MASTER THESIS
TITLE:
"Strategic Delegation, Managerial Incentives, R&D Investments and Market Competition in Oligopoly"

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Αφιερώνω την εργασία αυτή στους γονείς μου Γιώργο και Βιβή και στον αδερφό μου Νίκο, γιατί τους χρωστώ αυτό που είμαι και ότι θα γίνω. Στον Άκη Κλουτσινιώτη, Κωστή Τζανιδακη, Άννα Βεριγάκη, Στέλιο Βασιλείου, Νίκο και Μπέτυ Σιαφάκα, γιατί είναι όμορφο να έχεις δίπλα σου φίλους, που χαίρονται με την χαρά σου.Στους καθηγητές μου που εργάζονται στο master ανιδιοτελώς και ιδιαίτερα στον Κύριο Πετράκη, ο οποίος μου έμαθε να δίνω αξία στα δύσκολα. Τέλος στις Μαριέλα Παπαδάκη και Μαρία Χατζάκη για την ψυχολογική συμπαράσταση ,που μου προσέφεραν στις πολλές δύσκολες στιγμές του master.

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ABSTRACT

This Master Thesis investigates the effects of the strategic use of managerial delegation, to the firms' R&D investments and market competition in a Cournot duopoly model. In the first section there is an introduction. In section 2 there is an extended literature review on the subject. In the next section the model for a three stage duopolistic competition with R&D is being described, where it is assumed full delegation, short-run delegation or no delegation respectively. Section 4 sets out the results for Cournot quantity competition. In the following section the conditions under which delegation emerges endogenously (thus it is strictly dominant strategy for the competing firms) are investigated. The final section summarizes the results.

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, which is considered as reason for deviation from profit maximization[1]. Therefore many economists argue that a proper analysis of the firm's objective function should be based on the analysis of the owner manager relationship.

Using the terminology of Fershtman and Judd (1987), when we say "owner" we mean a decision maker whose objective is to maximize the profits of the firm. In the real world this could be the actual owner, a board of directors or a chief executive officer (CEO). By the term "manager", we refer to an agent that is hired by the owner in order to observe demand and cost conditions and make real time decisions. That is, owners delegate some decisions to their managers. These decisions may be concerning the short-run objectives of the firm (price, output), or the long-run decisions (R&D, location ect) as well[2] .

Why do owners delegate authority to their managers? According to Baik (2003) there are two main motives for delegation. The first refer to the case where owners seek to use superior ability, by hiring managers who have more ability than they do. It is true that in modern business world, as corporations become larger with increasingly sophisticated operations, there is an increase in the demand for specialized and highly qualified managers[3].The second has to do with strategic commitments gained through delegation, (therefore called strategic delegation). More

[1] Sklivas (1987)
[2] Barcena-Ruiz and Casado – Izaga 2001.
[3] Choe (2003)

specifically one owner wants to change his rival's behavior in his favor, by hiring a manager whose objective function is different than his.

2. LITERATURE REVIEW

The term "strategic delegation" has received great attention in the Industrial Organization literature. It was introduced by Schelling (1960) and determines a situation where delegation is being used as a "self commitment device». Vickers (1985), Fershtman and Judd (1987) and Sklivas (1987) (here forth VFJS), have studied managerial delegation under oligopoly. Segendorff (1998) examines delegation under bargaining situations. Corts and Neher (2001) discuss delegation under observable and unobservable managerial contracts, while Wauthy (1998), Krakel and Sliwka (2003), and Baik (2003) examine delegation in contests.

Fershtman and Kalai (1997) distinguish between two types of delegation: incentive delegation and instructive delegation. In the case of incentive delegation a player provides an incentive scheme for his delegate, and the delegate chooses an effort level which maximizes his payoff, given the incentive scheme. In the case of instructive delegation a player designs a set of instructions and requires his delegate to follow these instructions. For the purposes of this Thesis, according to the above classification, we adopt incentive delegation, that is, owners (players) provide compensation schemes for their managers (delegates) and the delegates choose their effort levels, given the compensation schemes.

According to Fershtman and Judd (1987), a proper analysis of the firm's objective function should be based on the analysis of the owner-manager relationship. For a monopolistic firm, this relationship can be described as a classical principal agent problem, which is characterized by the absence of risk sharing and asymmetric information considerations. In this case owners will motivate their managers to maximize profits[4]. However in oligopolistic markets things may be different. VFJS have proved that in a duopoly, non profit-maximizing firms may enjoy more profits than their profit- maximizing rivals. Thus, an optimal incentive scheme may include sales[5], market shares[6], or other non profit maximizing parameters.

Given the objectives of this Thesis, it is important to examine the VFJS model in more detail, because it sets the theoretical basis regarding to the literature of managerial strategic delegation in oligopoly. VFJS assume that there are two firms in an industry, each with one owner and one manager. They examine a two stage game. In the first stage, firms' owners simultaneously determine the incentive structure of their managers. Each owner must offer his manager a contract under which the manager expects to receive his opportunity cost of participation. In the second stage the competing managers play an oligopoly game by deciding about output or price values, with each firm's manager knowing about his incentive contract, as well as the one of his competitive manager. After all actions have taken place, each owner observes the costs and sales and hence the profits of his firm.

The strategic use of managerial incentives is very important to our analysis. VFJS have shown that profit maximizing owners will almost never ask their managers to maximize profits, when their contracts are observable. For example if firm's *i* manager is told to maximize sales revenues instead of profits, he will become very aggressive seller. Since his payoff is thereby affected, there will be change in his equilibrium behavior during the competition among managers. Moreover, firm's *j* manager equilibrium behavior will be affected, since he is aware of the other manager

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[4] See Demnetz, (1983), Fama and Jensen, (1983).

[5] VFJS
[6] Wauthy (1998)

new incentive for sales maximization. This result in the competing managers behavior, gives each owner the opportunity to be Stackelberg leader vis-a- vis the other firm’s manager when he determines his manager incentives. The above interaction results owners to twist their managers away from profit maximization, even though they are profit maximizers.

A very important hypothesis on VFJS model is that the incentive contracts are observable. Katz (1991) argues that unobservable contracts have no commitment value at all, hence the VFJS model is not realistic. Fershtman and Judd (1987) support that even if contracts are not observable, they will become common knowledge when the game is being repeated for several periods. Fershtman and Kalai (1997) analyze the conditions under which incentive contracts, even when unobservable, may affect the outcome of an ultimatum game. In a recent experiment, these results were tested by Fershtman and Greezy (2001).They have shown that unobservable delegation indeed matters, even if theory does not predict an effect of delegation. The main insight of Fershtman and Greezy’s study is that because of the introduction of a third player , the ultimatum game is perceived more competitive , which may drive player’s behavior to the game theoretic prediction.

Back to the VFJS model, owner *i* constructs an incentive scheme for his manager, according to some linear function R_i of his firm’s profits Π_i and Sales (or revenues) S_i where *i=1,2* the higher is R_i the higher is manager’s *i* bonus or, alternatively, the lower is the probability of being fired. Thus:

$$R_i = a_i \Pi_i + (1 - a_i) S_i$$

Where a_i is the managerial incentive parameter which is chosen by the owner in order to determine his manager’s incentives. Note that if $a_i = 1$ then manager *i* has the same incentives with owner *i*, that is profit maximization. If $a_i < 1$, then manager *i* is motivated to maximize sales than profits, while if owner *i* sets $a_i > 1$, then he penalizes his manager for sales.

If firms compete in quantities during the second stage , then, for simplicity VFJS assume a linear demand function $P = A - bQ$, where $Q = q_1 + q_2$, homogeneous products and constant marginal costs $c_i, i = 1,2$.

Thus firms i profits are given by the expression: $\Pi_i = (A - \text{bQ})q_i - c_i q_i$,

and sales by: $S_i = (A - \text{bQ})q_i$

By applying the Nash equilibrium to both stages of the game Sub-game Perfect Equilibrium (SPE) .The incentive equilibrium is solved by using backwards induction. In stage two managers compete in quantities. Because firm's output (q_i) does not enter manager's *i* utility directly, he chooses q_i to maximize R_i. Thus by maximizing R_i with respect to q_i, we obtain the reaction functions of managers 1 and 2, K_1 and K_2 respectively. By solving the system of $K_1(q_2, a_1)$ and $K_2(q_1, a_2)$, a Nash equilibrium results for the second stage: $q_1^*(a_1, a_2) = q_2^*(a_1, a_2)$. In stage one, owners choose a_i in order to set their managers incentives. Thus if we substitute $q_i^*(a_1, a_2)$, to the profit function Π_i and maximize with respect to a_i we obtain the SPE values of $a_1^* = a_2^*$.

It is important to be noticed that when owner i sets $a_i < 1$, manager's *i* reaction function shifts out, thus he behaves more aggressively. For example manager 1 reacts with greater q_1 for every q_2, than if he was a profit maximizer. The intuition behind this is, that now, firm's 1 manager gives less value to costs ($a_i * c_i$). Thus, in equilibrium, firm's 1 output increases, while firm's 2 output decreases (given that $a_2 = 1$).Therefore both owners are motivated to twist their managers away from profit maximization and set a_i less than unity, pushing both reaction curves out. As a result the Nash equilibrium output is greater than the Cournot model but still less than welfare optimum level. That is $\frac{A}{2b} > q_i^*(a_1^*, a_2^*) > q^c(1,1)$ i=1, 2. As a consequence profits of both firms are lesser than in Cournot competition, because of the prisoner's dilemma effect.

The outcome of the owner-manager game is completely different when managers compete in prices during stage two. The solution's procedure of this game is similar to the output-competition case. It is assumed symmetric product differentiation, linear demand and constant marginal costs. The linear demand function is given by $q_i = A - p_i - bp_j$, $0 < b < 1$, $i, j = 1,2$, $i \neq j$, $0 < c < \frac{a}{1-b}$, where p_i is firm's i price. Following backwards induction, VFJS obtain manager's 1,2 reaction functions $K_1(p_2, a_1)$ and $K_2(p_1, a_2)$ respectively, by maximizing R_i with respect to p_i .By solving the system of K_1 and K_2 the Nash equilibrium values of $p_1^*(a_1, a_2), p_2^*(a_1, a_2)$ result for stage 2. By substituting p_1^*, p_2^* to the profits function Π_i and maximizing over a_i the incentive parameters SPE values are obtained for stage 1 (a_1^*, a_2^*).Note that if owner I sets $a_i > 1$ then manager i becomes less aggressive , thus he responds with a greater p_i for any p_j. This results higher equilibrium prices than in Bertrand model, that is $p_i^*(a_1^*, a_2^*) > p^B(1,1)$ and higher profits.

The above analysis shows that when two firms compete in quantities, then owners would choose an incentive scheme that motivates their managers to be more aggressive ($a_i < 1$). Therefore output of both firms is higher, profits are lower and competition is more tensed than in the classic Cournot duopoly model. On the other hand, if firms compete in prices, then owners would motivate their managers to be less aggressive ($a_i > 1$). Thus, prices and profits are higher and firms behave more collusively than in the Bertrand model.

An important remark to the above analysis comes from Huck et all (2002).By designing an experiment, they tried to analyze strategic delegation in a Cournot duopoly based on VFJS model. Owners can choose among two different contracts which determine their managers' salaries. One contact motivate managers to maximize firm's profits, while the second contract gives an additional sales bonus. Although theory predicts the second contract to be chosen, it is only rarely chosen in experimental markets. This behavior is rational given that managers do not play according to the sub-game perfect equilibrium prediction when asymmetric contracts are given. Therefore Huck et all (2002) impose that delegation models predictions should be taken with care.

VFJS have pointed out, that on strategic delegation states, owners, are motivated to delegate short run decisions, such as on prices and output, to their managers. However there is another type of decisions that should be taken into consideration, regarding the long-run plans of the firm. These decisions may include location, product differentiation, research and development (R&D) ect.

Barcena-Ruiz and Casado-Izaga, cite two interesting examples of case-studies, that describe the delegation of the long-run decisions, in two well known firms: B.M.W. and Benetton. In both cases owners delegate short run decisions to their managers, while they keep the long-run decisions under their control. More specifically they study, whether firms' owners have incentives to delegate location decisions to their managers or not, by using the unconstraint Hotteling model and assuming that in each firm there is an owner and a manager. Their main findings are that if an owner takes location decision on his own, he avoids becoming a leader in incentives, thus he locates better in the market and faces smoother competition. On the other hand , if an owner delegates location decision to his manager, he risks becoming a leader in incentives, therefore having to choose a worse location in the market, facing more tensed competition. As a result owners prefer to keep the location decision to themselves.

The main purpose of this Thesis is to examine strategic delegation regarding R&D decisions. Thus it is worthwhile to present the main literature on this subject. Jianbo Zhang and Zhentang Zhang(1997) introduced the analysis of how separation of ownership and management affects firm's R&D and production decisions in a Cournot duopoly. They developed a model of strategic delegation with cost reducing R&D with the possibility of spillovers across firms in Cournot duopoly under homogeneous goods. Two firms, each having one owner and one manager, play a three stage game. In the first stage owners simultaneously sign incentive schemes for their managers. In the second stage managers make cost reducing R&D decisions non cooperatively. At the last stage managers simultaneously make output decisions in a Cournot quantity game. They found that when R&D spillovers are small, owners whil twist their manager's incentives away from profit maximization and towards sales. Thus managerial firms invest more in R&D , have higher output and lower prices than entrepreneurial firms. In the case where spillovers are large, then owners "penalize" managers for sales. Now managerial firms have lower R&D, lower output and higher profits than their entrepreneurial counterparts. Moreover managerial firms have lower profits comparing to entrepreneurial, regardless from spillovers.

Lambertini and Primavera (2000) developed a model where stockholders are assumed to evaluate the relative profitability of delegation versus process innovation. First they investigate a game where delegation and R&D activity are alternative strategies. This perspective results equilibriums where delegation is no longer the dominant strategy and whenever it is a dominant strategy, the associated equilibrium is not necessarily the outcome of prisoner's dilemma. Thus, at equilibrium, at least one firm remains entrepreneurial and prefers to undertake cost reducing R&D activities. Then they consider a game where R&D and delegation can be combined so as to activate cost reducing investments in a managerial firm. Their main findings are that in such a game: (i) the investment in cost – reducing R&D by entrepreneurial firms is a strictly dominated strategy, that is, it is never observed in equilibrium, (ii) firms always delegate control to managers, although they may not always undertake R&D investments. Finally (iii) the joint use of delegation and R&D for process innovation is not necessarily an equilibrium strategy, due to the fact that the R&D investment may be too expensive.

Zhentang Zhang (2002) investigates the strategic interactions between firms in both R&D and market place activities, on the owners' choice of managerial contracts. He also investigates the role of collusive R&D activities in influencing the design of managerial incentive scheme. He develops a Cournot duopoly three stage game, where in the first stage owners simultaneously design a managerial incentive scheme, in the second stage managers make R&D decisions and in the final stage managers make quantity decisions. He found that managers in a delegation game invest more in cost-reducing R&D, have higher output and lower profits as compared to the profit maximizers in an owner-run game. Secondly, he finds that R&D collusion induces owners in a delegation game to choose more aggressive managerial incentives, as compared to R&D competition, thus R&D investments and profits increase, while output decreases.

The above literature, considering that the alternative strategies of the rival firms are either no delegation at all, or full[7] delegation and given exogenously, examines separately the consequences of each strategy to the firm's profits and output. However little research has been done on the more realistic case where firms' owners' alternative strategies are no delegation, short run delegation or full delegation of authority to their managers and under which circumstances, strategic delegation emerges endogenously.

The topic of the proposed Master thesis is "Strategic Delegation, Managerial Incentives, R&D Investments and Market Competition in Oligopoly" and aims to develop a unified model in order to examine the motives of the firms' owners to delegate only short-run or both short-run and long-run decisions. The main idea is to compare two, three staged Cournot quantity games with R&D where in the first owners delegate only the short run decisions (quantity) to their managers, while in the second owners delegate both long run and short run decisions to their managers. The Sub-game perfect equilibrium (SPE) results, by applying backwards induction. Then using comparative statics we compare the results of each scenario to the case were no delegation takes place, which is both firms remain entrepreneurial. Moreover we investigate endogenously driven equilibria by examining owners' motives to deviate from each candidate SPE that result from each scenario. The contribution of this thesis will be the definition of the kind of decisions that should be delegated from each firm owner to their manager in an oligopolistic industry, given their rivals strategy.

[7] That is delegation of both short- run and long -run decisions of the firm

3. COURNOT COMPETITION WITH R&D

3.1: Case 1 (Full Delegation)

In this case we develop a model where both cost reducing R&D and quantity decisions are delegated to the managers based on Zhang (2002). There are two firms (1 and 2) run by a manager each, playing a three stage game. In the first stage owners set the incentive contracts of their managers. In the second stage managers compete in R&D activities, while in the final stage managers compete in a Cournot quantity model. The manager of each firm seek to maximize his objective function given by :

$$U_i = a_i P_i + (1 - a_i) R_i \qquad \textbf{(1)}$$

$i = 1,2$,where a_i is a managerial incentive parameter and P_i and R_i are firm's i profits and revenues function respectively. Note that owner i, by setting different levels of a_i can alter the aggressiveness of his manager. Thus if owner i chooses $a_i < 1$, he provokes his manager to put higher weight on revenues. If $a_i = 1$, then managers are profit maximizers.

During stage one owner i maximizes profits by choosing the incentive parameter a_i. This way he uses the incentive scheme U_i as a strategic device in order to commit his manager to a certain behavior in the following R&D and production stages.

In stage two, given the incentive scheme, manager i decides on cost reducing R&D investments x_i to maximize U_i. The marginal costs of firm i are given by $c_i = c - x_i$, where x_i is the R&D investment made by firm i. The cost of R&D is given by $\left(r/2\right)x_i^2$, where the parameter $r > 0$ is expressing the efficiency of R&D

production. Thus firm's i total cost function is given by: $TC_i = (c - x_i)q_i + \left(\frac{r}{2}\right)x_i^2$.

There are no R&D spillovers and no fixed costs.

In the final stage, given the incentive scheme and R&D decisions, manager i chooses output q_i to maximize U_i. We use a general demand function $p(Q) = A - Q$ assuming that $p' < 0$, where $Q = q_1 + q_2$.

In order to find the sub game perfect equilibrium (SPE) we use backwards induction.

Thus in stage three manager i chooses output q_i to maximize his objective function U_i. Therefore he solves the following expression:

$$\underset{q_i}{Max}\, U_i = a_i P_i + (1 - a_i)R_i \quad \text{or} \quad \underset{q_i}{Max}\, U_i = R_i - a_i TC_i$$

Where $P_i = (A - q_i - q_j)q_i - (c - x_i)q_i - (r/2)x_i^2$ **(2)**

$$R_i = q_i(A - q_1 - q_2) \qquad \textbf{(3)}$$

$$TC_i = (c - x_i)q_i + \left(\frac{r}{2}\right)x_i^2 \qquad \textbf{(4)}$$

The First Order Conditions (F.O.C.) for managers 1,2 can be written as :

$$\frac{\partial U_1}{\partial q_1} = 0$$

$$\frac{\partial U_2}{\partial q_2} = 0$$

Thus the following system of equations results, which represents the reaction function of each manager:

$$q_1 = \frac{A - q_2 - a_1(c - x_1)}{2} \qquad \textbf{(6)}$$

$$q_2 = \frac{A - q_1 - a_2(c - x_2)}{2} \qquad \textbf{(7)}$$

By solving the above system and rearranging we obtain the Nash equilibrium output of the third stage:

$$q_1 = \frac{A + a_2(c - x_2) + 2a_1(x_1 - c)}{3} \quad \textbf{(8)}$$

$$q_2 = \frac{A + a_1(c - x_1) + 2a_2(x_2 - c)}{3} \quad \textbf{(9)}$$

By substituting (**8**), (**9**) in U_i, the objective function of each manager results, depending on $x_1, x_2, a_1, a_2, A, c, r$, Thus:

$$U_1[\ x_1, x_2, a_1, a_2, Ac, r] \quad \textbf{(10)}$$

$$U_2[x_1, x_2, a_1, a_2, Ac, r] \quad \textbf{(11)}$$

During the second stage managers 1 and 2 decide about the R&D investments, seeking to maximize(**10)** and (**11**) respectively, therefore they solve the problem:

$$\underset{x_1}{Max} U_1[\ x_1, x_2, a_1, a_2, A, c, r]$$

$$\underset{x_2}{Max} U_2[x_1, x_2, a_1, a_2, A, c, r]$$

The F.O.C. can be written:

$$\frac{\partial U_1[\ x_1, x_2, a_1, a_2]}{\partial x_1} = 0$$

$$\frac{\partial U_2[\ x_1, x_2, a_1, a_2]}{\partial x_2} = 0$$

By solving the above equations over x_1 and x_2 respectively, we obtain the following system:

$$x_1 = -\frac{4(A - 2a_1c + a_2c - a_2x_2)}{8a_1 - 9r} \quad \textbf{(12)}$$

$$x_2 = -\frac{4(A - 2a_2c + a_1c - a_1x_1)}{8a_2 - 9r} \quad \textbf{(13)}$$

The solution of the above system gives x_1 and x_2 as functions of a_1, a_2, A, c, r :

$$x_1 = \frac{4(-4Aa_2 + 4a_1a_2c + 3Ar - 6a_1cr + 3a_2cr)}{8a_1(2a_2 - 3r) + 3r(-8a_2 + 9r)} \quad \textbf{(14)}$$

$$x_2 = \frac{4(-4Aa_1 + 4a_1a_2c + 3Ar - 6a_2cr + 3a_1cr)}{8a_1(2a_2 - 3r) + 3r(-8a_2 + 9r)} \quad \textbf{(15)}$$

By substituting (**14**) and(**15**) in P_1, P_2 respectively we obtain the profit function of each firm depending on a_1, a_2, A, c, r :

$$P_1[a_1, a_2] \quad \textbf{(16)}$$

$$P_2[a_1, a_2] \quad \textbf{(17)}$$

In the first stage of the game the owner of each firm sets the incentive parameter a_i in order to maximize his firm's profits. Thus they solve the problem:

$$\underset{a_1}{Max} P_1[a_1, a_2]$$

$$\underset{a_2}{Max} P_2[a_1, a_2]$$

The F.O.C. are given by:

$$\frac{\partial P_1[a_1, a_2]}{\partial a_1} = 0$$

$$\frac{\partial P_2[a_1, a_2]}{\partial a_2} = 0$$

By solving the above system of equations and rearranging we obtain the SPE values of the incentive parameter a_1^*, a_2^*, depending from A, c, r. Since the problem is symmetrical then $a_1^* = a_2^* = a^*$. More specifically:

$$a^{*} \; c, r \; - 192cr \; 135cr^{2} \; 4 + 9r \; , \; 512A^{2} \; 2 + 9 \; 96Acr \; 56 - 270r + 81r^{2} \; 96 \; r^{2} \; 234 - 3816r + 2025r^{2} \; 8 \; 12A - c \; 4 + 27r$$

(18)

By substituting (**18**) in (**14**), (**15**), (**8**), (**9**), (**2**), we obtain the SPE values of R&D investments, output and profits respectively. Thus:

$$x^{*} \; c, r \; - 96A^{2} \; - 32Ac \; + 9r \; c \; 3cr \; 4 + 45r \; 512A \; 2 + 9 \; 96Acr \; 56 - 270r + 81r^{2} \; 96 \; r^{2} \; 234 - 3816r + 2025r^{2} \; - 60cr + 351cr^{2} \; 16 \; 2 + 9 \; , \; 512A^{2} \; 2 + 9 \; 96Acr \; 56 - 270r + 81r^{2} \; 96 \; r^{2} \; 234 - 3816r + 2025r^{2}$$

(1**9**)

$$q^{*} \; c, \; 3r \; - 96A \; + 32Ac \; 2 + 9 \; c \; 3cr \; 4 + 45r \; , \; r \; 16A + 9Ar - 54cr \; 12A + 4c + 27cr \; A \; 4 + 9r \; 2cr \; 4 + 45r \; 4 \; A \; 32 - 14 \; 20 + 117 \; , \; 3r \; 16A + 9Ar - 54cr \; 12A + 4c + 27cr \; A \; 4 + 9r \; 2cr \; 4 + 45$$

(**20**)

$$P^*(A, c, r) = \ldots$$

[illegible]

$$(21)$$

$$u^*(A, c, r) = \ldots$$

[illegible]

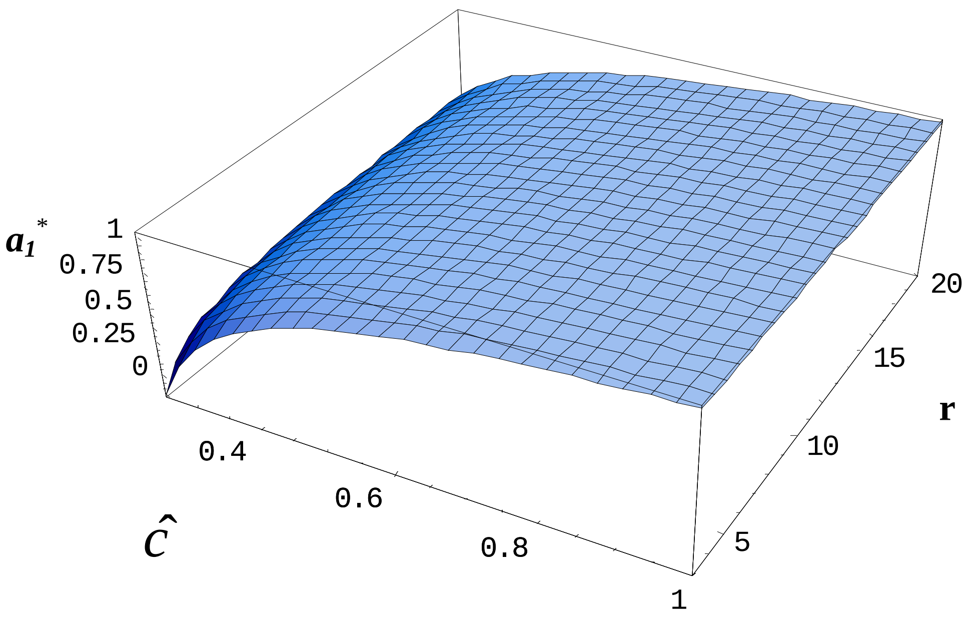
$$(22)$$

From (**18**) (**19**) (**20**) (**21**) (**22**) it is obvious that the SPE values of the incentive parameter, R&D investments, output, profits and managerial compensation depend from the parameters A, c, r. A is a constant that represents the amount of demand given zero production, while c is firm's marginal cost function constant, where $A > c$ always. Finally r is a parameter expressing the efficiency of R&D production.

At this point, it is important to determine the values of the parameters A, c, r , under witch (**18**) (**19**) (**20**) (**21**) (**22**) are significant, in order to represent diagrammatically our results. This will help us compare the results of this game to our next findings. For simplicity reasons we define a new parameter $\hat{c} = \frac{c}{A}$ which represents the initial marginal cost relating to the size of the market and we set $A = 1$.We assume that $A/4 \leq \hat{c} \leq 1$ and $r \geq 3$.The intuition behind this, is that the initial marginal cost should be relative high, so as firms are motivated to reduce it by introducing cost reducing R&D, while the cost of R&D introduction should be proportionally considerable in order to avoid corner solutions[8].

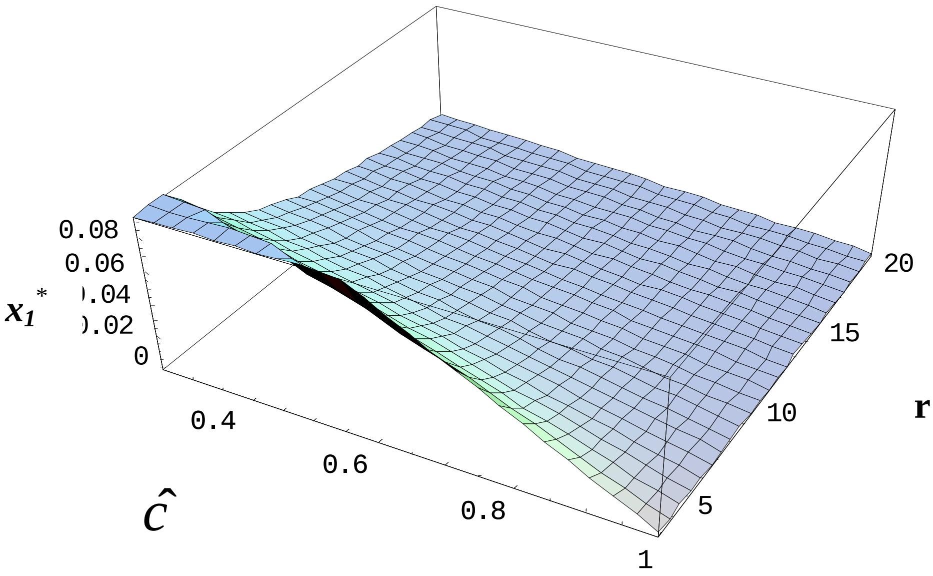
Thus we can now represent the above results diagrammatically:

SPE Managerial Incentive Parameter for case 1

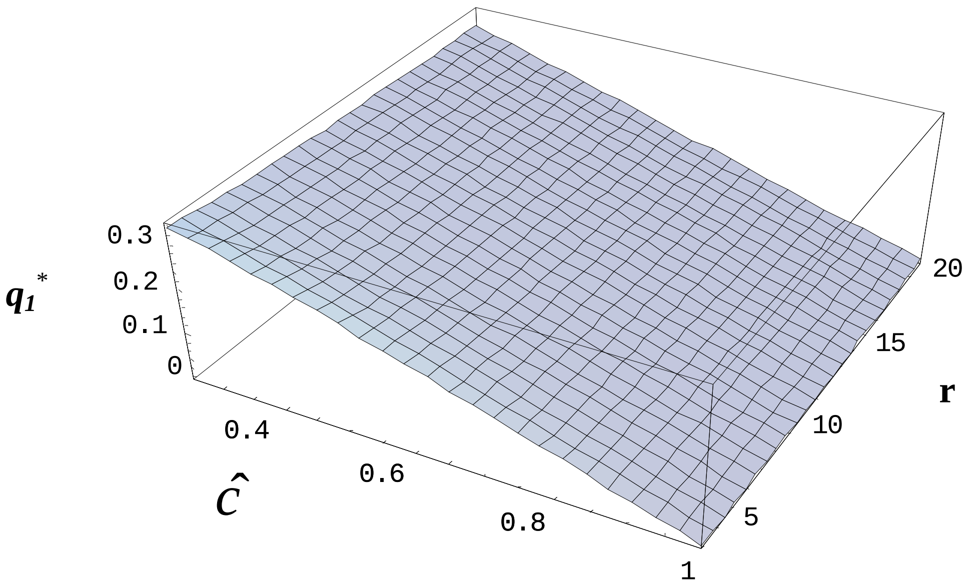


[8] That is, if the cost of R&D is negligible , firms will introduce cost reducing product innovation, until their cost become zero

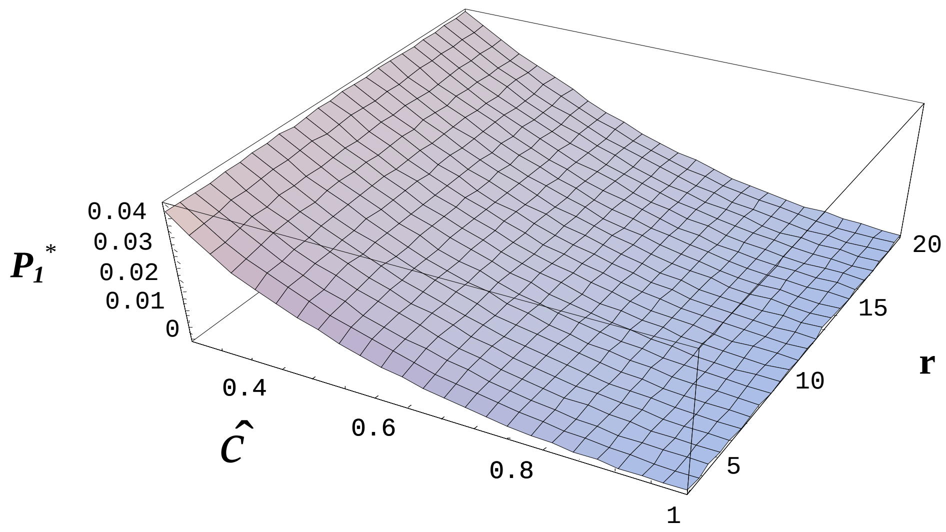
SPE R&D Investments for case 1



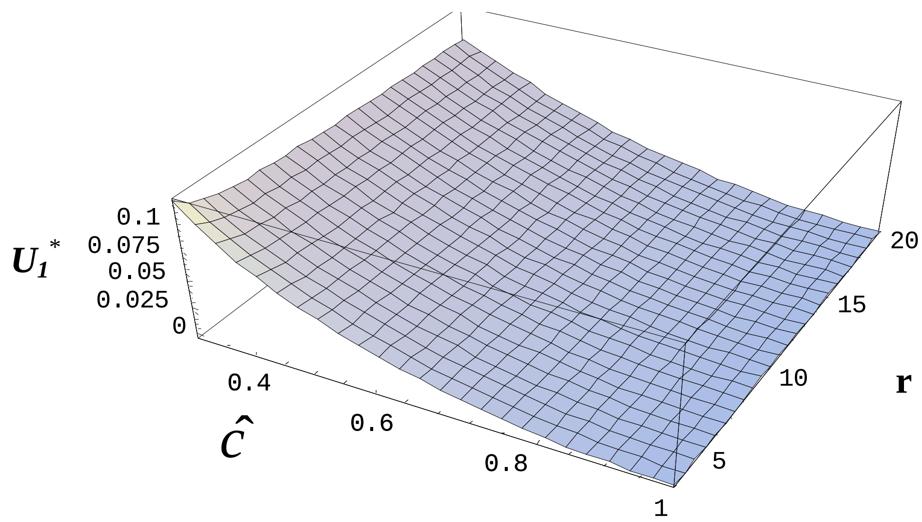
SPE Output for case 1



SPE Profits for case 1



SPE Compensation for case 1



3.2: Case 2 (Short-run Delegation)

Now we consider the scenario where only quantity decisions are delegated to managers, while owners decide about the cost reducing R&D investments. In this case we develop a three stage game. In the first stage owners decide about the R&D investments, and their decision becomes common knowledge. In the second stage, given their R&D decisions, owners decide about the incentive scheme about their firm's manager. Finally in the last stage managers compete in a Cournot quantity model. It is important to be noticed that the timing of the game is formed as above because , in the real business world it is common practice to decide about the long-run plans of the firm first, and according to them, decide about the short-run issues. In order to find the SPE of the game we apply backwards induction:

In the third stage managers compete in quantities.

Thus in stage three manager i chooses output q_i to maximize his objective function U_i. Therefore he solves the following expression:

$$\underset{q_i}{Max}\, U_i = a_i P_i + (1 - a_i) R_i \quad \text{or} \quad \underset{q_i}{Max}\, U_i = R_i - a_i TC_i$$

Where $P_i = (A - q_i - q_j)q_i - (c - x_i)q_i - (r/2)x_i^2$ **(23)**

$R_i = q_i(A - q_1 - q_2)$ **(24)**

$TC_i = (c - x_i)q_i + (r/2)x_i^2$ **(25)**

The First Order Conditions (F.O.C.) can be written as :

$$\frac{\partial U_1}{\partial q_1} = 0 \qquad \textbf{(26)}$$

$$\frac{\partial U_2}{\partial q_2} = 0$$

Thus the following system of equations results, which represents the reaction function of each manager:

$$q_1 = \frac{\mathrm{A - q_2 - a_1 (c - x_1)}}{2} \qquad \textbf{(27)}$$

$$q_2 = \frac{\mathrm{A - q_1 - a_2 (c - x_2)}}{2} \qquad \textbf{(28)}$$

By solving the above system we obtain the Nash equilibrium output of the third stage:

$$q_1 = \frac{A + a_2(c - x_2) + 2a_1(x_1 - c)}{3} \qquad \textbf{(29)}$$

$$q_2 = \frac{A + a_1(c - x_1) + 2a_2(x_2 - c)}{3} \qquad \textbf{(30)}$$

By substituting (**29**), (**30**) in U_i, the objective function of each manager results, depending on $x_1, x_2, a_1, a_2, A, c, r$, Thus:

$$U_1[\ x_1, x_2, a_1, a_2, A, c, r] \qquad \textbf{(31)}$$

$$U_2[x_1, x_2, a_1, a_2, A, c, r] \qquad \textbf{(32)}$$

It is obvious that the Nash equilibrium of stage 3 is identical to the equivalent equilibrium of the first case. By substituting (**29**) and (**30**) in (**23**) we obtain firm's 1 and 2 profits P_1, P_2 as functions of $a_1, a_2, x_1, x_2, A, c, r$:

$$P_1[a_1, a_2, x_1, x_2, A, c, r] \qquad \textbf{(33)}$$

$$P_2[a_1, a_2, x_1, x_2, A, c, r] \qquad \textbf{(34)}$$

In stage two, owners choose their managers incentives so as to maximize their firm's profits. Therefore they solve the following problem:

$$\underset{a_1}{Max}\, P_1[a_1, a_2, x_1, x_2, A, c, r]$$

$$\underset{a_2}{Max}\, P_2[a_1, a_2, x_1, x_2, A, c, r]$$

The F.O.C. can be written as:

$$\frac{\partial P_1[a_1, a_2, x_1, x_2, A, c, r]}{\partial a_1} = 0$$

$$\frac{\partial P_2[a_1, a_2, x_1, x_2, A, c, r]}{\partial a_2} = 0$$

By solving the above equations over a_1 and a_2 respectively, we obtain the following system of equations:

$$a_1 = \frac{-A + 6c - a_2 c - 6x_1 + a_2 x_2}{4(c - x_1)} \qquad \textbf{(35)}$$

$$a_2 = \frac{-A + 6c - a_1 c - 6x_2 + a_1 x_1}{4(c - x_2)} \qquad \textbf{(36)}$$

The solution of the above system gives a_1 and a_2 as functions of x_1, x_2, A, c .Thus:

$$a_1[x_1, x_2] = -\frac{A - 6c + 8x_1 - 2x_2}{5(c - x_1)} \qquad \textbf{(37)}$$

$$a_2[x_1, x_2] = -\frac{A - 6c + 8x_2 - 2x_1}{5(c - x_2)} \qquad \textbf{(38)}$$

By substituting (**37**) and (**38**) in (**33**) and (**34**) respectively we obtain the profit function of each firm as a function of x_1, x_2, A, c, r :

$$P_1[x_1, x_2, A, c, r] \qquad \textbf{(39)}$$

$$P_2[x_1, x_2, A, c, r] \qquad \textbf{(40)}$$

In the first stage of the game, the owners decide about the amount of R&D investments x_i that will maximize their firms' profits. Thus they solve the problem:

$$\underset{x_1}{Max}\, P_1[x_1, x_2, A, c, r]$$

$$\underset{x_2}{Max}\, P_2[x_1, x_2, A, c, r]$$

The F.O.C. are given by:

$$\frac{\partial P_1[x_1, x_2]}{x_1} = 0$$

$$\frac{\partial P_2[x_1, x_2]}{x_2} = 0$$

From the F.O.C. we obtain the following system of equations:

$$x_1 = \frac{12(A - c - 2x_2)}{-36 + 25r} \qquad \textbf{(41)}$$

$$x_2 = \frac{12(A - c - 2x_1)}{-36 + 25r} \qquad \textbf{(42)}$$

By solving the system of (**41**) and (**42**) we obtain the SPE values of the R&D investments x_1^*, x_2^*, depending from A, c, r .Because of symmetry it is:

$$x_1^*[A,c,r] = x_2^*[A,c,r] = x^*[A,c,r] = \frac{12(A - c)}{-12 + 25r} \qquad \textbf{(43)}$$

By substituting (**43**) in (**39**), (**40**), (**37**), (**38**), (**31**), (**32**), (**29**), (**30**) we obtain the SPE values of profits, incentive parameter, compensation and quantity respectively. Thus:

$$P^*[A,c,r] = \frac{2(A - c)^2 r(-36 + 25r)}{(12 - 25r)^2} \qquad \textbf{(44)}$$

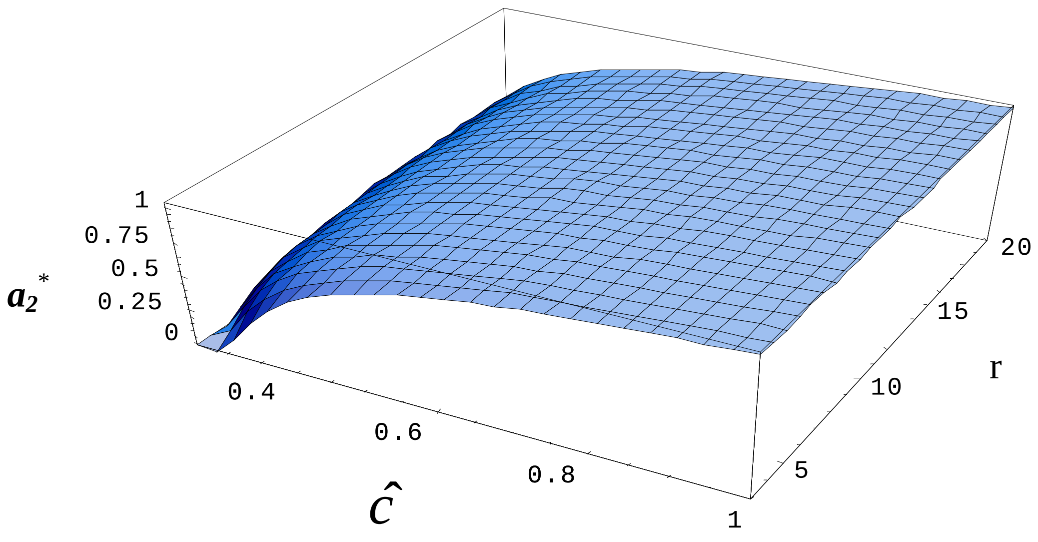
$$a^*[A,c,r] = \frac{12A - 5Ar - 30cr}{12A - 25cr} \qquad \textbf{(45)}$$

$$U^*[A,c,r] = \frac{4(A-c)^2 r[5c(108-125r)r + 6A(-36+35r)]}{(12-25r)^2(12A-25cr)} \quad \textbf{(46)}$$

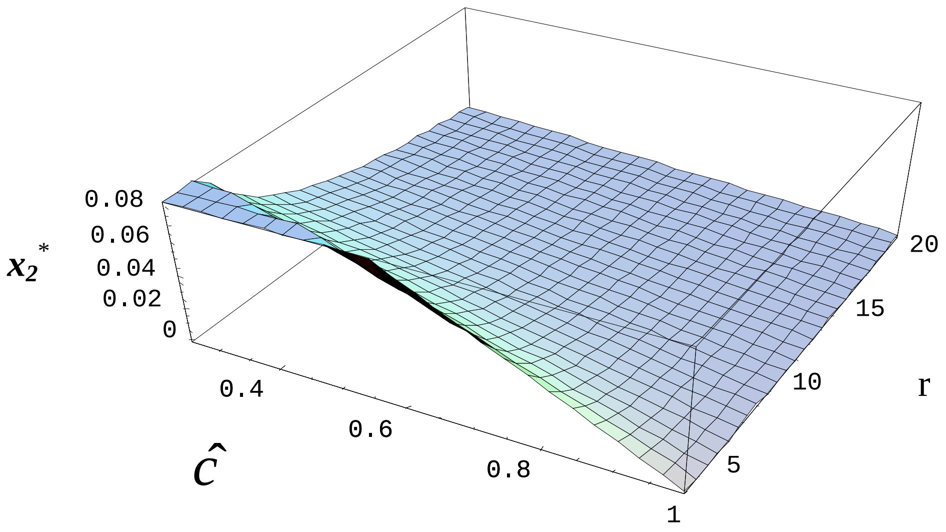
$$q^*[A,c,r] = \frac{10(A-c)r}{-12+25r} \quad \textbf{(47)}$$

The diagrammatical representation of the above results follows:

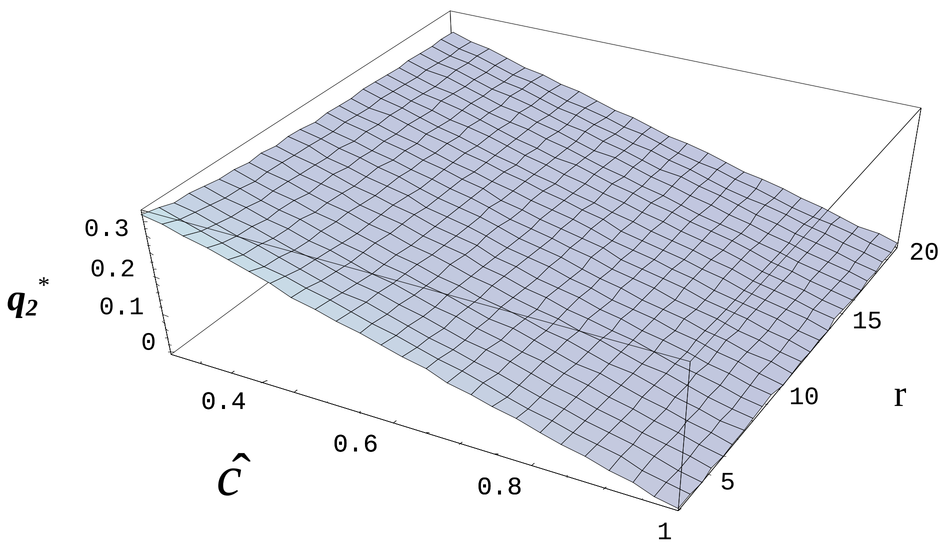
SPE Managerial Incentive Parameter for case 2



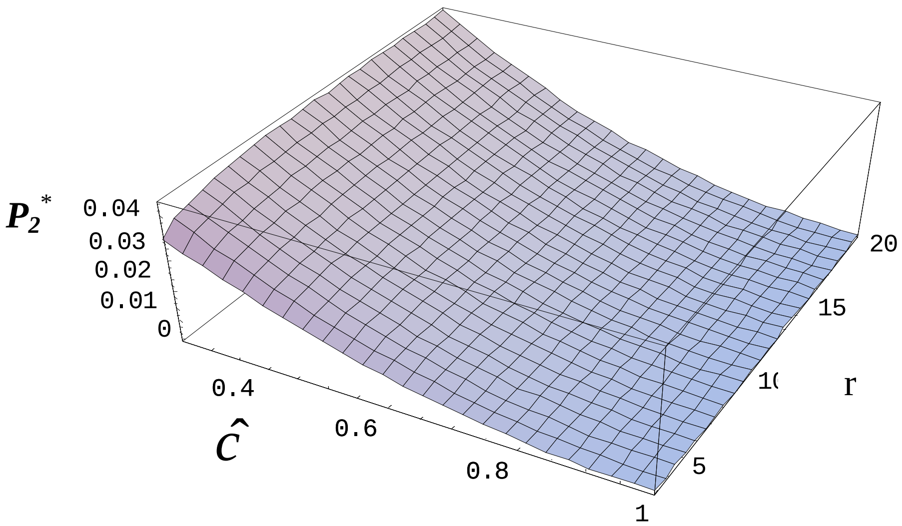
SPE R&D Investments for case 2



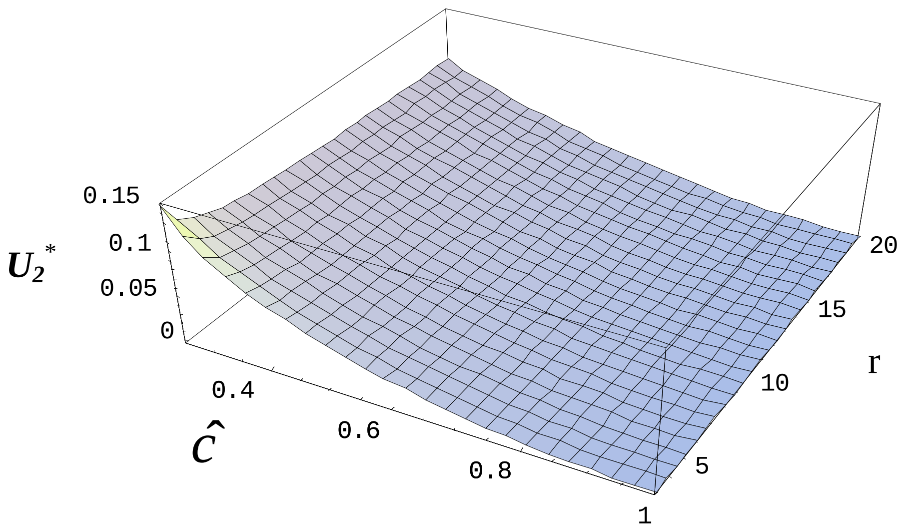
SPE Output for case 2



SPE Profits for case 2



SPE Compensation for case 2



3.3: Case 3 (No Delegation)

In this case we consider a simple Cournot duopoly model with R&D investments, where there is no managerial delegation. This means that both long–run and short-run decisions of firms 1, 2 are made by their profit maximizing owners. Therefore the managerial incentive parameters a_1, a_2 are equal to unity. By substituting $a_1 = a_2 = 1$ to the objective functions of managers 1,2: U_1, U_2 respectively, we obtain $U_1 = P_1$ and $U_2 = P_2$ meaning that the manager and the owner of each firm are identical. Thus, we have a two stage game , where in the first stage owners of each firm, decide about the amount of R&D investments that will maximize their firm's profits , while in the second stage they decide about the profit maximizing output.

In order to obtain the SPE of the game we apply backwards induction:

In the second stage the owner of each firm chooses output q_i in order to maximize his firm's profits P_i .Thus he solves the following problem:

$$\max_{q_i} P_i = (A - q_i - q_j)q_i - (c - x_i)q_i - (r/2)x_i^2$$

The F.O.C. are given by:

$$\frac{\partial P_1}{\partial q_1} = 0$$

$$\frac{\partial P_2}{\partial q_2} = 0$$

By solving the above equations we obtain, the reaction function of each owner:

$$q_1 = \frac{1}{2}(A - c - q_2 + x_1)$$

$$q_2 = \frac{1}{2}(A - c - q_1 + x_2)$$

By solving the above system of equations we obtain the Nash equilibrium output of the second stage. That is:

$$q_1 = \frac{1}{3}(A - c + 2x_1 - x_2) \qquad \textbf{(48)}$$

$$q_2 = \frac{1}{3}(A - c + 2x_2 - x_1) \qquad \textbf{(49)}$$

By substituting (**48**) in (**49**)the profit function of each firm results, depending on x_1, x_2, A, c, r :

$$P_1[x_1, x_2, A, c, r] \qquad \textbf{(50)}$$

$$P_2[x_1, x_2 A, c, r]] \qquad \textbf{(51)}$$

In the first stage the owner of each firm chooses R&D investments x_i in order to maximize his firm's profits $P_i[x_1, x_2]$. Therefore he solves the following problem:

$$\underset{x_1}{Max}\, P_1[x_1, x_2, A, c, r]$$

$$\underset{x_2}{Max}\, P_2[x_1, x_2, A, c, r]$$

The F.O.C. are given by:

$$\frac{\partial P_1[x_1, x_2]}{\partial x_1} = 0$$

$$\frac{\partial P_2[x_1, x_2]}{\partial x_2} = 0$$

The solution of the above equations over x_1, x_2 gives the following system of equations:

$$x_1 = \frac{4(A - c - x_2)}{-8 + 9r} \qquad \textbf{(52)}$$

$$x_2 = \frac{4(A - c - x_1)}{-8 + 9r} \qquad \textbf{(53)}$$

By solving the above system of equations we obtain the SPE values of R&D investments x_1^*, x_2^* depending from A, c, r. Because of symmetry:

$$x_1^* = x_2^* = x^*[A,c,r] = \frac{4(A - c)}{-4 + 9r} \qquad \textbf{(54)}$$

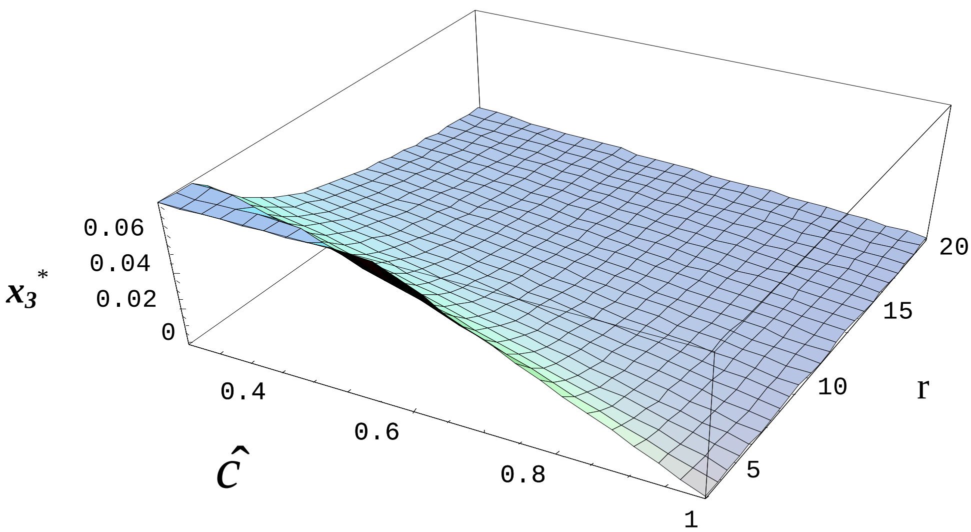
By substituting (**54**) in (**50**), (**51**), (**48**), (**49**) we obtain the SPE values of profits $P_1^* = P_2^* = P^*[A,c,r]$ and output $q_1^* = q_2^* = q^*[A,c,r]$ respectively:

$$P^*[A,c,r] = \frac{(A - c)^2 r(-8 + 9r)}{(4 - 9r)^2} \qquad \textbf{(55)}$$

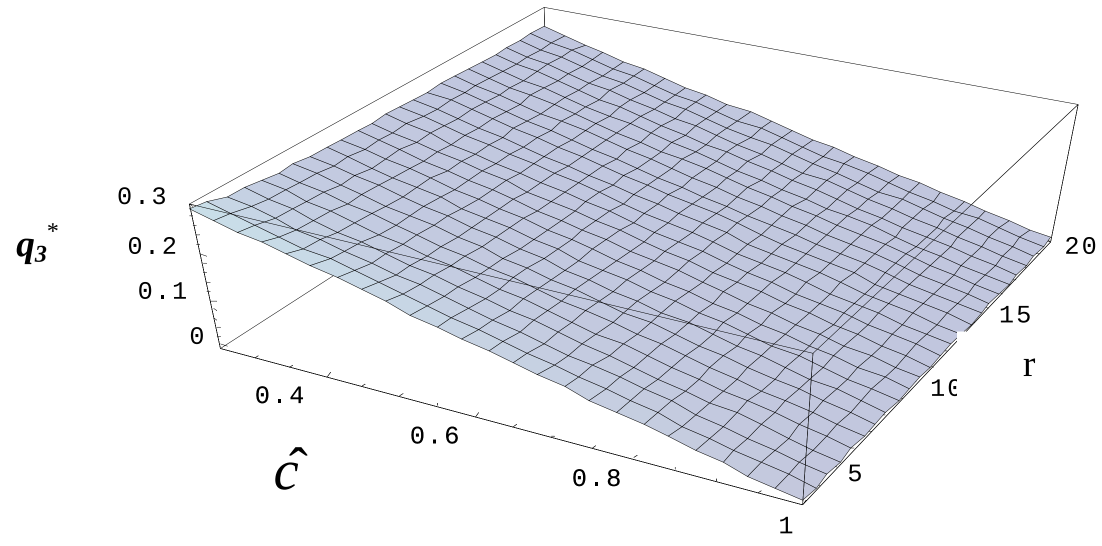
$$q^*[A,c,r] = \frac{3(A - c)r}{-4 + 9r} \qquad \textbf{(56)}$$

The diagrammatical representation of the above results follows:

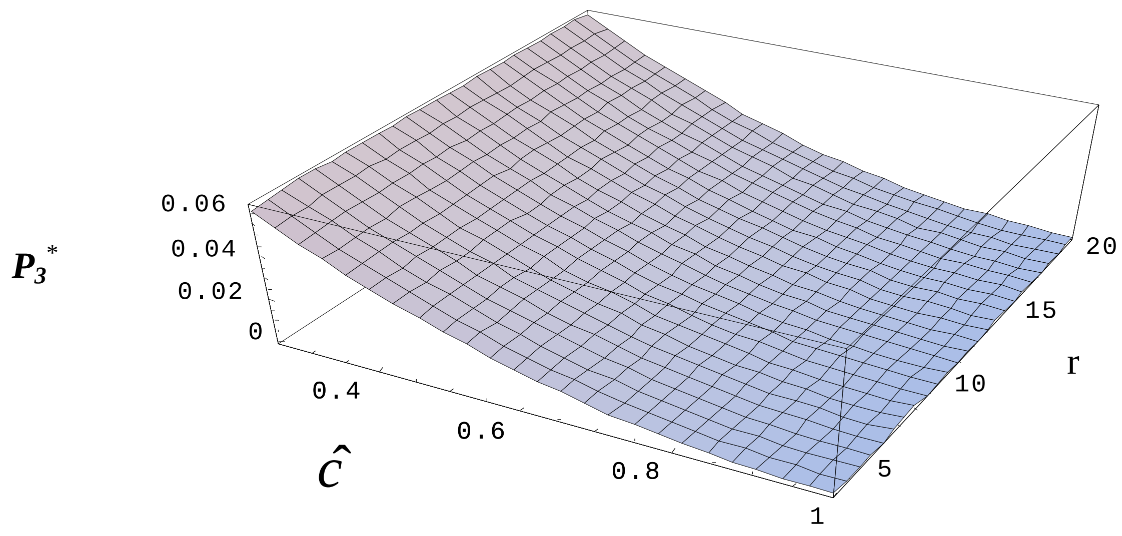
SPE R&D Investments for case 3



SPE Output for case 3



SPE Profits for case 3



4. COMPARATIVE RESULTS

In order to compare our findings regarding full delegation (case 1), short-run delegation (case2) and no delegation (case 3) it is useful to represent them diagrammatically. For this purpose we assume that the R&D efficiency parameter is constant and equal to 3 ($r = 3$)[9]:

Diagram 1: SPE managerial incentive parameter

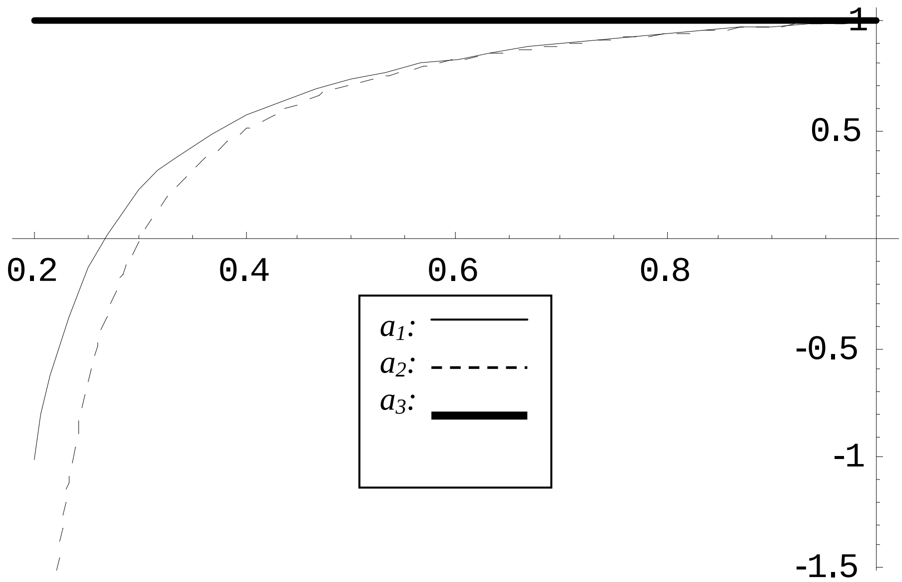


Diagram 1 represents the managerial incentive parameter in cases 1, 2 and 3 (a_1, a_2 and a_3 respectively) for different values of $\hat{c}$. It is obvious that a_i is less than unity in both cases 1 and 2 [10] ($a_1, a_2 < 1$ for every $\hat{c} \in [0.25,1]$). This means that firms' owners are motivated to set a less than unity when delegation takes place. Thus, firms' managers put less value to profits and higher value to sales, and become more aggressive than if they were profit maximizers. Moreover the managerial incentive

[9] But our results hold for every $r \geq 3$
[10] By assumption $a = 1$ in the third case

parameter is always higher in case 1 than in case 2 ($a_1 > a_2$ for every $\hat{c} \in [0.25,1]$) The intuition behind this, is that since in case 1 managers decide both about the long-run and the short-run of their firm, owners will set higher incentive parameter in order to motivate their managers to put more weight on profits and become less aggressive, than the case were they only decide about only the short-run plans of their firm.

Proposition 1: In a delegation game owners are always motivated to twist their managers away from profit maximization. Further more in the case if short-run delegation managers are always motivated to be more aggressive, than in the case of full delegation.

Diagram 2: SPE R&D investments

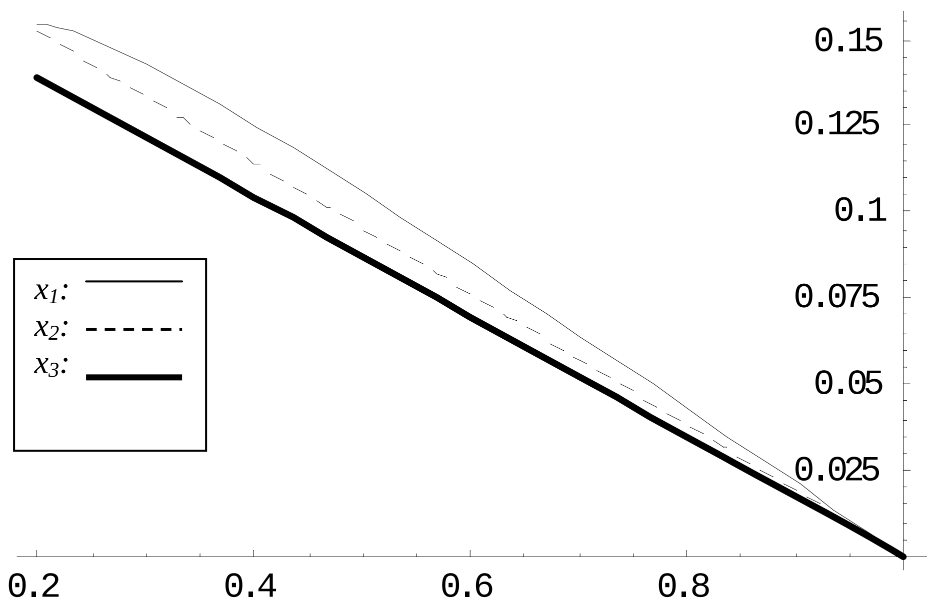
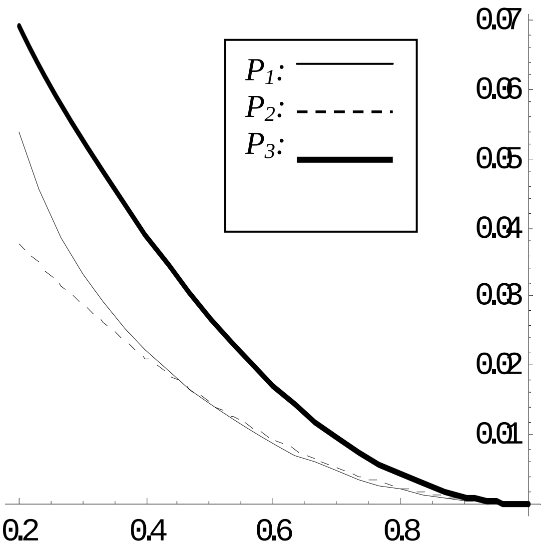


Diagram 2 represents firms R&D investments in cases 1, 2 and 3(x_1 , x_2 and x_3 respectively) for different values of $\hat{c}$. It can be shown that R&D investments are always higher in both cases 1 and 2, comparing to case 3 (for every $\hat{c} \in [0.25,1]$). Moreover R&D investments in case 1 are always larger, than in case 2(for

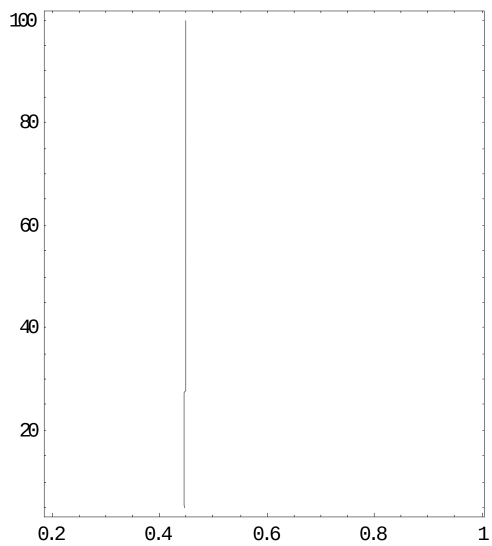
every $\hat{c} \in [0.25,1]$).That is $x_1 > x_2 > x_3$ for every $\hat{c} \in [0.25,1]$. The intuition behind this, is that in cases 1, 2 R&D investments are increased so as to confront the increased competition created by delegation. More specifically in case 2, owners will invest more in R&D in order to cope with the increased market competition they expect in the last stage, while in case 1 managers invest even more in R&D since they put less weight in cost[11].

Proposition 2: Managerial firms always invest more in R&D than entrepreneurial firms. In a delegation game firms always invest more in R&D under full delegation, comparing to short-run delegation.

Diagram 3: SPE Profits



Contour plot P_1-P_2

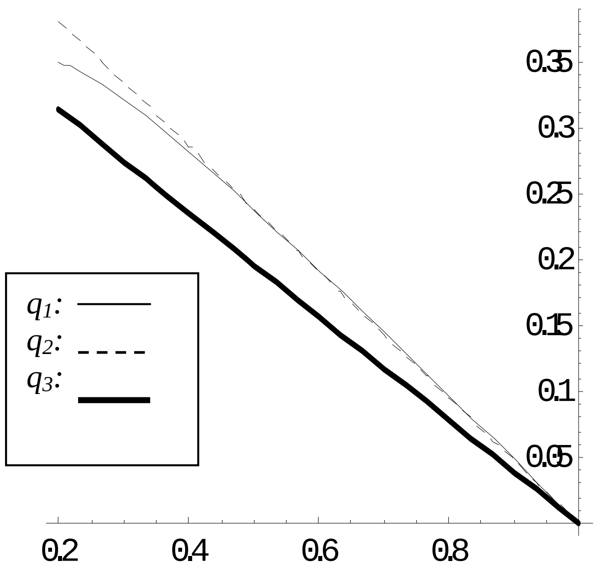


[11] Since managers compensation function is given by $U_i = a_i P_i + (1 - a_i) R_i$, when they choose R&D investments optimally, they put less weight in cost, than if they were profit maximizers.

Diagram 3 represents firms profits in cases 1, 2 and 3(P_1 ,P_2 and P_3 respectively) for different values of $\hat{c}$. It is obvious that firms’ profits are always lower in cases 1 and 2 than in case 1. The intuition behind this, is that increased competition under delegation decreases firms profits, comparing to the no delegation scenario. If $\hat{c} \in [0.25, 0.54)$, then firms’ profits in case 1 are higher than in case 2. If $\hat{c} = 0.54$, then firms profits are equal in cases 1, 2. If $\hat{c} \in (0.54, 1]$, then firms profits in case 1 are lower than in case 2.

Proposition 3: Managerial firms always have lower profits than entrepreneurial firms. In a delegation game, if firms initial marginal cost is relatively low ($\hat{c} \in [0.25, 0.54)$), then firms make higher profits under full delegation than under the short-run delegation scenario. If firms initial marginal cost is relatively high ($\hat{c} \in (0.54, 1]$), then firms’ profits are lower under full delegation, than under short-run delegation. If $\hat{c} = 0.54$, then firms profits are equal in both full and short-run delegation scenarios.

Diagram 4: SPE Output



Contour plot q1-q2

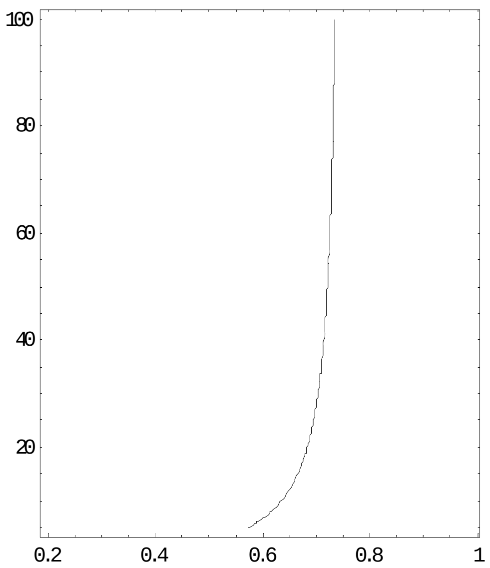


Diagram 4 represents firms' output in cases 1, 2 and 3(q_1 ,q_2 and q_3 respectively) for different values of $\hat{c}$. It is obvious that firms' output is always lower in cases 1 and 2 than in case 1. The intuition behind this, is that increased competition under delegation increases firms output, comparing to the no delegation scenario. If $\hat{c} \in [0.25, 0.54)$, then firms' profits in case 1 are higher than in case 2. If $\hat{c} = 0.54$, then firms profits are equal in cases 1, 2. If $\hat{c} \in (0.54,1]$, then firms profits in case 1 are lower than in case 2.

Proposition 4: Managerial firms always produce higher output than entrepreneurial firms. In a delegation game, if firms initial marginal cost is relatively low ($\hat{c} \in [0.25, 0.54)$), then firms produce lower output under full delegation than under the short-run delegation scenario. If firms initial marginal cost is relatively high ($\hat{c} \in (0.54,1]$), then firms' output is higher under full delegation, than under short-run delegation. If $\hat{c} = 0.54$, then firms' output equal in both full and short-run delegation scenarios.

5. ENDOGENOUS EQUILIBRIUM SCHEMES

In the last section we compared three candidate equilibria that result from cases 1,2 and 3.In order to investigate which equilibrium will finally result endogenously in the industry, we have to examine owners motives to deviate from the above candidate equilibria. Because this analysis is too long to take place in this master thesis, we only examine the possibility of deviation in case 2.That is, given that firms' 1 owner has chosen to delegate only short run decisions to his manager, firms'2 owner examines his firms' profitability, if he deviates to either no delegation (scenario 1) or to full delegation (scenario 2).For both scenarios we consider a Cournot duopoly, making the same assumptions considered in section 3.

5.1 Scenario 1: Deviation to no delegation

Now, given that firm's 1 owner delegates only short-run decisions to his manager, firm's 2 owner decides to deviate to no delegation. Thus a three staged game unravels as follows. In the first stage firm's 1 owner chooses R&D investments x_1, in order to maximize his firm's profits. In the second stage the owner of firm1 chooses the managerial incentive parameter a_1 that will maximize his profits, while firm's 2 owner chooses R&D investments x_2 optimally given x_1 (that is $x_2[x_1]$).

In stage 3 firm's 1 manager chooses output q_1 in order to maximize his compensation, while firm's 2 owner chooses output q_2 so as to maximize his firm's profits. As usual the solution concept is the Sub Game Perfect Equilibrium by backwards induction.

The objective functions of stage 3 are:

$$U_1[q_1, q_2, x_1, x_2, a_1, a_2] = a_1 P_1 + (1 - a_1) R_1 \quad \textbf{(57)}$$

$$P_2[q_1, q_2, x_1, x_2, a_1, a_2] = (A - q_1 - q_2)q_2 - (c - x_2)q_2 - (r/2)x_2^2 \quad \textbf{(58)}$$

By setting $a_2 = 1$, taking the F.O.C. with respect to q_1, q_2 and solving, one obtains:

$$q_1 = \frac{1}{3}(A - 2a_1 c + 2a_1 x_1 + c - x_2) \quad \textbf{(59)}$$

$$q_2 = \frac{1}{3}(A + a_1 c - a_1 x_1 - 2c + 2x_1) \quad \textbf{(60)}$$

Which can be plugged into P_1 and P_2 to write the relative objective functions of the second stage:

$$P_1[x_1, x_2, a_1] \quad \textbf{(61)}$$

$$P_2[x_1, x_2, a_1] \quad \textbf{(62)}$$

From the above equations we can write the F.O.C. with respect to a_1, x_2 respectively:

$$\partial P_1[x_1, x_2, a_1] / \partial a_1 = 0$$

$$\partial P_2[x_1, x_2, a_1] / \partial x_2 = 0$$

By solving the above system with respect to a_1, x_2 we obtain a_1, x_2 as functions of x_1. That is:

$$a_1[x_1] = \frac{A(4 - 3r) + c(15r - 16) + 2x_1 8 - 9r}{12(r - 1)(c - x_1)} \quad \textbf{(63)}$$

$$x_2[x_1] = \frac{A - c - 2x_1}{3r - 3} \qquad \textbf{(64)}$$

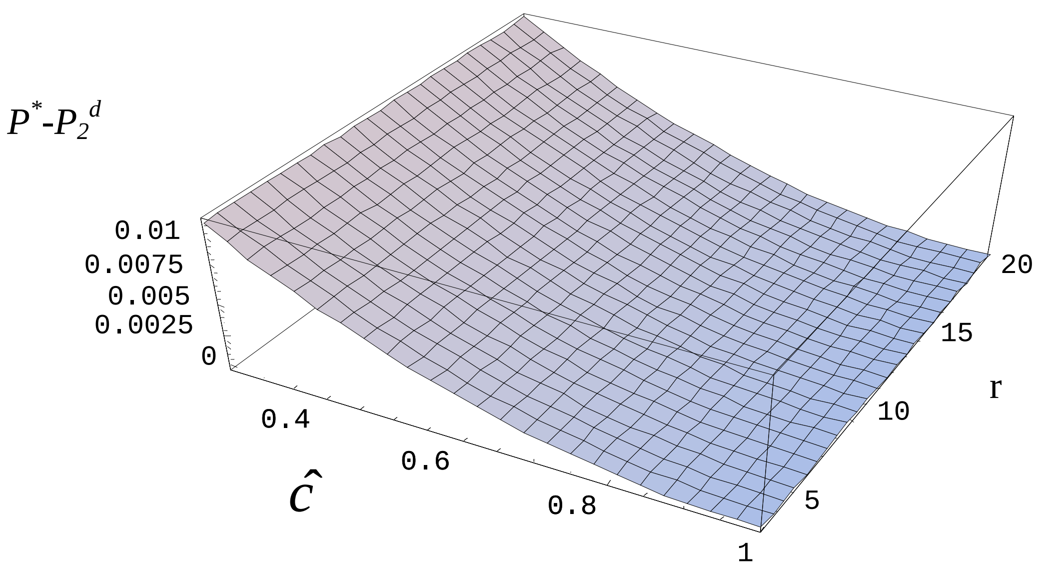
In stage 1 the owner of firm 1 will choose R&D investments x_1 equal to the case where both firms delegate short run decision (case2), because he thinks that firm's 2 owner will do the same. Thus $x_1^* = x^*_{S-R}[A,c,r] = \frac{4(A-c)}{-4+9r}$ **(65)**

By substituting x_1^* to **(63)** , **(64)** and $P_2[x_1, x_2, a_1]$ **(62)** we obtain the deviation equilibrium profits of firm 2:

$$P_2^d[A,c,r] = \frac{(A-c)^2 r(9r-8)(25r-36)^2}{144(25r^2 - 37r + 12)^2} \qquad \textbf{(66)}$$

By comparing the deviation profits $P_2^d[A,c,r]$ to the non deviation profits that result in case 2: $P^*[A,c,r] = \frac{2(A-c)^2 r(-36+25r)}{(12-25r)^2}$ we obtain that $P_2^d[A,c,r] < P^*[A,c,r]$ for every $\hat{c} \in [0.25,1]$. This result is obvious in **diagram 5** which represents the difference $P^*[A,c,r] - P_2^d[A,c,r] > 0$ for $\hat{c} \in [0.25,1], r \geq 3$.

Diagram 5: P^*-P_2^d



Thus the following results:

Proposition 5: In the short-run delegation case, no firm's owner is motivated to deviate from the symmetrical equilibrium towards no delegation.

5.2 Scenario 2: Deviation to full delegation

Now we assume that, given the fact that firm's 1 owner delegates only short run decisions to his manager, firm's 2 owner deviates by delegating both short-run and long-run decisions to his firm's manager. A three staged game is set as follows. In the first stage firm's 1 owner chooses R&D investments x_1 in order to maximize his profits, believing that firm's 2 owner will do the same. Firm's 2 owner decides to deviate to full delegation thus he chooses the managerial incentive parameter a_2 that will maximize his profits, given owner's 1 choice x_1 (that is $a_2[x_1]$).In stage 2 firm's 1 owner chooses the managerial incentive parameter a_1 that will maximize his firm's profits, while firm's 2 manager chooses R&D investments x_2 in order to maximize his compensation. In the final stage managers 1 and 2 compete in quantities seeking to maximize their compensation U_1 and U_2 respectively. The Sub Game Perfect Equilibrium results by applying backwards induction:

The objective functions of the third stage are given by:

$$U_1[q_1, q_2, x_1, x_2, a_1, a_2] = a_1 P_1 + (1 - a_1) R_1 \quad \textbf{(67)}$$

$$U_2[q_1, q_2, x_1, x_2, a_1, a_2] = a_2 P_2 + (1 - a_2) R_2 \quad \textbf{(68)}$$

By taking the F.O.C. with respect to q_1, q_2 and solving, one obtains:

$$q_1 = \frac{A + a_2(c - x_2) + 2a_1(x_1 - c)}{3} \quad \textbf{(69)}$$

$$q_2 = \frac{A + a_1(c - x_1) + 2a_2(x_2 - c)}{3} \quad \textbf{(70)}$$

Which can be plugged into P_1 and U_2 to write the relative objective functions of the second stage:

$$P_1[x_1, x_2, a_1, a_2] \quad \textbf{(71)}$$

$$U_2[x_1, x_2, a_1, a_2] \quad \textbf{(72)}$$

The F.O.C. with respect to a_1, x_2 can be written:

$$\partial P_1[x_1, x_2, a_1, a_2] \big/ \partial a_1 = 0$$

$$\partial U_2[x_1, x_2, a_1, a_2] \big/ \partial x_2 = 0$$

By solving with respect to a_1, x_2 we obtain: $a_1[x_1, a_2]$(**73**), $x_2[x_1, a_2]$(**74**). We know by assumption that in stage 1 firm's 1 owner will choose $x_1^* = x^*_{S-R}[A, c, r] = \frac{4(A - c)}{-4 + 9r}$, thus (**73**),(**74**) become $a_1[a_2]$(**75**), $x_2[a_2]$(**76**).

By substituting (**75**), (**76**) and (**65**) in $P_2[x_1, x_2, a_1, a_2]$ the objective function of stage 1 is given by $P_2[a_2]$ (**77**)

The F.O.C. with respect to a_2 can be written:

$$\partial P_2[a_2] \big/ \partial a_2 = 0 \quad \textbf{(78)}$$

By solving (**78**) we obtain the deviation S.P.E. managerial incentive parameter:

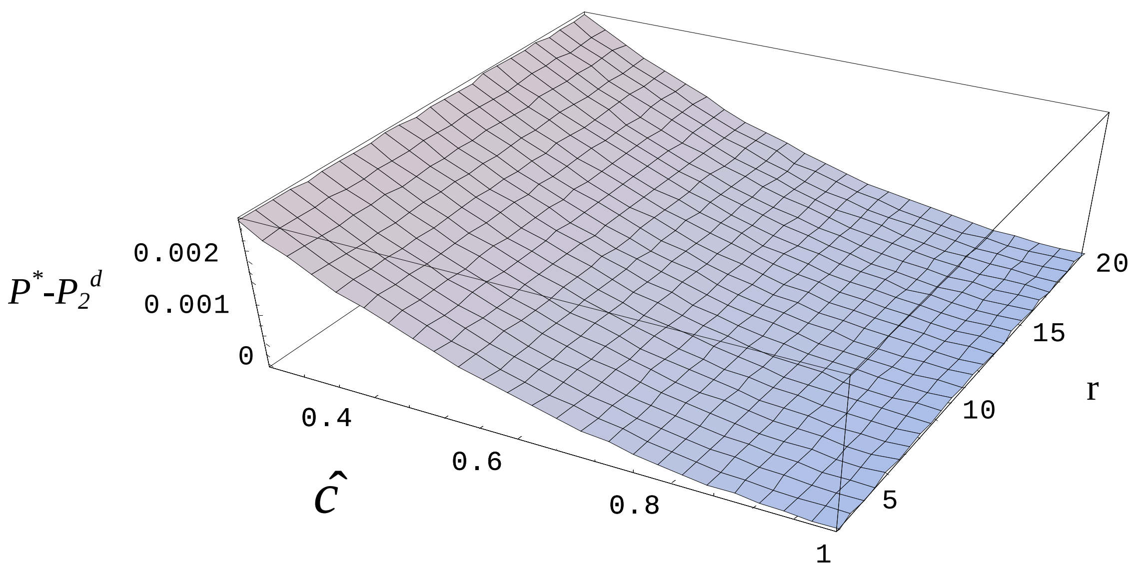
$$a_2^d = \frac{144A + 8Ar - 416cr - 75Ar^2 + 300cr^2}{216A - 72c - 150Ar - 258cr + 225cr^2} \quad \textbf{(79)}$$

By substituting (**79**)to (**77**)we obtain firm's 2 deviation equilibrium profits

$$P_2^d[A,c,r] = .\frac{(A-c)^2(25r-36)^2 r}{4(25r-12)^2(3r-4)} \quad \textbf{(80)}$$

By comparing the deviation profits $P_2^d[A,c,r]$ to the non deviation profits that result in case 2: $P^*[A,c,r] = \frac{2(A-c)^2 r(-36+25r)}{(12-25r)^2}$ we obtain that $P_2^d[A,c,r] < P^*[A,c,r]$ for every $\hat{c} \in [0.25,1]$. This result is obvious in **diagram 6** which represents the difference $P^*[A,c,r] - P_2^d[A,c,r]$ for $\hat{c} \in [0.25,1], r \geq 3$.

Diagram 6: P^*-P_2^d



Thus the following proposition results:

Proposition 6: In the short-run delegation case, no firm's owner is motivated to deviate from the symmetrical equilibrium towards full delegation.

6. CONCLUSIONS

Existing literature regarding strategic delegation in oligopoly with R&D, considers that firms' owners' alternative decisions are either full delegation or no delegation. More over , it restricts on comparison between these two scenarios without considering endogenously merging equilibria.

We assume a more realistic scenario where firms' owners' alternative strategies are: Full delegation (case 1), Short-run delegation (case2) and No delegation (case3).We found that R&D investments are higher in case 1 than in case 2 and lower in case 3 than both delegation scenarios. The managerial incentive parameter is larger in case 1 than in case 2 and less than unity in both delegation cases. Firm' profits are always larger in no delegation case comparing to both delegation cases. If the initial marginal cost is relative low, then firms' profits are higher in case 1, than in case 2. However this result is being inverted when the initial marginal cost grows larger. Firms' output is always lower in no delegation case, comparing to both delegation cases. If the initial marginal cost is relative low, then firms' output is lower in case 1, than in case 2. However the opposite result holds if the initial marginal cost is larger.

After having compared the three candidate equilibria (that is [F,F] for case 1 , [S,S] for case 2 and [N,N] for case 3) we examine which equilibrium will merge endogenously. To do so we investigate firms' owners' motives to deviate from the above candidate equilibria. We found that no owner is motivated to deviate from [S,S].Further research remains to be made on firms owners motives to deviate from the other two candidate equilibria (that is [F,F] and [N,N]) so as to define the endogenous merged equilibrium of our model.

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