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Do firms' owners delegate both short-run and long-run decisions to their managers in equilibrium?

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Do firms' owners delegate both short-run and long-run decisions to their managers in equilibrium? *

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Abstract

The present paper explores the scope of strategic delegation, to the firms' R&D investments and market competition in a Cournot Oligopoly. The firms' owners' have two alternative strategies: either the Full Delegation (FD) one, in which firms' owners delegate both short-run and long-run decisions to their managers, or the Partial Delegation (PD) one, in which firms' owners delegate only short-run decisions to their managers. We investigate which delegation strategy will emerge in equilibrium, under the assumption that there is no credible commitment between the firms' owners over the strategy they will select. We find that the Universal Partial Delegation is never an equilibrium configuration. If the initial unit cost is relatively high (low), the Universal Full Delegation (Coexistence) configuration is the only endogenously emerging equilibrium. However, the above results are sensitive to the existence of the commitment assumption.

JEL Classification: C20, C72, L22, O33.

Keywords: Strategic Delegation, Oligopoly, R&D Investments, Equilibrium Delegation Schemes.

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1 Introduction

Orthodox economic theory treats firms as economic agents whose main objective is to maximize profits. However, modern corporations are characterized by a separation of ownership and management, in other words delegation of authority from owners to managers. According to Baik (2003), there are two main incentives for delegation. The first one derives from the owners' need to exploit specific competencies that certain individual managers may embody, in order to improve the efficiency of their firms and obtain competitive advantages. The second one has to do with the acquisition of a commitment ability, that allows firms' managers to render credible strategies that owners would not be willing to choose. More specifically, the owner of a firm can change the behavior of the rival firm in his favor, by hiring a manager whose preferences are different from his own. This sort of delegation has prevailed in the literature as "strategic delegation" and was introduced by the seminal contribution of Schelling (1960).

More recently, Vickers (1985), Fershtman and Judd (1987) and Sklivas (1987) (henceforth VFJS) have developed the theoretical basis regarding the use of delegation in gaining a strategic advantages in oligopoly. In this line of research, each owner offers an incentive contract to his manager in order to direct him to a more aggressive behavior in the market, thus, forcing the competing manager to reduce output. In particular, a two-stage oligopoly model is considered in the above series of papers. At the first stage of the game, profit-maximizing owners choose compensation schemes for their managers that are linear combinations of own profits and own sales. At the second stage, managers, aware of the compensation terms, compete in the market over quantities. Each owner, when determining his manager's incentives, has the opportunity to obtain a competitive advantage in the market, provided that the rival owner does not delegate output decisions to his manager. In equilibrium, all owners act in the same way at the game's first stage and firms end up in a prisoners' dilemma situation.[1]

Nonetheless, this early work neglects that, despite the short-run oriented decisions such as output, there is another type of decisions that should be taken into consideration. This regards the long-run plans of the firm, such as cost reducing research and development (R&D) investments, which were first introduced to the VFJS model by Zhang & Zhang (1997). The purpose of this paper is twofold:

[1] The opposite holds when VFJS assume that firms compete in prices. In this case, both firms increase their profitability under strategic delegation regimes.

First, to examine the strategic interactions that arise between firms and the subsequent market performance, when firms owners' alternative strategies are either Full Delegation (FD), in which they delegate both short-run and long-run decisions to their managers, or Partial Delegation (PD), in which they delegate only short-run decisions to their managers. To do so, we assume a duopolistic industry in which firms compete in quantities (short-run decisions) and cost reducing R&D investments (long-run decisions). We consider three possible configurations; the first is the Universal Full Delegation (FD, FD) one, in which both the rival owners choose the Full Delegation strategy, the second refers to the Universal Partial Delegation (PD, PD) one, in which both owners select the Partial Delegation strategy, while the third is the Coexistence Delegation configuration (FD, PD) in which one owner delegates both the cost reducing R&D and the quantity decisions, while his rival delegates only quantity decisions to his manager.[2] Focusing on symmetric scenarios, we find that R&D investments are higher under the Universal FD, than under the Universal PD configuration. If the initial marginal cost is relatively low, the profits of the firms are higher under the Universal FD comparing with the Universal PD configuration. However, this result is reversed when the initial marginal cost becomes larger. The firm that follows the FD (PD) strategy in the Coexistence configuration invests more (less) in R&D and have higher (lower) profits than in both Universal Delegation scenarios, always.

Second, to investigate which type of decisions (short-run or long-run) will prevail in equilibrium, assuming there is no credible commitment between the competing owners regarding the strategy that they will follow. More specifically, we test the stability of each one of the above delegation configurations, through the examination of each firms' owner's incentives to unilaterally deviate by employing a different delegation strategy. We find that the Universal PD is never an equilibrium delegation configuration. If the initial unit cost is relatively high (low), the Universal FD (Coexistence) configuration is the only equilibrium one. However, the Universal FD, is the only equilibrium regime, under the assumption of an ex-ante commitment between the rival owners about the strategy they will follow, despite the cost.

In this line of research, Zhang & Zhang (1997) and Z. Zhang (2002) analyze how separation of ownership and management affects firm's R&D investments and production decisions.

[2] It is straightforward from the VFJS model that, for given technologies, delegation of decisions from owners to managers is always the dominant strategy. Hence, any subgame that includes owners' strategy of delegating no decisions to his manager and sticking to pure profit maximization (No Delegation) is not considered here.

They consider a Cournot duopoly in which both firms choose simultaneously either the Full Delegation or the No Delegation Strategy. They find that, under Full Delegation and for low (high) R&D spillovers firms invest more (less) in cost-reducing R&D, produce higher (lower) output and always obtain lower profits as compared with the No Delegation strategy.[3] In a similar context, Lambertini (2004), examines an asymmetric case in which the owner of one firm selects No Delegation, while his rival chooses Full Delegation. He finds that, in equilibrium, the second firm will invest more in R&D and will have higher output and profits, than the first firm, regardless of spillovers. Kopel & Riegler (2005) endogenize the selection between No Delegation and Full Delegation, by assuming credible commitment between the rival owners. Their main finding is that R&D spillovers do not affect firms' owners equilibrium strategy, therefore, they will always choose Full Delegation.

The above research does not consider Partial delegation as a possible owners' strategy. Empirical evidence, however, shows that in most cases owners tend to delegate only short-run decisions to their managers, whereas they prefer to maintain control on the long-run decisions. Barcena-Ruiz and Casado-Izaga (2005) cite some interesting case-studies, which describe the type of decisions delegated, in three well known firms: B.M.W., Benetton and Microsoft. In all of the above cases, although owners delegate short-run decisions to their managers, they play a dominant role in the long-run decisions of their firm. Colombo and Delmastro (2004) use empirical results to conclude that owners will probably not delegate to their managers strategic decisions that involve considerable financial resources, such as the long-run decisions of their firms. Hence, owners will typically delegate to their managers only short-run decisions.

Barcena-Ruiz and Casado-Izaga (2005) examine whether the owners of firms have incentives to follow Full or Partial Delegation under a different category of decisions. They consider location as the long-run decision and that the rival firms compete in strategic complements (prices) in the market, assuming that owners can commit themselves to a given strategy. Their main finding is that firms' owners always choose the Partial Delegation strategy. In contrast, we show that if firms compete in strategic substitutes (quantities) and there is no credible commitment for the chosen owners' strategy, then Partial Delegation never appears in equilibrium.

[3] In a recent paper, Kopel & Riegler (2006) amend the solution concept of Zhang & Zhang (1997), indicating that due to computational mistakes, some of their propositions do not hold.

The rest of this paper is organized as follows: Section 2 presents the model. In Section 3, the different subgames are solved and a detailed comparative analysis is presented. In Section 4, the conditions under which delegation emerges endogenously are investigated, assuming no ex-ante commitment between the competing owners. In Section 5, the case where there is credible commitment about the type of the decisions that owners delegate to managers, is examined. Section 6 provides some concluding remarks.

2 The Model

In this section, we develop a model embodying managerial incentives, R&D investments and output market competition. Consider a homogeneous duopolistic industry, in which firms are denoted by $i, j = 1, 2$, $i \neq j$. The inverse demand function of the final good is linear, and is given by:

$$P = A - Q \tag{1}$$

where, $A > 0$ and $Q = q_1 + q_2$ is the aggregate output.

Each firm is endowed initially with constant returns to scale technology in with marginal cost equals C. Following D'Aspremont & Jacquemin (1988), and Zhang & Zhang (1997), firm i can invest in R&D for cost-reducing process innovation which decreases its marginal cost to $C - x_i$, where x_i is the cost reduction due to R&D investments. There are diminishing returns to R&D, i.e. the cost of R&D is given by rx_i^2 , where r is a measure of effectiveness of R&D. As r increases, the expenditure required for a firm to obtain a given cost reduction also increases. Thus, we argue that the parameter r is negatively related to the efficiency of the R&D technology. To guarantee interior solutions, we assume that $\frac{1}{4} \leq c = \frac{C}{A} \leq 1$ and $r \geq \underline{\mathrm{r}} = 2.25$, where $c = \frac{C}{A}$ represents the efficiency of the initial technology relative to the market size. Hence, the initial marginal cost should be relatively high, so that the firms have incentives to reduce it by spending in cost reducing R&D, and the effectiveness of an R&D investment is not too high.[4] Thus, firm i's total cost function is given by:

$$TC_i = (C - x_i)q_i + rx_i^2, \ i = 1, 2 \tag{2}$$

[4] We also assume that there are no R&D spillovers.

Therefore, firm i's profit function is:

$$\Pi_i = (A - q_1 - q_2)q_1 - (C - x_i)q_i - rx_i^2, \; i, j = 1, 2; i \neq j \tag{3}$$

In this market each firm has an owner and a manager. Following Fershtman and Judd (1987), when we say "owner" we mean a decision maker whose objective is to maximize the profits of the firm. This could be the actual owner, a board of directors, or a chief executive officer. The term "Manager" refers to an agent that the owner hires to make real time operating decisions, and who could maximize profits or act according to a personal objective function.

Following VFJS, each owner offers to his manager a "take it or leave it" incentive contract.[5] Under this contract, the incentive structure takes a particular form: the risk-neutral manager i is paid at the margin, in proportion to a linear combination of own profits and own sales. In particular the manager of firm i will be given an incentive to maximize:

$$M_i = a_i \Pi_i + (1 - a_i)R_i \tag{4}$$

Where a_i is the managerial incentive parameter and Π_i and R_i denote firm i's profits and revenues, respectively. Note that owner i, by setting different levels of a_i, can manipulate the aggressiveness of his manager, since the manager acts as if his firm's marginal cost were $a_i(C - x_i)$.[6] Thus, if owner i chooses $a_i < 1$, he provokes his manager to put a higher weight on revenues, therefore he becomes more aggressive. If $a_i = 1$, then manager i is a profit maximizer and subsequently owner i and manager i coincide, since $M_i = \Pi_i$.[7] We assume that firms' owners cannot commit themselves to a given strategy.[8]

In order to examine which type of decisions will firms' owners delegate to their managers in equilibrium, we consider a four stage game with the following timing: at the first stage, both firms' owners, simultaneously and independently, decide whether they will delegate both the

[5] Although in real life the terms of the managerial contracts can be determined via owners-managers negotiations, it is a regular assumption in the strategic delegation literature that the market for managers is perfectly competitive and the owners have all the power during the negotiations, i.e., they offer to their managers "take it or leave it" incentive contracts (see Vickers, 1985; Fershtman and Judd, 1987; and Sklivas, 1987).

[6] This can be seen if one rewrites eq.(4) as $M_i = R_i - a_i TC_i$ (Zhang & Zhang ,1997).

[7] A standard assumption in the strategic delegation literature is that manager i will finally receive only his reservation wage. Since his reward is linear in in profits and revenues, he is compensated with $A_i + B_i M_i$ for some constants A_i, B_i with $B_i > 0$. Since he is risk neutral, he acts so as to maximize M_i and the values of A_i and B_i are irrelevant.

[8] In Section 5 we discuss the case in which owners can commit to a certain strategy during a stage zero of the game.

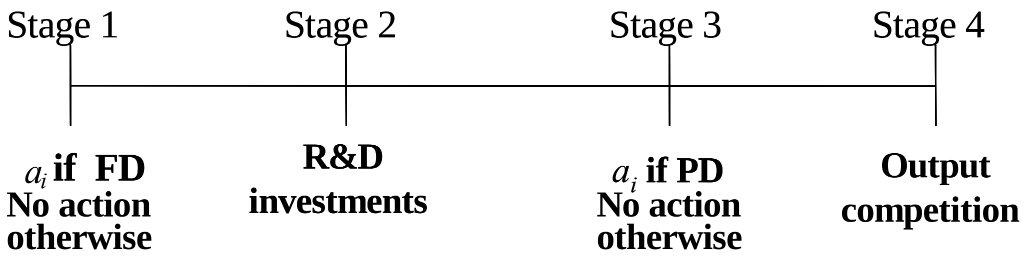

Figure 1: The timing of the game.

R&D investments and the quantity decisions to their managers (thus choosing whether to follow the Full or the Partial Delegation strategy). Hence, in the case of FD, the owner of firm i sets a_i optimally at the first stage, before manager i decides over the R&D investments.[9] If owner i chooses to follow the PD strategy, then a_i is selected after the R&D investments stage. At the next stage R&D investments are decided simultaneously, either by owners or by managers. At stage three, only the owner(s) who choose(s) to follow the PD sets a_i. At the last stage, both managers compete in quantities.[10] The above game will be solved backwards by employing the Subgame Perfect Nash Equilibrium (SPNE) solution concept. Figure 1 visualizes the timing of the game.

[9] This assumption is essential in order for delegation to have a strategic value. Katz (1991) argues that unobservable contracts have no commitment value at all. Fershtman and Judd (1987) support that even if the contracts are not observable, they will become common knowledge when the game is repeated for several periods. More recently, Kockesen & Ok (2004) argue that, to the extent that the renegotiation is costly and/or limited, in a general class of economic settings, strategic aspects of delegation may play an important role in the contract design, even if the contracts are completely unobservable.

[10] It is important to note that the timing of the game is formalized as above, because in the real business world it is common practice first to decide about the long-run plans of the firm and, according to them, decide about the short-run issues. See for instance Zhang & Zhang (1997).

3 Equilibrium Analysis

The game has three different subgames which provide us with the candidate equilibrium configurations: the first one is the Universal Full Delegation (FD, FD), in which the rival owners delegate both the R&D investments and the quantity decisions to their managers. The second one refers to the Universal Partial Delegation (PD, PD), in which only quantity decisions are delegated to managers. The third is the Coexistence Delegation configuration (FD, PD) in which one owner delegates both the R&D investments and the quantity decisions to his manager, whereas his rival delegates only quantity decisions to his manager.

At the last stage of the game, given the R&D investments and the optimal incentives to managers, each manager sets output optimally, with respect to his objective function given by eq.(4). From the First Order Conditions (foc), the reaction function of each manager is given by:

$$q_i = \frac{A - q_j - a_i(C - x_i)}{2} \tag{5}$$

By solving and rearranging, we obtain the equilibrium output of the fourth stage:

$$q_i(x_i, x_j, a_i, a_j) = \frac{A + a_j(C - x_j) - 2a_i(C - x_i)}{3} \tag{6}$$

As usual, given that firms compete in quantities, the quantity set by manager i increases with a_j and decreases with a_i.[11]

3.1 Universal Full Delegation: (FD, FD).

Considering the FD configuration, at the first stage owners set the managerial incentives for their managers. At the second stage managers compete in R&D investments, whereas at the third stage there is no action.

Hence, at the second stage, given the optimal incentives set by owners, managers maximize their compensation (eq.4) with respect to R&D investments. The solution of the system of the

[11] It is already known from the strategic delegation literature (see VFJS), that since quantities are strategic substitutes, then incentives are also strategic substitutes. The intuition behind this is that each owner encourages his manager to behave more aggressively (by setting the lowest possible a_i), because this way he can obtain a decrease in his rival's output and an increase in their own output, thus they can obtain a competitive advantage in the market. This is easy to be demonstrated in our model from eq.(5) and (6).

foc yields firm i's optimal R&D investments:

$$x_i(a_i, a_j) = \frac{6r(A - 2a_iC + a_jc) - 4a_j(A - a_iC)}{27r^2 - 12r(a_i + a_j) + 4a_ia_j} \tag{7}$$

At the first stage of the subgame, owners set simultaneously the incentive parameters a_i and a_j, so as to maximize their profits. With respect to $c = \frac{C}{A}$, imposing symmetry, solving the system of the foc and rearranging, the equilibrium values for the managerial incentive parameters are given by:

$$a_i = a_j = a^{FF}(c, r) = \frac{8 - 3r[c(22 + 45r) - 12] + \Psi}{24 - 4c(27r + 2)} \tag{8}$$

Where,

$\Psi = \sqrt{64 - 576r - 672rc + 9r^2c\{720 - 432r + c[196 + 9r(225r - 212)]\}}$

By substituting eq.(8) in (7), (6) and (3) we obtain the equilibrium values of R&D investments, output and profits x^{FF}, q^{FF} and Π^{FF}, respectively.[12]

3.2 Universal Partial Delegation: (PD, PD).

At the first stage of this subgame there is no action. At the second stage, owners decide about the R&D investments, while at the third stage owners set the incentive schemes for their managers.

Hence, at the third stage of the game each owner selects optimally his manager's incentives by maximizing his profits with respect to a_i. The solution of the system of the foc yields the following a_i:

$$a_i(x_i, x_j) = \frac{2(3C - 4x_i) + 2x_j - A}{5(C - x_i)} \tag{9}$$

At the second stage, owners simultaneously set the R&D investments so as to maximize their profits. By substituting $c = \frac{C}{A}$, imposing symmetry, solving the system of the foc and rearranging, we obtain the SPE values of the R&D investments:

$$x_i = x_j = x^{PP}(c, r) = \frac{6(1 - c)}{25r - 6} \tag{10}$$

[12] Due to space limits, some algebraic formulas are not presented. These are available from the authors, upon request.

By substituting eq.(10) in (9), (6) and (3), the corresponding SPE values of the managerial incentive parameter, quantity and profits are given by:

$$a^{PP}(c,r) = \frac{6+5r(1-6c)}{6-25cr} \tag{11}$$

$$q^{PP}(c,r) = \frac{10r(1-c)}{25r-6} \tag{12}$$

$$\Pi^{PP}(c,r) = \frac{2r(25r-18)(1-c)^2}{(25r-6)^2} \tag{13}$$

At this point, it is interesting to investigate the way that the different delegation strategies affect the R&D investments, the managerial incentive parameters, as well as output and profits, in the two symmetric delegation configurations.

By comparing the R&D investments given by x^{FF} and x^{PP}, respectively, the following proposition derives.

Proposition 1 *:In a symmetric delegation game, firms always invest more in R&D in the Universal Full Delegation configuration, compared with the Universal Partial Delegation one.*

The intuition behind proposition 1 is that, in the Universal FD, it is the non profit maximizing (hence more aggressive) managers who decide about R&D investments, which increases competition at the R&D investments stage of the game, unlike the Universal PD, in which case, less aggressive profit maximizing owners invest in R&D.

Proposition 2 compares the managerial incentive parameters given by a^{FF} and a^{PP}, respectively:

Proposition 2 *:In the Universal Partial Delegation configuration, managers are manipulated by owners to be more aggressive, than in the Universal Full Delegation one.*

This proposition implies that the managerial incentive parameter is always higher in the Universal FD configuration than in the Universal PD one. The insight behind this result is that increased R&D investments lead to better technology and to less aggressiveness during the quantity competition case in the FD strategy, than in the PD one. Hence, in the Universal FD owners will set a higher managerial incentive parameter in order to stimulate their managers to become less aggressive, comparing with the Universal PD configuration.

Proposition 3 stands for the comparison of the firms' output given by q^{FF} and q^{PP} respectively.

Proposition 3 *In a symmetric delegation game, if the initial marginal cost is relatively low (high), firms produce lower (higher) output in the Universal Full Delegation configuration, than in the Universal Partial Delegation one.*

For proof see Appendix.

The intuition behind this result is the output effect in R&D investments.[13] From propositions 1 and 2 it is obvious that there are two opposite effects on output. First, in the Universal FD, firms will invest more in R&D acuiring better technology, which leads to higher output, than in the Universal PD. Second, in the Universal FD owners will typically choose softer incentive schemes for their managers, causing lower output comparing with the Universal PD configuration. For relatively low initial unit cost, the dominant effect is the second one. However, if the initial marginal cost is high, given R&D investments, the dominant effect is the first one, since the gain from the reduction of the marginal cost increases, if production is amplified. Therefore, under a relatively high c, firms that have invested more in R&D at the early stages of the game (that is, in the Universal FD), tend to produce more, in order to increase the benefit from the technology improvement.

Proposition 4 compares the firms' profits given by Π^{FF} and Π^{PP}, respectively.

Proposition 4 *In a symmetric delegation game, if firms initial marginal cost is relatively low (high), then for* $r > \underline{r}$ *firms make higher (lower) profits in Universal Full Delegation than in the Universal Partial Delegation configuration.*

For proof see Appendix.

The rationale in this case is that, from propositions 1, 2 and 3, there are three effects on firms' profits. First, in the FD strategy, firms will have higher expenses regarding R&D, which increases cost and reduces their profitability, comparing with the PD one. Second, in the FD strategy owners will typically choose softer incentive schemes for their managers, which increase firms' profits, since it weakens the prisoners' dilemma effect comparing with the PD one. Third, overproduction by both firms under strategic delegation regimes is negatively

[13] See Bester & Petrakis (1993).

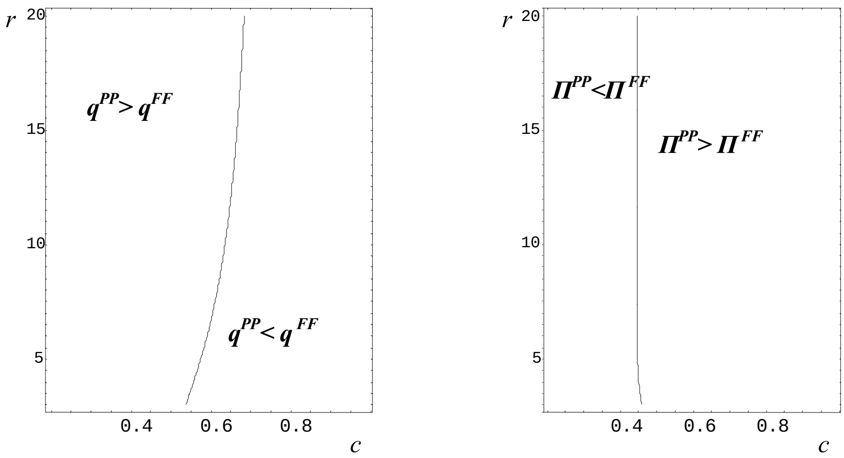

Figure 2: Firms' output and profits in Univ.FD and Univ.PD configurations.

connected to their profitability. For low c, higher output and fiercer market competition in the Universal PD configuration lead to lower profits, compared with the Universal FD. For high c, higher output and R&D expenses under Universal FD lead to the opposite result. Figure 2 visualizes the results in propositions 3 and 4, respectively.

3.3 Coexistence of Delegation Schemes: (FD, PD).

In the Coexistence configuration, without loss of generality, we assume that owner i follows the FD strategy, while his rival chooses the PD one. Hence, at the first stage of this subgame, owner i selects the managerial incentives for his manager, while his rival takes no action. At the next stage manager i along with owner j decide about the R&D investments, following which owner j set the incentives for his manager.[14]

At the third stage of the game, owner j chooses a_j that maximizes his profits. By taking the foc and solving, one obtains:

$$a_j(x_i, x_j, a_i) = \frac{6}{4} - \frac{A + a_i(C - x_i)}{4(C - x_j)} \tag{14}$$

[14] Here, the sequence of decisions is set this way, so that the R&D investments and output decisions are taken simultaneously. Also see Barcena-Ruiz and Casado-Izaga (2005) for a similar timing.

At the second stage of the game, manager i and owner j choose R&D investment levels to maximize their compensation and profits respectively. The solution of the system of the foc yields the following expressions:

$$x_i(a_i) = \frac{3[A(r-1) + C(a_i + 2r - 3a_i)]}{8r(2r-1) - 3a_i(3r-1)} \tag{15}$$

$$x_j(a_i) = \frac{3a_i(A-C) - 4r[A - C(2-a_i)}{3a_i(3r-1) - 8r(2r-1)} \tag{16}$$

At the first stage of the game, owner i maximizes his profits with respect to a_i. By solving the foc, we obtain the SPE value of the managerial incentive parameter for manager i:

$$a_i^{FP}(c,r) = \frac{r[c(64r^2 - 98r + 22) - r(16r-7) + 12] - 3}{(3r-1)\{6 - 6r + c[r(16r-19) - 3]\}} \tag{17}$$

By substituting eq.(17) in (16), (15), (6) and (3), each firm's equilibrium values of R&D investments, managerial incentive parameter, output and profits of each firm, respectively, are given by:

$$a_j^{FP}(c,r) = \frac{r\{14 + 9r - 8r^2 + 4c[r(14r-25) + 5]\} - 3}{r\{17 - 8r + c[r(48r-83) + 17]\} - 3} \tag{18}$$

$$x_i^{FP}(c,r) = \frac{6(r-1)(1-c)}{r(16r-25) + 3} \tag{19}$$

$$x_j^{FP}(c,r) = \frac{(1-c)[r(8r-17) + 3]}{(3r-1)[r(16r-25) + 3]} \tag{20}$$

$$q_i^{FP}(c,r) = \frac{8r(r-1)(1-c)}{r(16r-25) + 3} \tag{21}$$

$$q_j^{FP}(c,r) = \frac{2r(1-c)[r(8r-17) + 3]}{(3r-1)[r(16r-25) + 3]} \tag{22}$$

$$\Pi_i^{FP}(c,r) = \frac{4r(r-1)^2(1-c)^2}{r(48r^2 - 91r + 34) - 3} \tag{23}$$

$$\Pi_j^{FP}(c,r) = \frac{r(2r-1)(1-c)^2[r(8r-17)+3]^2}{[r(48r^2-91r+34)-3]^2} \tag{24}$$

By comparing the equilibrium values of R&D investments, managerial incentive parameter, output and profits in the Coexistence configuration, with the ones obtained in both the symmetric delegation configurations (Universal FD and Universal PD) the following proposition derives:

Proposition 5 *In the Coexistence configuration, the owner of firm $i(j)$ increases (decreases) the aggressiveness of his manager, compared with both symmetric delegation configurations. Thus firm $i(j)$ invests more (less) in R&D, produces higher (lower) output and has higher (lower) profits, comparing with its competitor and both symmetric delegation configurations, always.*

The intuition behind this result is that, since owner i sets the managerial incentives for his manager first, he becomes leader in incentives, thus he increases the aggressiveness of his manager in order to obtain a competitive advantage over his competitor at the subsequent stages of the game. Moreover, from (17) one obtains that if $c \in [0.25, 0.44)$, $r \geq \underline{r}$ then $a_i^{FP} \leq 0$. This means that owner i may give a negative weight on profits (hence even higher weight on sales) in his manager's utility, in order to induce a more aggressive behavior by the latter and hence strengthen his leadership in incentives. As a result, his manager invests more in R&D, produces higher output and his firm obtains higher profits comparing with both symmetric delegation configurations and his rival.

4 Equilibrium Delegation Schemes

In this section the determination of the equilibrium delegation configuration is examined, under the assumption that there is no ex-ante commitment between the rival owners regarding the strategy they will follow. As thisis standard in the game theoretic literature we first propose a candidate equilibrium configuration, and then check whether or not it survives all possible deviations. Thus, we need to examine owners' incentives to unilaterally deviate from each of the above candidate equilibrium configurations. The way we precede is as follows: given that the owner of firm 1 has chosen one of the above strategies (PD or FD), the owner of firm 2 examines his profitability, if he switches to a strategy different from the one specified for each candidate equilibrium configuration.

We examined all possible scenarios and our main findings are that firms' owners always have incentives to deviate from the Universal PD configuration. Regarding the Coexistence configuration, if the initial unit cost is relatively high (low), the owner that had initially chosen the PD strategy will always (never) have incentives to deviate towards the FD one. If the initial unit cost is relatively high (low) owners never (always) have incentives to deviate from the Universal FD configuration. The following proposition summarizes:

Proposition 6 *For given $r \geq \underline{r}$, if c is relatively low, then the Coexistence configuration is an equilibrium one. For given $r \geq \underline{r}$, if c is sufficiently large, then the Universal Full Delegation is an equilibrium configuration.*

In what follows, we describe the main arguments that drive our results.

4.1 Universal Full Delegation as a candidate equilibrium.

Universal Full Delegation is an equilibrium configuration when no owner has incentives to unilaterally deviate towards the PD strategy. The deviation game unravels as follows: given the fact that firm 1's owner delegates both short-run and long-run decisions to his manager, supposing that firm 2's owner will do the same, the latter deviates by delegating only short-run decisions to his manager. At the first stage of the deviation game firm 1's owner sets the managerial incentive parameter $a_1 = a^{FF}$, while firm 2's owner postpones his decision. At the next stage R&D decisions are taken by manager 1 and owner 2, following which, owner 2 sets the incentive parameter of his manager optimally. Finally at the last stage both firms' managers compete in quantities.[15]

By comparing the deviant owner's profits Π_2^d with the profits that result in the Universal FD Π^{FF} we obtain that $\Pi_2^d > \Pi^{FF}(\Pi_2^d < \Pi^{FF})$, for a relatively low (high) c. Thus, if the initial unit cost is relatively high, no firm's owner has incentives to deviate from the Universal FD.

It is important to note that there are two main levels of competition that both influence negatively the profitability of each strategy: market and R&D competition. While, in general,

[15] See appendix for the solution concept.

in the FD strategy quantity competition is softer, R&D competition is more intense, comparing with the PD one.

In the case of the Universal FD configuration, it is obvious that if c is relatively high, then the owner of each firm has incentives to remain more aggressive during the R&D competition stage (by delegating long-run decisions to his manager) in order to benefit from the reduction of the unit cost, during the forthcoming market competition stage. Hence, there are no incentives for deviation towards the PD strategy. But if c is relatively low, then both firm's owners have incentives to increase their profitability in comparison with their previous status, by switching from Full to Partial Delegation, so as to reduce their R&D expenditures, since the gain from the reduction of the marginal cost is also low. Thus, the Universal FD is an equilibrium configuration, provided that the initial marginal cost is relatively high.

4.2 Universal Partial Delegation as a candidate equilibrium.

We next propose as a candidate equilibrium configuration the Partial Delegation one. In order to test the stability of this configuration the following deviation game is considered: given owner 2's choice to delegate only short-run decisions to his manager, firm 1's owner examines the profitability of his firm in the case that he deviates and delegates both short-run and long-run decisions to his manager. Hence, at the first stage, owner 1 deviates and selects the managerial incentives for his manager $a_1 = a_i^{FP}$, while his rival takes no action. At the next stage, manager 1 and owner 2 set the R&D investments, following which owner 2 sets the incentives for his manager. At the final stage both managers compete in quantities. Note that, the solution concept of this deviation game coincides with the Coexistence Delegation configuration. Hence, the deviant owner's profits are given by: $\Pi_1^d = \Pi_i^{FP}$.

Since from proposition 5 we have $\Pi_1^d = \Pi_i^{FP} > \Pi^{PP}$, the deviant owner's profits are higher comparing to the profits that result in the Universal PD configuration, always. Therefore, both firms' owners always have incentives to deviate from the Universal PD scenario towards the FD strategy, because this way they will become leaders in incentives and obtain a competitive advantage in the market. Hence, the Universal PD is never an equilibrium configuration.

4.3 Coexistence scenario as a candidate equilibrium.

In order to investigate whether the Coexistence configuration is an equilibrium one, two possible deviations have to be examined. Firstly, owner 1 may deviate from the FD to the PD strategy. Secondly, owner 2 may deviate from PD to the FD strategy.

In the first deviation game, under the assumption that owner 2 delegates only short-run decisions to his manager, firm 1's owner deviates by also delegating only short-run decisions to his manager. At the first stage of the game, owner 1 decides to deviate to PD thus he takes no action, following which, both owners invest in R&D optimally. In this case the deviation game is identical to the Universal PD scenario. The rational behind this is that since owner 1 takes no action during the first stage of the game, his intention to deviate becomes common knowledge in the second stage.

By considering proposition 5 and comparing the deviation profits of owner $1(\Pi_1^d = \Pi^{PP})$, with the profits that the same owner obtains in the Coexistence Delegation scenario (Π_i^{FP}), we obtain that $\Pi_1^d < \Pi_i^{FP}$, always. Thus, owner 1 has no incentives to deviate towards the PD strategy.

In the second deviation game, given the fact that firm 1's owner delegates both short-run and long-run decisions to his manager, firm 2's owner deviates by also delegating both short-run and long-run decisions to his manager. At the first stage of the deviation game, firm 1's owner selects the managerial incentive parameter a_1, presuming that firm 2's owner will follow the PD strategy, thus, he sets $a_1 = a_i^{FP}$. On the other hand, firm 2's owner sets the managerial incentive parameter which is the best response to his rivals choice: $a_2(a_1)$. At stage two, both managers invest in R&D, followed by both managers competing in quantities.[16]

By comparing the deviation profits Π_2^d, with the profits that result in the Coexistence Delegation scenario we obtain that $\Pi_2^d > \Pi_j^{FP}(\Pi_2^d < \Pi_j^{FP})$ for a relatively high (low) c. Thus, if the initial unit cost is relatively low (high), owner 2 has no(always) incentives to deviate towards the FD strategy.

The intuition behind this result is that for a relatively high initial marginal cost, owner 2 has incentives to deviate towards the FD, because he seeks to benefit from the reduction of the initial marginal cost that is created by the increased R&D investments in the FD strategy. But if the initial marginal cost is low, this benefit is also low, thus there are no incentives for

[16] See appendix for the solution concept.

deviation towards the FD strategy. On the other hand, owner 1, given the fact that his rival follows PD strategy, he is leader in incentives and therefore dominates the market, thus he will never deviate towards the PD strategy, since such an act would decrease his profitability comparing with his previous status. Therefore, if the initial unit cost is relatively low, the Coexistence configuration is an equilibrium one.

5 Extensions

Existing literature attempts to endogenize the selection of the equilibrium delegation strategy by assuming that there is credible commitment between the rival owners when they select their delegation strategy. Therefore, we need to explain how our results may change under the same assumption.

The timing of the game remains the same, except we now add a stage zero, in which owners commit over the strategy that they will select. As argued above, there are three different subgames: the first one is the Universal FD configuration, the second onerefers to the Universal PD one, while the third one is the Coexistence configuration. All of the above scenarios have already been examined and the corresponding profits are shown in figure 3. The following proposition summarizes:

Proposition 7 *Assuming the existence of ex-ante commitment ability between the rival owners over the type of decisions they will delegate, Universal Full Delegation is the unique Subgame perfect Nash equilibrium.*

The rationale behind this result is that as seen from figure 3 and proposition 5, the FD strategy dominates the PD one. If owner i selects the PD strategy then owner j's best response is the FD one, since $\Pi_j^{PF} > \Pi^{PP}$. Furthermore, if owner i selects FD then owner j's best response is FD, since $\Pi^{FF} > \Pi_j^{FP}$. Therefore, under the assumption of credible commitment between the competing owners, Universal FD is the unique equilibrium configuration. Hence, altering the ex-ante commitment assumption, leads to different equilibrium strategy for a low initial marginal cost.

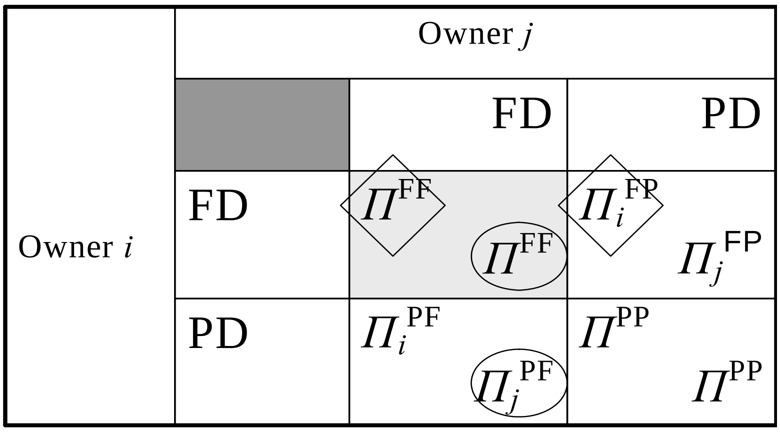

Figure 3: Matrix of profits at stage zero.

6 Conclusions

The literature regarding strategic delegation in oligopoly with R&D investments considers that the alternative strategies of firms' owners are either Full Delegation or No Delegation.

We assume a more realistic model where firms' owners' alternative strategies are either Full Delegation, in which owners delegate both the cost reducing R&D and the quantity decisions to their managers, or Partial Delegation, in which quantity decisions are delegated to managers, while owners decide themselves about the cost reducing R&D investments. In order to examine the implications of each delegation strategy on the firms' R&D investments and market performance, we compare three possible configurations; the first one is the Universal Full Delegation (FD, FD), the second one refers to the Universal Partial Delegation (PD, PD), while the third one is the Coexistence configuration (FD, PD). We find that R&D investments are higher in the Universal FD than in the Universal PD configuration. If the initial marginal cost is relatively low, then firms' profits are higher in the Universal FD comparing with the Universal PD configuration. However, this result is reversed when the initial marginal cost grows larger. In the Coexistence configuration, the firm that follows the FD (PD) strategy always invests more (less) in R&D, and obtains higher (lower) profits, than both symmetric delegation configurations.

After having compared the three alternative delegation configurations, we examine which one will prevail in equilibrium, assuming there is no credible commitment between the competing owners regarding the type of decisions delegated to managers. To do so, we investigate firms' owners incentives to deviate from each of the above candidate equilibrium configurations. We find that owners always have incentives to deviate from the Universal Partial Delegation configuration. In the case that the initial unit cost is relatively high (low) owners have always (never) incentives to deviate from the Coexistence configuration. If the initial unit cost is relatively high (low) owners will never (always) deviate from the Universal Full Delegation configuration. However, if one assumes the existence of credible commitment, the Universal Full Delegation is the unique equilibrium configuration.

The analysis was carried out for a duopolistic market structure. We are of the opinion that the duopolistic market reveals all essential implications, considering the firms' owners' incentives to strategically delegate their firm's decisions to managers. We are also aware of the limitations of our analysis in assuming specific functional forms. However, it is the nature of the equilibrium conditions driving our results that allows us to argue that these results will also be valid under general demand and cost functions. The use of more general forms would jeopardize the clarity of our findings, without significantly changing their qualitative character. Given the current debate about the market implications of Strategic Managerial Delegation the present paper sheds light on the type of decisions firms' owners will delegate to managers in oligopolistic markets.

Appendix

Appendix A1: Proof of proposition 3

By comparing the SPE values of firms' output in Universal FD and Universal PD, q^{FF} and q^{PP}, respectively, it can be shown that if $c \in [0.25, 0.54), r \geq \underline{r}$, then $q^{FF} - q^{PP} < 0$. If $c \in [0.54, 1), r \geq \underline{r}$, then $q^{FF} - q^{PP} > 0$.

Appendix A2: Proof of proposition 4

By comparing the SPE values of firms' profits in Universal FD and Universal PD, Π^{FF} and Π^{PP}, respectively, it can be shown that that if $c \in [0.25, 0.46), r \geq \underline{r}$, then $\Pi^{FF} - \Pi^{PP} > 0$. If $c \in [0.46, 1), r \geq \underline{r}$, then $\Pi^{FF} - \Pi^{PP} < 0$.

Appendix B1: Universal FD configuration's deviation game.

In this case, the solution concept of the deviation game coincides to the one in the Coexistence configuration, except that, at the first stage owner 1 will set $a_1 = a^{FF}$ presuming that firm 2's owner will do the same. By substituting $a_1 = a^{FF}$ in eq.(16), (15), (6) and (3), the deviant firm's profits are given by Π_2^d.

Appendix B2: The Coexistence configuration's deviation game.

Here, the second deviation game is similar to the solution concept in the Universal FD, except that, at the first stage of the deviation game firm 1's owner chooses the managerial incentive parameter a_1 believing that firm 2's owner will follow the PD strategy. Thus, he sets $a_1 = a_i^{FP}$. On the other hand, firm 2's owner sets the managerial incentive parameter that is the best response to his rival's choice: $a_2(a_1)$. Hence, he maximizes:

$$\Pi_2^d[a_1 = a_i^{FP}, a_2(a_1)] \tag{25}$$

with respect to a_2 in order to obtain a_2^d. Plugging a_2^d in eq.(25), the deviant profits Π_2^d derive.

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