $\pi_i = (p - c_i)\, q_i - \Gamma_i$.

[3] There exists a large literature on R&D with spillovers, which cannot be duly accounted for here. See, e.g., Kamien *et al.* (1992), Suzumura (1992) and Amir (2000).

Zhang and Zhang (1997) combine Fershtman and Judd's (1985) approach to managerial incentives as a linear combination of profits and sales, to the linear-quadratic model of process R&D with spillovers due to d'Aspremont and Jacquemin (1988). It can be easily shown that Fershtman and Judd's model is equivalent, up to a simple re-parametrisation, to Vickers's (1985).[4] Therefore, I will adopt the formulation introduced by Vickers, whereby the incentive to firm i's manager is a linear combination of profits and output:

$$M_i = \pi_i + \theta_i q_i = (a - q_i - q_j)\, q_i - (c_i - \theta_i)\, q_i - bk_i^2 \tag{3}$$

where θ_i, the extent of delegation, is chosen by shareholders so as to maximise profits. If $\theta_i = 0$, then firm i's shareholders either don't hire a manager or oblige her/him to strictly maximise profits.

A brief summary of the analysis contained in Zhang and Zhang (1997) is in order. They compare the two symmetric games where either (i) both firms hire a manager who decides how much to invest in R&D and how much to produce, or (ii) neither firm hires a managers, so that k_i and q_i are both chosen by shareholders to maximise profits. The latter case coincides of course with d'Aspremont and Jacquemin (1988). The findings of Zhang and Zhang's model are the following (Zhang and Zhang, 1997, p. 394):

1. It is optimal to hire a manager (i.e., $\theta^* > 0$) only if the spillover parameter β is sufficiently low. Otherwise, $\theta^* = 0$ and firms remain entrepreneurial.

2. For all levels of β such that $\theta^* > 0$, managerial firms invest more in R&D and produce than entrepreneurial firms. This also implies that the equilibrium price is lower when the market is served by managerial firms.

3. Consequently, managerial firms obtain lower profits than entrepreneurial firms, for all levels of β such that $\theta^* > 0$.

The bottom line, although not explicitly stressed by Zhang and Zhang (1997), is that managerialisation enhances technical progress but hinders profits. In a sense, this setup has an Arrowian flaviour, as it reveals that making a Cournot market more competitive by (symmetrically) hiring managers with a taste for output expansion, ultimately leads to higher R&D efforts and lower production costs.

[4] The proof is omitted for brevity. See Lambertini and Trombetta (2002) for details.

This suggests that shareholders should not like managerialisation. However, in game-theoretical terms, this may be an unavoidable outcome ensured by the underlying prisoners' dilemma driving the shareholders' incentives towards managerialisation, which is surely the case in the basic Cournot model without R&D (Vickers, 1985; Lambertini and Trombetta, 2002). That is, if the delegation of control to managers is a strictly dominant strategy, then the resulting equilibrium outcome whereby both firms are managerial is compelling, although Pareto-inefficient from the shareholders' standpoint. The remainder of the paper focusses upon the asymmetric case where $\theta_i > 0$ and $\theta_j = 0$, $i, j = 1, 2$, $i \neq j$, in order to clarify that, if the rival firm is entrepreneurial, then hiring an agressive manager yields superior productive efficiency, a larger market share and higher profits for the managerial firm, which under certain conditions may even become a monopolist. Therefore, (i) delegation is indeed a dominant strategy, and (ii) adopting a strict profit-maximising behaviour turns out to be myopic and counterproductive.

3 The asymmetric case

Under the assumption that firm i is managerial while firm j is entrepreneurial, the three-stage game unravels as follows. In the first stage, firm i's shareholders choose θ_i to maximise profits; in the second (third) stage, the manager of firm i and the shareholders of firm j choose noncooperatively and simultaneously their respective R&D efforts (output levels). As usual, the solution concept is the subgame perfect equilibrium by backward induction.

The objective functions at the market stage are:

$$\begin{gathered} M_i = (a - q_i - q_j)\, q_i - (c_i - \theta_i)\, q_i - bk_i^2 \\ \pi_j = (p - c_j)\, q_j - bk_j^2 \end{gathered} \tag{4}$$

Taking the first order conditions (FOCs) w.r.t. q_i and q_j and solving, one obtains:

$$q_i^* = \frac{a - 2c_i + c_j + 2\theta_i}{3}\,;\; q_j^* = \frac{a - 2c_j + c_i - \theta_i}{3}\,, \tag{5}$$

which can be plugged into M_i and π_j together with (2), to write the relevant objective functions at the second stage, where R&D efforts are determined:

$$\begin{aligned} M_i &= \frac{1}{9}\left[(a-\overline{c})^2+(2k_i-k_j)^2-k_i^2\left(9b+4\beta-\beta^2\right)-4k_j^2\beta\left(1-\beta\right)+\right.\\ &\quad +4\theta_i^2+2\left(a-\overline{c}\right)\left(k_i\left(2-\beta\right)-k_j\left(2\beta-1\right)+2\theta_i\right)+\\ &\quad \left.+2k_ik_j\beta\left(5-2\beta\right)+4\theta_i\left(k_i\left(2-\beta\right)-k_j\left(2\beta-1\right)\right)\right] \end{aligned} \tag{6}$$

$$\pi_j=\frac{\left[a-\overline{c}+k_i\left(2\beta-1\right)+k_j\left(2-\beta\right)-\theta_i\right]^2}{9}-bk_j^2. \tag{7}$$

From (6-7), we can write the FOCs w.r.t. k_i and k_j :

$$\begin{aligned} \frac{\partial M_i}{\partial k_i} &= \frac{2}{9}\left[(a-\overline{c})\left(2-\beta\right)+k_i\left(4\left(1-\beta\right)-9b+\beta^2\right)+\right.\\ &\quad \left.-k_j\left(2\left(1-\beta^2\right)-5\beta\right)+2\theta_i\left(2-\beta\right)\right]=0 \end{aligned} \tag{8}$$

$$\frac{\partial \pi_j}{\partial k_j}=2\left[\frac{\left(2-\beta\right)\left(a-\overline{c}+k_i\left(2\beta-1\right)+k_j\left(2-\beta\right)-\theta_i\right)}{9}-bk_j\right]=0. \tag{9}$$

Solving the system (8-9), we obtain the equilibrium expressions of R&D efforts, for a generic value of θ_i :

$$k_i^*=\frac{\left(2-\beta\right)\left[\left(a-\overline{c}\right)\left(2-3b-\beta\left(3-\beta\right)\right)-\theta_i\left(6b+\beta-2\right)\right]}{\left[9b-\left(2-\beta\right)\left(1+\beta\right)\right]\left[2-3b-\beta\left(3-\beta\right)\right]} \tag{10}$$

$$k_j^*=\frac{\left(2-\beta\right)\left[\left(a-\overline{c}\right)\left(2-3b-\beta\left(3-\beta\right)\right)+\theta_i\left(3b-\beta\left(2-\beta\right)\right)\right]}{\left[9b-\left(2-\beta\right)\left(1+\beta\right)\right]\left[2-3b-\beta\left(3-\beta\right)\right]} \tag{11}$$

which clearly coincide with the optimal R&D efforts in d'Aspremont and Jacquemin (1988) iff $\theta_i=0$. Substituting (10-11) into π_i and solving $\partial\pi_i/\partial\theta_i=0$, the optimal extent of delegation is determined:[5]

$$\theta_i^*=\Psi\cdot\frac{\left[27b^2-6b\left(2-\beta\right)\left(1+\beta\right)+\left(2-\beta\right)^2\left(1+\beta\left(3\beta-2\right)\right)\right]}{\left[27b^2+4+3b\left(2-\beta\right)\left(4\beta-5\right)-\beta^2\left(15-\beta\left(13-3\beta\right)\right)\right]} \tag{12}$$

where:

$$\Psi\equiv\frac{\left(a-\overline{c}\right)\left(2-3b-\beta\left(3-\beta\right)\right)}{2\left(2-\beta-6b\right)} \tag{13}$$

[5] Firm i's FOC for profit maximisation is omitted for brevity. Details are available upon request.

If the ratio b/β is sufficiently high, θ_i^* is positive. For instance, if one takes $b=1$, then $\theta_i^*>0$ for all $\beta\in[0,1]$.

Having characterised the subgame perfect equilibrium, we can list the equilibrium expressions of outputs, R&D efforts and profits of the two firms:

$$q_i^* = \frac{9b\left(a-\overline{c}\right)\left[3b-\left(2-\beta\right)\left(1-\beta\right)\right]}{2\left[27b^2+4+3b\left(2-\beta\right)\left(4\beta-5\right)-\beta^2\left(15-\beta\left(13-3\beta\right)\right)\right]} \tag{14}$$

$$q_j^* = \frac{3b\left(a-\overline{c}\right)\left[3b-4+\beta\left(8-3\beta\right)\right]\left[9b-\left(2-\beta\right)\left(1+\beta\right)\right]}{2\left(6b+\beta-2\right)\left[27b^2+4+3b\left(2-\beta\right)\left(4\beta-5\right)-\beta^2\left(15-\beta\left(13-3\beta\right)\right)\right]} \tag{15}$$

$$k_i^* = \frac{3\left(a-\overline{c}\right)\left(2-\beta\right)\left[3b-\left(2-\beta\right)\left(1-\beta\right)\right]}{2\left[3b\left(2-\beta\right)\left(5-4\beta\right)-27b^2+\left(2-\beta\right)^2\left(\beta\left(3\beta-1\right)-1\right)\right]} \tag{16}$$

$$k_j^* = \frac{\left(a-\overline{c}\right)\left(2-\beta\right)\left[9b-\left(2-\beta\right)\left(1+\beta\right)\right]\left[\left(2-\beta\right)\left(2-3\beta\right)-3b\right]}{2\left(6b+\beta-2\right)\left[3b\left(2-\beta\right)\left(5-4\beta\right)-27b^2+\left(2-\beta\right)^2\left(\beta\left(3\beta-1\right)-1\right)\right]} \tag{17}$$

$$\pi_i^* = \frac{9b\left(a-\overline{c}\right)^2\left[3b-\left(2-\beta\right)\left(1-\beta\right)\right]^2}{4\left(6b+\beta-2\right)\left[27b^2+4+3b\left(2-\beta\right)\left(4\beta-5\right)-\beta^2\left(15-\beta\left(13-3\beta\right)\right)\right]} \tag{18}$$

$$\pi_j^* = \frac{b\left(a-\overline{c}\right)\left[3b-4+\beta\left(8-3\beta\right)\right]^2\left[9b-\left(2-\beta\right)^2\right]\left[9b-\left(2-\beta\right)\left(1+\beta\right)\right]^2}{4\left(6b+\beta-2\right)\left[27b^2+4+3b\left(2-\beta\right)\left(4\beta-5\right)-\beta^2\left(15-\beta\left(13-3\beta\right)\right)\right]} \tag{19}$$

Likewise, one can also obtain the equilibrium espressions of marginal costs and market price, which are omitted for brevity. Notice that, when comparing equilibrium outputs, R&D efforts and profits, the measure of market size, $a-\overline{c}$, is obviously irrelevant, such comparison depending upon $\{b,\beta\}$ only. In order to further simplify the matter, b can be normalised to one without any further loss of generality. By doing so, the comparative evaluation of the performance of the two firms can be carried out over the admissible interval of the technological spillover $\beta\in[0,1]$. The first relevant result is:

Remark 1 $k_i^*, q_i^* > 0$ *for all* $\beta\in[0,1]$; $k_j^*, q_j^*>0$ *for all* $\beta\in(0.131,1]$, *and conversely for all* $\beta\in[0,0.131)$.

That is, while the managerial firm is viable for all admissible spillover levels, the entrepreneurial firm needs a sufficiently high spillover from the rival to be active. Moreover:

Remark 2 $k_i^* > \max\left\{0, k_j^*\right\}$ *and* $q_i^* > \max\left\{0, q_j^*\right\}$ *for all* $\beta \in [0, 1]$.

These results can be interpreted as follows. The present model is one where two asymmetric firms compete in output levels. In particular, the asymmetry relates to their respective marginal costs, due to the fact that R&D incentives are different, since firm i has hired a manager while firm j has not. As the manager has a taste for output expansion, she/he has also a higher propensity to invest in process R&D, because an increase in productive efficiency will bring about an increase in output. Therefore, a managerial firm competing against an entrepreneurial firm, will invest more than the rival in R&D activities. This ultimately implies that, as in any asymmetric Cournot market, there exists a range of the cost differential $c_j - c_i$ above which the relatively less efficient firm, in this case the entrepreneurial one, is thrown out of business. Hence, $\pi_j^* = 0$ for all $\beta \in [0, 0.131)$. Note that this conclusion has a remarkable Schumpeterian flavour: R&D incentives reflect the relative size (as measured by maket shares) and the profit performance of firms.

Remarks 1-2 entail:

Proposition 3 *For all* $\beta \in [0, 0.131)$, *the managerial firm (i.e., firm i) is a monopolist.*

Finally, comparing (18) and (19), we obtain:

Proposition 4 $\pi_i^* > \pi_j^*$ *for all* $\beta \in (0.131, 1]$.

The above Proposition of course replicates the result we know since the seminal paper by Vickers (1985). However, in the present model, a novel result adds to the picture. More precisely, it is worth stressing that, if firms endogenously control their reciprocal spillovers, then it is possible for the managerial firm to monopolise the market by keeping the spillover outgoing to the rival low enough to lead the entrepreneurial firm to shut down. This would require, of course, rearranging the model by making spillovers β_i and β_j, firm-specific. However, even in the case of exogenously given external effects, it is quite sensible to presume that the effective spillover that each firm receives from the rival be smaller than 10% (see, e.g., Jaffe, 1986). In such a case, the empirical relevance of Proposition 3 would be non-negligible.

4 Concluding remarks

I have examined R&D competition between a managerial firm and an entrepreneurial one, in a Cournot market. Although seemingly at odds with the economic incentives that should lead to a separation between ownership and control within all firms alike, this appears to be a relevant situation in view of the current state of competition on the opposite shores of the Atlantic, with firms behaving as short termers in the US *vis à vis* their more forward looking counterparts in Western Europe. While the former set of firms provides their managers with large incentives in order for them to align to profit maximisation, the latter group of firms has a looser hold on managers, who may consequently reinvest profits into long-term development plans. The outcome of the simple theoretical model I have exposed seem to be in line with observation, i.e., it predicts that delegation to managers interested in output expansion will translate into larger R&D efforts and productive efficiency as compared to the performance of a strictly profit-seeking firm. This may ultimately yield monopoly power for the managerial firm, if technological spillovers in the industry are low enough.

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