Endogenous managerial compensation contracts in experimental quantity-setting duopolies

Managerial compensation contracts in quantity-setting duopoly*

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Abstract

In a quantity setting duopoly we experimentally test the ability of managerial compensation schemes to provide a commitment device aiming at gaining leadership in the product market. The novelty of our experiment is the choice between Relative Performance and Profit-Revenue based rewards. In line with our model, the former are chosen more frequently than the latter. Output reacts to the contract terms in the expected way, although it tends to exceed the predicted levels. Firm owners tend to use more balanced weights for their managers' objectives than the theory predicts.

Keywords: Experimental economics; Oligopoly theory; Managerial delegation; Endogenous contracts

JEL Classification: D43; L21

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1 Introduction

It is well established that in modern firms, where ownership and management are separated (Fama and Jensen, 1983), one of the key aspects of corporate governance relates to managerial compensation (van Witteloostuijn et al., 2007).

In this context, owners choose their managers' compensation contracts so as to motivate them to gain a competitive advantage in the market (Murphy, 1999; Jensen et al., 2004).[1] Several corporate performance measures have been associated with managerial compensation. Early empirical studies (Baker et al., 1988; Jensen and Murphy, 1990; Lambert et al., 1991) suggest that CEO compensation is positively associated with profits and revenues. Moreover, industry-level analyses suggest that contracts combining own profit and revenues are widely adopted in the CEO compensation practice in US "new economy" firms (Nourayi and Daroca, 2008), the US electric industry (Duru and Iyengar, 1999) and the US gas utility industry (Agrawal et al., 1991).[2] There is also evidence suggesting that top executives' compensation is based on their "relative performance", i.e., a manager's compensation is a combination of own profits and the relative performance against the rivals' profits (Gibbons and Murphy, 1990; Barro and Barro, 1990; Janakiraman et al., 1992).[3] Aggarwal and Samwick (1999) and Joh (1999) find that contracts of this type are widely adopted both in the US and Japanese manufacturing sector. Regarding the UK, Keasy (2008) suggests that relative shareholder return growth remains the most popular performance measure linked with executive compensation.[4]

Despite this variety in managerial compensation practices, most of the relevant literature

[1] At this point, it is useful to bear in mind two alternative interpretations of delegation. According to the first one, following Fershtman and Judd (1987) and Sklivas (1987), an owner hires a manager and directs him via an appropriate incentive contract. The alternative interpretation is the one presented by Miller and Pazgal (2002). The problem faced by the owner of each firm is to choose the best type of manager among those that are available, while each manager is committed to behaving in a certain manner by virtue of his personality type.Kopel and Brand (2012), examine the case in which firms deviate from profit maximization by including stakeholder interests in their objective function. Recently, Kopel and Marini (2014) developed a model in which a consumer cooperative was shown to prefer to pay a flat compensation to a manager with an intrinsic motivation, while a profit maximizing firm delegates through an extrinsic incentive contract.

[2] The strategic use of managerial compensation contracts combining own profits and revenues has been introduced in the literature by Vickers (1985), Fershtman (1985), Fershtman and Judd (1987) and Sklivas (1987). In this line of research, an owner has the opportunity to delegate the output decision to his manager and by offering him an appropriate compensation contract, to direct the manager to a more aggressive behavior in the market. This forces rival firms to reduce their output.

[3] Miller and Pazgal (2001; 2002; 2005) formalize relative performance contracts.

[4] Moral hazard issues arising in a strategic delegation context are usually ignored by the relevant literature, which focusses exclusively on the use of delegation of authority from owners to managers as a credible commitment for gaining competitive advantage in the market.

has focused more on different explanations why delegation is used under specific assumptions than on the choice of the compensation scheme itself. For example, Barcena-Ruiz and Espinosa (1996) show the value of long-term commitment on a given incentive contract. González-Maestre (2000) studies the interplay between delegation and divisionalization of the firm, while Moner-Colonques et al. (2004) predict that multiproduct firms will adopt partial delegation. In this paper we focus on the choice between two alternative managerial compensation schemes. We provide a theoretical framework and experimentally test its predictions concerning the choice between a scheme combining own profits and revenues and an alternative one based on own profits and relative performance. Laboratory data are obtained under two alternative settings, depending on the ability of firm owners to commit, or not, on contract types before choosing their respective contract terms.[5] This allows us to test the relative importance of strategic commitment on specific contract types in a context for which real world data are naturally unavailable.

The predictions of the theoretical model are the following: First, in equilibrium, firms' owners choose to compensate their managers with Relative Performance (RP) contracts, rather than with Profit-Revenue (PR) based ones. However, if the choice of a managerial scheme and the contract terms is simultaneous (two-stage versus three-stage game), both options can be an equilibrium. Second, the managerial incentive parameters set by RP-compensating owners direct their managers relatively closer to profit-maximization than the parameters set by PR-compensating owners do. This holds for symmetric configurations, where both firms' owners choose to compensate their managers with contracts of the same type. The opposite holds in asymmetric configurations where the types of contracts chosen differ across rival firms. And third, firm-level output set under universal adoption of RP contracts is lower than the output set under universal adoption of PR contracts, while in asymmetric contract configurations the above ranking is reversed.

We tested the predictions of the theoretical model in the laboratory implementing the two-stage and three-stage versions of the model. A total of four 36-subject sessions were run, two under each scenario. Eighteen owner-manager pairs, labeled as firms, were randomly formed

[5] A key assumption in the strategic managerial delegation literature is that firms' owners commit over the types of contracts that they choose to compensate their managers. Yet, Manasakis et al. (2010) find that when there is no such commitment, each type of contract is an owner's best response to the rival owner's contract choice, leading to multiplicity of equilibria.

at the beginning of each session. These pairs were kept fixed throughout the 50 periods of the session in order to encourage the development of a cooperative relationship between the agents who formed each firm. In each period, firms were matched into pairs forming nine random duopolies in order to preserve the one-shot nature of the market game and avoid any collusive outcomes (Huck et al., 2004; Holt, 1985).

Our paper contributes to the literature investigating the corporate performance measures that owners choose to compensate their managers. In a related paper, Huck et al. (2004), study strategic managerial compensation contracts in a private duopoly. The authors adopt a discrete strategy space where owners choose among two different contracts. The first contract (No-Delegation) gives managers incentives for strict own profit-maximization, while the second contract (Delegation) gives an additional sales bonus. Given the owners' choices regarding the types of contracts, managers choose output from a discrete strategy space. Their experimental evidence suggests that the delegation contract is rarely chosen. More specifically, owners direct their managers towards mere profit-maximization, with a relative frequency of more than 66% in all treatments.

Recently, Du et al. (2013) in an experimental framework examined the use of strategic delegation in a mixed duopoly where one owner maximizes profits and the rival maximizes social welfare. The owners set incentive contracts that are a linear combination of profits and sales, while the managers' choice over output is restricted to values [0,8]. They analyse the choice of the managerial incentive parameter indirectly, by measuring the level of the corresponding output that is chosen in the second stage by owners. Their experiment partially verifies the theoretical equilibrium of the delegation game. By taking in to account learning effects, the verification depends on owners gaining experience through prior playing training sessions with robot managers.

We depart from these papers in several ways. First, in our experiment, owners have a broader strategy space, regarding the types of contracts from which they choose to compensate their managers. Second, owners have an almost continuous strategy space on the managerial incentive parameter that weighs own profits against either own revenues or relative performance. Third, managers select output also from an almost continuous strategy space. By doing so, we test not only whether owners direct their managers away from strict own profit-maximization, but also the effects of contracts chosen by owners on output levels set by managers. Finally, the distinction between the two-stage and the three-stage scenario allows us, first, to contrast the two alternative motives offered by the theoretical analysis for the prevalence of RP contracts, and second, to investigate the relative importance of the owners' commitment over contracts types for their managers, before setting their respective contract terms.

Our main finding is that under both treatments, RP contracts were more frequently chosen by owners than PR contracts. This evidence is in line with the theory. We are also able to contrast the two alternative motives offered by the theoretical analysis for the prevalence of RP contracts. Our experimental evidence reveals that the prevalence of RP contracts can be fully explained by the firms owners' selection of the Pareto-superior equilibrium contract types. This, in turn, refutes the importance of strategic commitment over contract types for explaining the prevalence of RP contracts.

Regarding the managerial incentive parameters, our results reveal that firms' owners only rarely chose to compensate their managers according to their own profits alone. This is in line with the theory. Moreover, we find that under both treatments, PR-compensating owners set higher incentive parameters as compared to the RP-ones.

Finally, regarding the effects of contract types and managerial incentive parameters on output levels, our experimental evidence implies the following: First, the output levels are higher than those predicted by the theory. This holds for all cases except for the output level set by RP-compensated managers in asymmetric contract configurations. However, under universal RP-rewarding contracts, which is the most frequent contract combination, this deviation is slightly more than 10% of the predicted theoretical level. This is in line with other quantity setting experimental markets (Huck et al., 1999) and is contrast with a sharp convergence to equilibrium usually reported in price-setting experiments (Garcia-Gallego, 1998). Third, as the managerial incentive parameters increase, inducing managers to focus more on own profits, managers' output choices become less aggressive. That is, managers set lower output when their incentives depend more on their firms' profits and less on the alternative objectives of revenue or relative performance. This finding is in line with the theory too.

The rest of the paper is organized as follows: Section 2 describes and briefly analyzes the theoretical model that leads to a number of hypotheses that will be tested experimentally. Section 3 presents the experimental design. Section 4 reports the results. Finally, Section 5 concludes. The experimental instructions are included in the Appendix.

2 The theoretical framework

We consider a homogeneous good industry where two firms, denoted by $i, j = 1, 2$, $i \neq j$, compete in quantities. The (inverse) demand function for the final good is given by $P(Q) = A - Q$, where $Q = q_1 + q_2$ is the aggregate output. Firms produce with constant returns to scale technologies and have the same constant marginal cost c, with $c < A$. Hence firm i's profits are:

$$\Pi_i = (A - q_i - q_j - c)q_i \tag{1}$$

In this industry, each firm has an owner and a manager. Following Fershtman and Judd (1987), "owner" is 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. "Managers" are agents hired by owners to make real time operating decisions concerning output. Following Straume (2006), we consider that each manager chooses the firm's output so as to maximize his compensation which is set according to a contract provided by the owner.

Each owner compensates his firm's manager according to one of the following two types of contracts. The first is the Profit-Revenue, PR, contract. Following Fershtman and Judd (1987) and Sklivas (1987), under this type of contract, the compensation scheme takes a particular form: manager i is paid in proportion to a linear combination of own profits and revenues. More formally, under this type of contract, manager i's compensation is given by:

$$C_i^{PR} = \alpha_i^{PR}\Pi_i + (1 - \alpha_i^{PR})R_i \tag{2}$$

where Π_i and R_i are firm i's profits and revenues respectively, and α_i^{PR} is the managerial incentive parameter which is chosen optimally by firm i's owner so as to maximize his profits, with $0 \leq \alpha_i^{PR} \leq 1$. If $\alpha_i^{PR} < 1$, firm i's owner directs his manager away from strict profit-maximization towards including consideration of revenues and thus, manager i becomes a more aggressive seller in the market. The higher the α_i^{PR} is, the higher is the weight that owner i puts on own profits. If $\alpha_i^{PR} = 1$, manager i's behavior coincides with owner i's objective for strict profit-maximization.

The second type of contract is the Relative Performance, RP, one. Following Miller and Pazgal (2001; 2002; 2005), under this type of contract, firm i's owner compensates his manager by putting a weight α_i^{RP} on own profits and a weight $(1-\alpha_i^{RP})$ on the difference between own profits and the profits of the rival firm, with $0 \leq \alpha_i^{RP} \leq 1$. Under this type of contract, manager i's compensation is given by:

$$C_i^{RP} = \alpha_i^{RP}\Pi_i + (1-\alpha_i^{RP})(\Pi_i - \Pi_j) \tag{3}$$

The lower the α_i^{RP} is, the higher is the weight that owner i puts on relative performance, directing, thus, his manager to become a more aggressive seller in the market. If $\alpha_i^{RP} = 1$, the manager's behavior coincides with the owner's objective for strict profit-maximization.

To investigate the types of managerial compensation contracts that firms' owners choose to compensate their managers in equilibrium, we consider a three-stage game with observable actions, with the following timing. In the first stage, each firm's owner commits to one of the two types of contracts, $D \in \{PR, RP\}$. In the second stage, each owner sets the respective managerial incentive parameter α_i^D. In the third stage, managers set output.

An alternative two stage game with observable actions is also considered, according to which, in the first stage, each owner chooses both the type of contract D and the respective managerial incentive parameter α_i^D. In the second stage, managers set output. The latter captures a situation in which there is no ex-ante commitment over the type of contract that each owner offers to his manager. The crucial, yet reasonable, assumption here is that the type of contract and the contract terms that owner i sets are not observable by the rival owner before contract-setting is everywhere completed. This alternative game helps us to evaluate the relative importance of strategic commitment on an owner's choice of contract type. The equilibrium concept employed to solve the above games is the subgame perfect equilibrium.

Consider first the *Universal Profit-Revenue, UPR*, configuration of contracts. In this case, both firms' owners commit to a PR contract with which they compensate their managers. In the third stage, manager i chooses q_i to maximize his utility given by eq. (2). Taking the first order conditions and solving the system of equations, the output level that manager i sets is:

$$q_i^{PR}(\alpha_i^{PR}, \alpha_j^{PR}) = \frac{A - c(2\alpha_i^{PR} - \alpha_j^{PR})}{3} \tag{4}$$

From (4), it can be checked that: $\frac{\partial q_i^{PR}}{\partial \alpha_i^{PR}} < 0$ and $\frac{\partial q_i^{PR}}{\partial \alpha_j^{PR}} > 0$. That is, the weight owner i sets on own profits affects negatively the output level chosen by manager i, while owner j's weight on own profits affects q_i positively.

In the second stage, each owner i chooses α_i^{PR} so as to maximize profits given by:

$$\Pi_i^{PR}(\alpha_i^{PR}, \alpha_j^{PR}) = \frac{(A - c(2\alpha_i^{PR} - \alpha_j^{PR}))(A - c(3 - \alpha_i^{PR} - \alpha_j^{PR}))}{9} \tag{5}$$

Solving the system of the first order conditions, we obtain equilibrium managerial incentive parameters, output levels and profits:

$$\alpha_i^{PR} = \frac{-A + 6c}{5c}; \quad q_i^{PR} = \frac{2(A-c)}{5}; \quad \Pi_i^{PR} = \frac{2(A-c)^2}{25}. \tag{6}$$

Second, the *Universal Relative Performance* configuration, URP, of contracts is examined. In this case, both firms' owners commit to an RP contract with which they compensate their managers. In the third stage, manager i chooses q_i to maximize his utility given by eq. (3). Solving the system of the first order conditions, the output level that manager i sets is:

$$q_i^{RP}(\alpha_i^{RP}, \alpha_j^{RP}) = \frac{(A-c)\left(2 - \alpha_i^{RP}\right)}{4 - \alpha_i^{RP}\alpha_j^{RP}} \tag{7}$$

From (7), note that $\frac{\partial q_i^{RP}}{\partial \alpha_i^{RP}} < 0$ and $\frac{\partial q_i^{RP}}{\partial \alpha_j^{RP}} > 0$. That is, the higher the weight owner i sets on own profits, the lower the output level chosen by manager i, while the higher owner j's weight on own profits, the higher the output chosen by manager i.

In the second stage, each owner i chooses α_i^{RP} so as to maximize profits given by:

$$\Pi_i^{RP}(\alpha_i^{RP}, \alpha_j^{RP}) = \frac{(A-c)^2\left(2 - \alpha_i^{RP}\right)\left(\alpha_i^{RP}\left(1 - \alpha_j^{RP}\right) + \alpha_j^{RP}\right)}{\left(4 - \alpha_i^{RP}\alpha_j^{RP}\right)^2} \tag{8}$$

Solving the system of first order conditions, we obtain the equilibrium managerial incentive parameters, output levels and profits:

$$\alpha_i^{RP} = \frac{2}{3}; \quad q_i^{RP} = \frac{3(A-c)}{8}; \quad \Pi_i^{RP} = \frac{3(A-c)^2}{32}. \tag{9}$$

Finally, the *Coexistence* configuration of contracts is investigated. Without loss of generality, owner i commits to compensate his manager with a PR contract, while owner j commits to an RP contract. In the third stage, manager i (j) chooses q_i (q_j) to maximize his utility given by eq. (2) ((3)). Solving the system of the first order conditions, output levels are:

$$q_i^{pr}(\alpha_i^{pr}, \alpha_j^{rp}) = \frac{A + c(1 - 2\alpha_i^{pr})}{4 - \alpha_j^{rp}} \tag{10}$$

$$q_j^{rp}(\alpha_i^{pr}, \alpha_j^{rp}) = \frac{A(2 - \alpha_j^{rp}) - c(2 - \alpha_i^{pr}\alpha_j^{rp})}{4 - \alpha_j^{rp}} \tag{11}$$

As above, the weight an owner sets on own profits affects negatively the output level chosen by his manager, while the rival owner weight on own profits affects it positively (it can be checked that $\frac{\partial q_i^{pr}}{\partial \alpha_i^{pr}} < 0$, $\frac{\partial q_j^{rp}}{\partial \alpha_i^{pr}} > 0$, and $\frac{\partial q_j^{rp}}{\partial \alpha_j^{rp}} < 0$, $\frac{\partial q_i^{pr}}{\partial \alpha_j^{rp}} > 0$).

In the second stage, owners set the incentive parameters so as to maximize profits given by:

$$\Pi_i^{pr}(\alpha_i^{pr}, a_j^{rp}) = \frac{[A - c(2\alpha_i^{pr} - 1)] \left[A - c\left(3 - 2\alpha_i^{pr} - \alpha_j^{rp} + \alpha_i^{pr}\alpha_j^{rp}\right)\right]}{\left(4 - \alpha_j^{rp}\right)^2} \tag{12}$$

$$\Pi_j^{rp}(\alpha_i^{pr}, \alpha_j^{rp}) = \frac{\left[A\left(2 - \alpha_j^{rp}\right) - c\left(2 - \alpha_i^{pr}\alpha_j^{rp}\right)\right] \left[A - c\left(3 - 2\alpha_i^{pr} - \alpha_j^{rp} + \alpha_i^{pr}\alpha_j^{rp}\right)\right]}{\left(4 - \alpha_j^{rp}\right)^2} \tag{13}$$

Solving the system of the first order conditions, we obtain the equilibrium managerial incentive parameters, output levels and profits:

$$\alpha_i^{pr} = 1; \quad q_i^{pr} = \frac{A - c}{4}; \quad \Pi_i^{pr} = \frac{(A - c)^2}{16} \tag{14}$$

$$\alpha_j^{rp} = 0; \quad q_j^{rp} = \frac{A - c}{2}; \quad \Pi_j^{rp} = \frac{(A - c)^2}{8} \tag{15}$$

Using the equilibrium profits expressions under the UPR, URP and coexistence of both contracts configurations, it is easy to check that, in the first stage, each firm's owner will opt for a RP contract. Hence, the Universal Relative Performance contract configuration emerges in the unique subgame perfect equilibrium of the three-stage game.[6,7]

On the other hand, in the two stage game where owners are unable to commit to a specific contract type, before setting its respective contract terms, multiple equilibria arise regarding the type (and the terms) of contract that each owner chooses.[8] Using the Pareto criterion for equilibrium selection, owners would realize that it is in their mutual interest to move towards the equilibrium that ensures them the highest profits, that is, the URP contract configuration equilibrium. Thus, it is expected that in the two stage game too, each owner will choose to compensate his manager with an RP contract.

We concentrate now on the hypotheses which will be tested with our experimental design.

We begin by considering the owners' contract type choices with which they will compensate their managers. Our theoretical analysis predicts universal adoption of RP contracts in both the 2-stage and 3-stage games.

However, if coordination on one of multiple equilibria in the 2-stage game requires too much in terms of owners' rationality, we would expect a higher frequency of RP contracts in the 3-stage game. Otherwise, RP contracts should be adopted in both games with similar frequencies.

Thus, from a practical point of view, comparing the 2-stage and 3-stage games allows us to evaluate the role of strategic commitment to a contract type before choosing its respective terms. The above lead to the following hypothesis that will be tested experimentally:

HYPOTHESIS 1: (H1.1) *Relative Performance contracts will be preferred by owners over Profit-Revenue ones and* (H1.2) *The frequency of Relative Performance contracts will be* **lower** (higher) *in the* **absence** (presence) *of owners' commitment over the contract type*

[6] For further details see Manasakis et al. (2010). The intuition behind this result goes as follows: An RP contract makes a manager's behavior less susceptible to strategic manipulation by rival managers. Less scope for strategic manipulation gives to the rival owner less reason to provide incentives for aggressive behavior to his manager. This implies that the owner who chooses the RP contract for his manager obtains competitive advantage in the market, for any contract choice of the rival owner. This, in turn, makes the selection of an RP contract each owner's best response to whatever the rival owner's choice is.

[7] Note that if both owners set the managerial incentive parameters equal to 1, equilibrium output level and profits are $q_i^N = \frac{(A-c)}{3}$ and $\Pi_i^N = \frac{(A-c)^2}{9}$, respectively. In the strategy space of Huck et al. (2004), this is equivalent to the "No-Delegation" case where owners themselves decide over the output levels. It is easy to check that output (profits) set under any of the managerial compensation contracts discussed above is higher (lower) than that set in the "No-Delegation" case. Intuitively, owner i, by using a managerial compensation contract strategically, directs his manager to a more aggressive behavior in order to force the rival manager to reduce output. Because both owners act in the same way at the game's contract stage, firms end up in a prisoners' dilemma situation. Naturally, the increased market supply leads to lower profits.

[8] For a formal proof see Manasakis et al. (2010).

before choosing its respective contract terms.

Given the above arguments, it is straightforward that the equilibrium contracts' managerial incentive parameters should be set at a level such that RP-compensating owners gain higher profits than the PR-ones. This can be formalized in the following hypothesis:

HYPOTHESIS 2: (H2.1) *Under universal adoption of each type of contract, Relative Performance-compensating owners set managerial incentive parameters at a level higher than that set by Profit-Revenue-compensating owners.* (H2.2) *In asymmetric contract configurations, the aforementioned ranking is expected to be reversed.* (H2.3) *No difference is expected between the two stage and three stage games.*

Firms' output is expected to be higher under UPR contracts than under URP contracts. The opposite ranking holds for firms' profits. This explains why the latter equilibrium is more profitable for firms' owners than the former. In asymmetric contract configurations, an RP-compensated manager sets output at a level higher than that set by his PR-compensated rival manager. Furthermore, according to expressions (4), (7), (10) and (11), and the follow up discussion, own output should react negatively to increases in a firm's own managerial incentive parameter and positively to the rival firm's incentive parameter, under all contract configurations. The above can be summarized in the following hypothesis:

HYPOTHESIS 3: (H3.1)*Compared to the case of Universal Relative Performance contracts, output will be higher under Universal Profit-Revenue contracts. Whenever the two contract types coexist, an RP-compensated manager is predicted to set output at a level higher than that set by his PR-compensated rival.* (H3.2) *A firm's output will be higher the lower the firm's own managerial incentive parameter and the higher the rival firm's incentive parameter.*

3 Experimental design

We have tested the predictions of the theoretical model outlined above in a laboratory experiment.

A total of 144 subjects participated in the sessions. They were volunteers recruited among 2nd and 3rd year students enrolled in the Business and Human Resources degrees at the *Universitat Jaume I* (Castellón, Spain) according to standard protocols used in the *Laboratori d'Economia Experimental* (*LEE*). Each session lasted approximately 100 minutes.

The experiment was organized under two treatments. A total of four 36-subject sessions were run, two under each treatment. In the first treatment, labeled as *3-stage* game, the choice of contract type precedes the choice of the managerial incentive parameter. Then, managers set output. In the second treatment, labeled as *2-stage* game, owners choose simultaneously both the type of contract with which to compensate their managers and the respective managerial incentive parameter, before managers decide on their firms' output. Incentive parameters were chosen between 0 and 1 (inclusive) using up to two decimal digits, whereas output was chosen among the integers in the range between 0 and 500. The experiment was programmed using the z-Tree toolbox (Fischbacher, 2007).

At the beginning of each session written instructions were given to the subjects and each of them was randomly assigned the role of an owner or a manager. Eighteen owner-manager pairs, labeled as *firms*, were randomly formed at the beginning of each session. These pairs were kept fixed throughout the 50 periods of the session in order to encourage the development of a cooperative relation between the agents who formed each firm. Nine duopolies were randomly formed in each period in order to preserve the one-shot nature of the market game. In order to increase the number of completely independent observations per session, matching occurred within three groups of 6 owner-manager pairs (firms), that is, three independent matching groups of 12 subjects each. However, this precise detail was not known by the subjects who had an additional difficulty to guess the total group size and assess the likelihood of being re-matched with the same firm in two different periods, given that the computer network of the *LEE* is installed in two distant rooms between which there is no possibility of visual contact. No significant difference was found across matching groups within each treatment and, thus, data from the same treatment were pooled together. Following this design, a total of three totally independent observations per session is guaranteed by the fact that strategies and the history experienced by each subject were never contaminated nor did they contaminate decision making within the other two matching groups. Therefore, in a very strict statistical sense, our conclusions are based on behavior within six totally independent groups per treatment.

In order to facilitate learning in the quantity-setting stage, owners could change their managers' compensation contract every 3 periods, during the first 30 periods and in every period, during the last 20 periods.[9] Before subjects made their decisions in the second and third stages of the game they were informed on previous stage actions by other players in the same market. At the end of each period, each subject's feedback included full information on strategies and outcomes of all players in the same market. No other decision making aid was available to them.

The four sessions were run on two dates. The order between the 2-stage and the 3-stage session was changed across the two dates to minimize the probability that a subject could anticipate the treatment that would be implemented should any information have been transmitted from one session to another. Each subject participated in one session only. Therefore, sessions 1 and 4 correspond to the 3-stage treatment, while sessions 2 and 3 belong to the 2-stage treatment.

The total amount spent on subject payoffs was $2,739$ euros which implies slightly above 19 euros per subject earnings, ranging between 7.3 and 29.6 euros (an owner subject in a 3-stage treatment and an owner-subject in a 2-stage treatment respectively). Subjects in the 3-stage treatment received slightly lower payments than in the 2-stage one (18.7 and 19.3 euros respectively). An exchange rate of 1 euro per $80,000$ EXCUs was used.

Following closely the contracts studied in the theoretical model, the contract schemes for the experiment were designed after a series of pilot sessions in order to guarantee that subjects with different roles could earn similar expected rewards. In particular, the PR contract took the following formula: 20.000 EXCUs as a fixed salary plus a half of a linear combination between the profits and the revenues of the firm. The respective formula for the RP contract was: 20.000 EXCUs as a fixed salary plus a half of a linear combination between the firm's profits and the difference between the firm's profits and the profits of the rival firm.[10]

The model's parameter values implemented in the experiment were $A = 1000$ and $c = 200$. Under this set of parameters, in the *Universal* PR equilibrium, both owners should set $\alpha_i^{PR} = 0.2$ and managers should set the corresponding equilibrium output levels at $q_i^{PR} = 320$. The respective values in the *Universal* RP equilibrium are $\alpha_i^{RP} = 0.666$ and $q_i^{RP} = 300$. The equilibrium contract terms and output levels when owner i chooses the PR contract while j

[9] Previously, this format has been efficiently implemented as a learning facilitating device in several experiments on multistage oligopolies such as in Barreda-Tarrazona *et al.* (2011), Camacho-Cuena *et al.* (2005) and Fatás-Juberías *et al.* (2013).

[10] For the instructions given to subjects, see the Appendix.

chooses the RP one are: $\left[\alpha_i^{PR},\ \alpha_j^{RP},\ q_i^{PR},\ q_j^{RP}\right] = [1,\ 0,\ 200,\ 400]$.

A strict test of the theoretical model should aim at comparing the observed data on contract types, contract terms and outputs to the aforementioned theoretical predictions. However, real human agents learn from trial-and-error strategies and may make systematic mistakes due to a number of reasons.[11] Thus, we focus mainly on the test of the predictions provided by the qualitative hypotheses $H1 - H3$ stated in the previous section.

4 Experimental results

Let us now proceed with the presentation of the experimental results. We begin with the overall descriptive statistics of our experiment.

4.1 Overall descriptive statistics

Table 1 provides aggregate adoption frequencies for the two contract types. While the aggregation of data does not allow us to test any specific hypothesis, we obtain a first picture indicating that RP contracts were adopted in over 70% of the cases in both treatments. We proceed now with a more detailed analysis of the data taking into account the different possible contract configurations arising from the choices of both owners.

[11] A vast literature has been dedicated to various factors that may be responsible for observed shortcomings of human behavior in complex environments, such as mis-perception of feedback (Paich and Sterman, 1993; Sterman, 1994), limitations in subjects' learning when exposed to strategic complexity (Richards and Hays, 1998), or multi-task decision making (Kelly, 1995). A number of factors that favor subjects' improvement of performance have, also, been identified. For example, trial-and-error algorithms have been shown to facilitate convergence of the strategies played by uninformed subjects toward symmetric, full-information equilibrium predictions, as shown in Garcia-Gallego (1998) for the case of a price-setting oligopoly. While full convergence near the theoretical benchmark is obtained in the symmetric single-product setting of Garcia-Gallego (1998), the introduction of multiproduct firms in Garcia-Gallego and Georgantzis (2001) or the asymmetry in Garcia-Gallego *et al.* (2004) provide sufficiently unfavorable environments for the hypothesis of convergence to the theoretical prediction to be rejected.

Table 1: Contract adoption frequencies						
	Treatment					
	2-Stage		**3-Stage**		**Both**	
Contract Type*	RP	PR	RP	PR	RP	PR
Relative Frequency	73.3%	26.7%	70.9%	29.1%	72.1	27.9%
* Profit-Revenue Contract $=PR$, Relative Performace Contract $=RP$						

4.2 Types of contracts and contract configurations

Regarding the total number of occasions in which each contract type was adopted, we find that, in both treatments, the frequency of RP adoption was significantly higher than that of PR. More specifically, RP vs. PR contracts were chosen 1320 vs. 480 times in the 2-stage treatment and 1277 vs. 523 times in the 3-stage treatment. However, the prediction of universal adoption of RP contracts is confirmed less frequently than these numbers may suggest. To see this, we refer to Table 2.

What we are really interested in is to investigate whether the combination of owners' contract choices is as predicted by the equilibria of the theoretical model. As shown in Table 2, more than half of our experimental duopolies took place under *Universal RP* contracts. This holds for both the 2-stage ($988/1800 = 54.89\%$) and the 3-stage ($932/1800 = 51.78\%$) treatments. Contrary to this, the *Universal PR* configuration received scarce support (8.22% for the 2-stage and $9,89\%$ for the 3-stage). In fact, the frequency of *Universal PR* is approximately one fourth of the frequency of *Coexistence* of the two contract types, $PRRP$ and $RPPR$, in the same market[12].[13]

[12] Hereafter, $PRRP$ indicates the configuration where owner 1 chooses the PR contract and owner 2 chooses the RP contract. The opposite holds for $RPPR$.

[13] A χ^2 test ($p < 0.001$) has been used to confirm the significance of the difference between the aforementioned observed frequencies and a random distribution of strategy pairs uniformly across the corresponding outcomes of the game in the contract stage.

Table 2: Owners' choices of contract types			
Treatment	UPR	URP	$PRRP$ & $RPPR$
2-stage	8.22%	54.89%	36.89%
3-stage	9.89%	51.78%	38.33%
Total	9.06%	53.33%	37.61%

Note also that firms' owners only rarely chose to compensate their managers in a way directing them to strict own profit maximization. More specifically, only in 4% (6%) of the contracts in the 3-stage (2-stage) treatment, owners set the managerial incentive parameter equal to one. This result comes in sharp contrast to the experimental evidence of Huck *et al.* (2004). They find that the "No-Delegation" strategy is chosen with a relative frequency of more than 66% in all their treatments.

These results clearly confirm Hypothesis H1.1. Furthermore, we find that the frequency of RP contracts is not higher in the when owners commit over the contract type before choosing its respective contract terms. This result indicates that the prevalence of the *Universal* RP configuration over the *Universal* PR alternative one can be fully explained by the subjects' selection of the Pareto-superior equilibrium contract types and refutes the importance of strategic committment over contract types for expaining the prevalence of RP contracts. Therefore, we can state the following result:

RESULT 1: 1. *Under both treatments, Relative Performance contracts are significantly more frequent than Profit-Revenue ones (confirming H1.1).* **2.** *The adoption frequency of Relative Performance contracts does not vary across the 2-stage and 3-stage treatments (rejecting H1.2).*

It is also interesting to see the dynamics of contract adoption frequencies. Figure 1 presents the evolution of RP contract adoption in the two treatments, starting from below 40% in period 1, and reaching frequencies close to 90% in period 50. Figure 2 presents the same data broken down by contract combination. Figure 2 shows that in both treatments, *Universal* PR adoption represents a small and rather stable proportion of choices. The coexistence of both contracts decreases over time while *Universal* adoption of RP contracts increases up to around 3/4 of the cases.

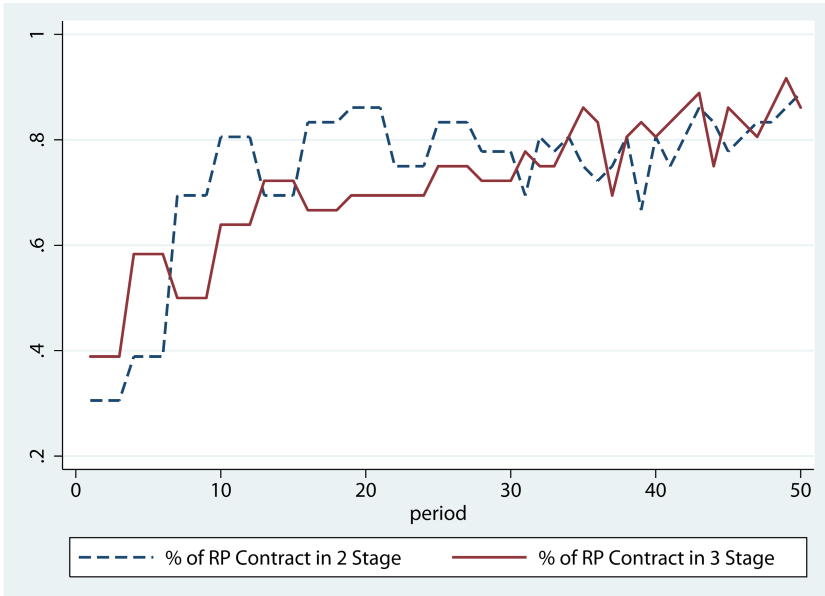

Figure 1: Evolution of individual RP contract adoption.

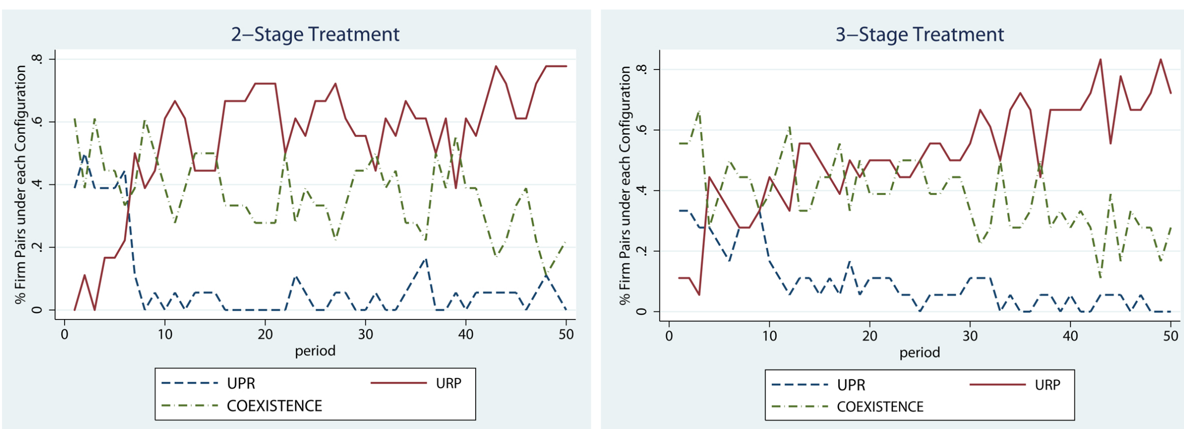

Figure 2: Evolution of Contract Combinations.

4.3 Managerial incentive parameters

Let us now present our findings regarding owners' choices of managerial incentive parameters. We present our evidence in Table 3 and Figure 3.

Table 3: Owners' choices of managerial incentive parameters

Configuration		UPR	URP	$PRRP$	$RPPR$
	Predicted α	0.200	0.666	1	0
2-stage	Mean α	0.579	0.471	0.571	0.472
	St. dev.	0.242	0.254	0.285	0.247
3-stage	Mean α	0.611	0.485	0.620	0.485
	St. dev.	0.278	0.277	0.292	0.276

Figure 3: Evolution of incentive parameter by contract combination.

Recall that our theoretical analysis predicts $\alpha_i^{PR} = 0.2$ and $\alpha_i^{RP} = 0.666$. Regarding the symmetric configurations of contracts, our experimental evidence leads to the following observations. First, under universal contract adoption in both treatments, the average incentive parameter set by PR-compensating (RP-compensating) owners was higher (lower) than the predicted one. This implies that PR-compensating (RP-compensating) owners' intention towards profit-maximization was stronger (weaker) than predicted. Figure 3 shows a dynamic picture of these observations, depicting observed incentive parameters against their respective theoretical values (plotted as an horizontal line). No systematic trend is observed in any of these parameter series, whereas fluctuations in the case of universal PR contracts are due to the small and noisy sample under this configuration.

In absolute values, the deviation of observed incentive parameters from the respective predicted equilibrium values for PR contracts was twice the deviation for RP contracts.

Interestingly enough, within each treatment, PR-compensating owners set, on average, incentive parameters higher than those set by the RP-compensating ones.[14] This is in contrast to the theory's predictions and implies that PR-compensated managers were directed relatively closer to profit-maximization than RP-compensated ones. Note also that for both contract types, the difference in incentive parameters across treatments (2-stage vs 3-stage) is not statistically significant.[15]

The evidence regarding the relatively higher managerial incentive parameters set by PR-compensating owners can be rationalized as follows: PR-compensating owners, anticipating the fierce market competition that their contract choices would give rise to, might realize that it is in their mutual interest to direct their managers towards a relatively less aggressive behavior (higher α_i^{PR}), so as to increase their profits. Thus, in order to mitigate this Stackelberg warfare, they set relatively high managerial incentive parameters, directing their managers to a less aggressive behavior than RP-compensating owners did.

In asymmetric configurations, our theory predicts that the PR-compensating owner sets $\alpha_i^{PR} = 1$ and the RP- one sets $\alpha_j^{RP} = 0$. Regarding the asymmetric contract configurations, our experimental evidence leads to the following three observations. First, under both treatments, the average incentive parameter set by PR-compensating (RP-compensating) owners was lower (higher) than the predicted one. Second, as in the symmetric contract configurations, in mixed contract schemes too,PR-compensating owners set, on average, incentive parameters higher than those set by the RP-compensating ones.[16] This holds for both treatments, it is in line with the theoretical model's prediction, and implies that RP-compensated managers were directed relatively closer to profit-maximization than PR-compensated ones. Third, for both

[14] Within each treatment, the difference in incentive parameters across contract types is significant, as shown by a Mann-Whitney test comparing medians of independent groups ($p = 0.033$ for the 2-stage treatment and $p = 0.025$ for the 3-stage treatment).

[15] Given a PR contract, the statistical significance of the difference in incentive parameters across treatments (2-stage vs 3-stage) is rejected by a Mann-Whitney test comparing the medians of independent groups ($p = 0.25$). The respective test for an RP contract rejects the statistical significance of incentive parameters across treatments too ($p = 0.48$).

[16] Within each treatment, the difference in incentive parameters across contract types is significant, as shown by a Mann-Whitney test comparing medians of independent groups ($p = 0.038$ for the 2-stage treatment and $p = 0.019$ for the 3-stage treatment).

contract types, the difference in incentive parameters across treatments (2-stage *vs.* 3-stage) is not statistically significant. In fact, the incentive parameters in the asymmetric contract structures are very close to those reported in the symmetric contract configurations.[17]

The most striking pattern observed in the evidence reported so far is that given a contract type, owners set very similar incentive parameters across treatments. More specifically, PR-compensating owners fix α_i^{PR} around $0.57 - 0.62$, while RP-compensating owners fix α_i^{RP} around $0.47 - 0.48$. In fact, these values do not depend on the contract type used by the rival owner or on the rival owner's contract observability (3-stage treatment vs. 2-stage treatment). While the observed incentive parameters deviate from their corresponding theoretical values[18], some of the predictions contained in Hypothesis 2 are confirmed. More specifically:

RESULT 2: 1. *The prediction of the theory (H2.1) concerning the relatively higher incentive parameters (i.e., lower aggressiveness) set by Relative Performance-compensating owner pairs, over Profit-Revenue compensating owner pairs, is not confirmed, whereas the prediction (H2.2) concerning the relatively lower incentive parameters (i.e., higher aggressiveness) set by Relative Performance-compensating owners, over their Profit-Revenue rivals, is confirmed.* **2.** *The managerial incentive parameter set by an owner is independent of the contract used by the rival owner and of whether the rival owner's contract was observed or not before the contract terms were chosen (confirming H2.3).*

4.4 Output levels

Finally, we focus on the effects of contract types and managerial incentive parameters on output levels. Table 4 presents descriptive statistics.

Recall that our theoretical results predict $q_i^{RP} = 300$ and $q_i^{PR} = 320$ in the two symmetric configurations, while when owner i chooses the PR contract and j chooses the RP one, the prediction is: $q_i^{PR} = 200$ and $q_j^{RP} = 400$. As shown in Table 4, for both symmetric contract configurations, the output levels set in the experiment exceed our equilibria predictions,

[17] The significance of the corresponding differences is rejected by the respective Mann-Whitney tests obtaining $p - values$ such that $p > 0.5$ in all cases.

[18] For both symmetric configurations, there is a systematic deviation of observed incentive parameters from the respective predicted equilibrium values, upwards for Profit-Revenue contracts and downwards for Relative Performance contracts. For asymmetric configurations, there is a systematic deviation of observed incentive parameters from the respective predicted equilibrium values, downwards for Profit-Revenue contracts and upwards for Relative Performance contracts.

whereas, for asymmetric configurations, this is true only for PR-compensated managers. In fact, in asymmetric configurations, RP-compensated managers set quantities well below the corresponding equilibrium level. Therefore, the deviations of output from equilibrium cannot be uniformly attributed to some subject-specific bias or the framing of our setup as a competitive market environment.[19] Furthermore, comparing overall output levels with output corresponding to the subgame perfect equilibria may be misleading because it ignores that conditional optimality of output choices must be viewed with respect to the actual decisions in the preceding stages.

Table 4: Managers' choices on output levels

Configuration		UPR	URP	$PRRP$	$RPPR$
	Predicted q	320	300	200	400
2-stage	Mean q	364.608	358.725	359.241	346.271
	St. dev.	106.741	98.922	95.029	93.334
3-stage	Mean q	347.905	359.505	343.177	355.357
	St. dev.	99.829	90.662	94.548	87.498

In Table 5 we present the average deviation of the incentive parameter from its equilibrium prediction, as well as the absolute and relative deviations of output and profit from the corresponding equilibria conditional on the observed incentive parameters. Contrary to Harrison's (1989) "flat max" critique, according to which objective functions may be too flat near the optimum to give an informative feedback to subjects, we observe that even moderate deviations from equilibrium output have caused significant deviations from the corresponding equilibrium profits. Even in the most frequently observed configuration of URP, a relatively high profit loss of 59% is observed under both treatments, despite the fact that the relative deviation of quantity is the lowest (13-14%) among all contract configurations. This implies that managers may have attributed some exceptionally low earnings to the contracts they had been offered rather than to their own wrong decisions or to their interaction with other managers in the market. Subsequently, the owners' decisions have also diverged from the corresponding

[19] This could have been the effect of using the word "rival" when referring to the other firm or the explicit encouragement to maximize own profit in the instructions.

equilibrium incentive parameters due to the noisy choices of managers and the little number of observations under some contract configurations. We consider as evidence in favor of this conjecture the fact that deviations of the incentive parameter from the corresponding equilibrium values have been smaller in the case of URP, which has occurred more frequently, giving owners more feedback from past actions.

Table 5: Average deviation from equilibrium choices conditional on alpha

	2-Stage				3-Stage			
Deviation	UPR	URP	$PRRP$	$RPPR$	UPR	URP	$PRRP$	$RPPR$
alpha* (α)	0.37	-0.19	-0.42	0.47	0.41	-0.18	-0.38	0.48
quantity (q)	69.8	35.5	82.4	34.2	55.2	38.8	70.8	51.5
relative deviation	25%	13%	31%	14%	21%	14%	28%	20%
Firm Π **(in 000's)**	-48.0	-28.7	-26.9	-38.2	-36.2	-27.8	-27.4	-36.1
relative deviation	-77%	-59%	-50%	-61%	-56%	-59%	-51%	-55%

* The observed deviation in alpha is with respect to the SPNE alpha.

Figure 4 depicts output dynamics within each contract combination. Apart from the aforementioned divergence from theoretical predictions, we observe that output levels exhibit persistent oscillations over the 50 periods of the experiment.

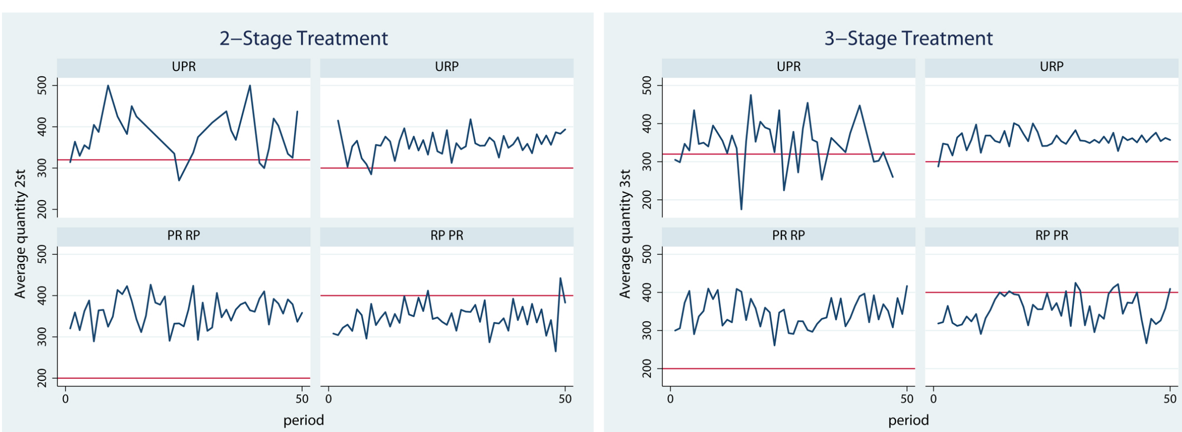

Figure 4: Evolution of quantity by contract combination.

A remaining question concerns the response of output to a given contract and a specific incentive parameter. Panel data analysis is a useful tool for dealing with the temporal and individual dimensions of our experimental data. We report here the results of a Prais and Winsten correlated panel regression for quantity. A Hausman $\chi^2(11)$ test value of 5.78 does not allow us to reject that the difference in the coefficients is not systematic, hence we use a random effects model.

Using a test for serial correlation, we reject the null of no autocorrelation: $\chi^2(1)$=25.65. Moreover, due to the fact that we grouped the firms into matching groups where they play against each other, there will be contemporaneous correlation effects.

The presence of heterogeneity, autocorrelation, and contemporaneous correlation in our data drives us to choose a panel corrected standard errors estimation method with a panel specific AR(1) structure of the form:

$$\texttt{quantity}_{it} = \beta_0 + \beta_1 \cdot \texttt{alpha}_{it} + \beta_2 \cdot \texttt{other\_alpha}_{it} + \varepsilon_{it}, \tag{16}$$

where $\varepsilon_{it} = \rho_i \cdot \varepsilon_{it-1}$.

	Coef.	**Std. Err.**	**z**	**P>z**	**95% Conf. Interval**
constant	373.34	5.89	63.42	**0.000**	[361.80, 384.88]
upr	-32.63	17.52	-1.86	0.063	[-66.97, 1.72]
prrp	-4.44	12.61	-0.35	0.725	[-29.15, 20.26]
rppr	-26.10	10.38	-2.51	**0.012**	[-46.45, -5.75]
alpha	-27.99	8.67	-3.23	**0.001**	[-44.98, -10.99]
alpha upr	46.33	23.91	1.94	0.053	[-0.52, 93.19]
alpha prrp	-2.99	16.96	-0.18	0.860	[-36.23, 30.25]
alpha rppr	16.81	13.75	1.22	0.221	[-10.14, 43.77]
oth alpha	-12.54	7.08	-1.77	0.077	[-26.41, -1.34]
oth alpha upr	13.41	21.95	0.61	0.541	[-29.60, 56.42]
oth alpha prrp	15.99	14.47	1.11	0.269	[12.36, 44.36]
oth alpha rppr	18.95	13.35	1.42	0.156	[-7.22, 45.11]

Table 6: Prais-Winsten regression, correlated panels corrected standard errors (PCSEs) for Quantity.

Group variable: firmid; Time variable: period; Number of obs = 3,600; Number of groups = 72; Panels: correlated (balanced); Autocorrelation: panel-specific AR(1); Obs. per group: 50; Estimated covariances = 2,628; Estimated autocorrelations = 72; Estimated coefficients = 12; $R^2 = 0.57$; Wald $\chi^2(11) = 25.62$; Prob $> \chi^2 = 0.0074$; $\rho_i = 0.389, 0.308, 0.450, 0.426, 0.377, ..., 0.350$.

Table 6 presents the estimates of a model in which output choice is explained by own and rival incentive parameters for each contract combination. The basic contract configuration is Universal RP because it was the most frequently observed. Hence, constant, alpha, and other alpha refer to this configuration, while all other estimated parameters measure the size and significance of the difference in the parameters estimated with respect to this basic configuration. The results confirm that output reacts to the incentive parameter in the expected way: as the incentive parameter increases, inducing managers to focus more on own profit, output choices become less aggressive. In fact, the estimated coefficient (-27.98, p=0.001) does not significantly vary across different contract configurations.[20] Therefore, the more manager incentives depend on their firms' profits, the lower the quantity they set.

With regard to the predicted effect (second part of H3.2) of the rival's incentive parameter on a firm's output choice, we obtain no significant evidence.

The estimated model can also help us address the first part of the third hypothesis concerning the ranking of output choices across different contract configurations. We observe that the hypothesis is rejected, especially because in mixed contract configurations, RP-compensated managers set (alpha's being equal) significantly lower output than their PR-compensated rivals (-26.10, p=0.012).

In fact, output has, generally speaking, been invariant to alternative contract configurations. These results suggest an overall rejection of Hypothesis 3.1.

This may be a consequence of poor learning in the final stage of the game due to noisy feedback from the two preceding stages.

Summarizing the aforementioned discussion on output reactions to contract types and terms we state:

RESULT 3: *Output has reacted in the expected way to the terms of a firm's own contract*

[20] For Universal PR, we have very few observations and the difference in the coefficients is not significant at 5%.

(confirming the first part of H3.2). Other reactions do not systematically follow the pattern predicted by H3.

5 Concluding Remarks

The experimental approach adopted here allows us to build a bridge between the standard neoclasical approach to oligopoly delegation and behavioral data from a population of human agents who have certainly not used any explicit optimization rule, but rather, a noisy learning from trial-and-error. The most important of our findings can be generalized to state that some of the predictions obtained under the assumption of perfect foresight and unlimited calculus capacity are robust to the noise created by interacting learning agents.

With respect to the specific framework studied here, our main finding is that *Relative Performance* contracts were more frequently chosen by owners than *Profit-Revenue* ones, a result which is in line with the theory. Moreover, the prevalence of RP contracts can be fully explained by the firms owners' selection of the Pareto superior equilibrium contracts, and thus, it does not depend on whether firms' owners can commit, or not, to specific contract types before choosing their respective terms. Our experimental evidence further suggests that, in contrast to the theoretical prediction, in symmetric contract configurations, PR-compensating owners direct their managers relatively closer to profit-maximization than the RP-compensating owners do. In line with the theory, the same phenomenon occurs under asymmetric contract configurations. Finally, output levels set in the experiment tend to exceed their theoretical predicted values. Hence, managerial contracts and incentive parameters chosen by the firms' owners result in a Stackelberg warfare fiercer than what the theory predicts.

Our results indicate that deviation from profit maximization succesfully induces a more aggressive output setting behavior. Further, the pro-competitive role of relative performance-based incentives is recognized and appropriately used by firm owners wishing to gain a competitive advantage in the market. In fact, this finding is particularly interesting for both theory and decision making by firms in the real world, because it is obtained in a far more realistic environment than that of fully rational players assumed in theory. Equally interesting for both theorists and decision makers is the non significance of revealing the contract type before choosing the contract terms. Thus, the positive effect of relative performance-based rewards on firms' profits is sufficient for this type of contracts to prevail over the profit-revenue alternative. Given that it is usually impossible to identify the effects of different strategic variables on specific stages of the decision making process, our experiment constitutes a unique source of evidence on specific predictions of oligopoly delegation theories. The noise in the quantity-setting stage has added a further challenge on the assumptions of the theory. In such a framework, the adoption of relative performance incentives and the effectiveness of the contract term parameter to induce more aggressive market behavior are particularly positive findings regarding the links between the theory and more complex environments with real human agents.

In the present paper we restricted attention to contracts combining either own profits and revenues or own profits and relative performance. Yet, there is evidence suggesting that CEO compensation is linked with own market share (Peck, 1988; Borkowski, 1999). Ritz (2008) and Jansen et al. (2007) formalize contracts combining own profits and own market share. Thus, an interesting direction for future experimental research could be to expand the firms owners' strategy space by allowing them to compensate their managers with contracts combining own profits and own market share as well.

6 Appendix: Experiment instructions (translated from Spanish)

6.1 Owner Instructions (2-stage treatment)

Your decisions in this experiment will help us study human behavior in specific economic contexts. The experiment is financed by public research funds. Read these instructions carefully, taking into account that a better understanding of the decision making context will help you earn more money and generate more reliable and, thus, useful data.

You are the owner of one of the two firms selling a given product. You will delegate the output decision of your firm to a manager whom you have hired for this purpose.

You will have to decide on the compensation method which your firm will adopt to remunerate your firm's manager. Your decisions in each period will become public information to all agents involved in the same market before output decisions are made. Managers will have to take these decisions as given and then fix their firm's output. Contracts may be of the following types:

Contract Type 1: 20.000 experimental currency units (EXCUs) as a fixed salary plus half of a linear combination between the firm's profits and the firm's revenues.

$$C_1 = 20000 + \frac{1}{2} \cdot (\alpha \cdot \Pi + (1 - \alpha) \cdot \mathit{Revenue})$$

Choosing the value of alpha you can vary the weight given by your firm to each of these two objectives (profit and revenue) in the variable compensation of the firm's manager.

Contract Type 2: 20.000 experimental currency units (EXCUs) as a fixed salary plus half of a linear combination between the firm's profits and the difference between your firm's and the rival's profits.

$$C_2 = 20000 + \frac{1}{2} \cdot (\alpha \cdot \Pi + (1 - \alpha) \cdot [\Pi - \Pi_{other}])$$

Choosing the value of alpha you can vary the weight given by your firm to each of these two objectives (profit and difference in profits) in the variable compensation of the firm's manager.

When choosing the contract terms you should take into account that your earnings will be: a fixed amount of 20.000 EXCUs plus the firm's profit.

The market will take place for 50 subsequent periods. In each one of them, following your choice of contract and that of the rival firm's owner managers will make output decisions simultaneously choosing output levels between 0 and 500 product units. You may change your manager's compensation method every 3 periods during the first 30 periods and every period after period 30.

The manager of your firm will be randomly assigned to you once and will be kept fixed throughout the experiment. In each period, you will form a market with a (different) single rival firm which will be chosen randomly among the firms formed by the participants of this experiment in the same way as your firm.

Your objective is to maximize your cumulative compensation. The more EXCUs you earn the higher will be your payment in cash at the end of the session. We give you a fixed initial payment of 100.000 EXCUs which will be added to your earnings from the experiment. The exchange rate is 1 euro for every 80,000 EXCUs.

Only for the 3-stage treatment: You and the owner of the rival firm will first know the contract chosen by each one of you and then you will decide on the value of alpha. Only after these two decisions have been made by owners, the managers receive information on contract types and incentive parameters chosen in order to make their firms output decisions.

Thank you for your participation and remember that, once these instructions are read, any communication or action which is not controlled by the organizers is prohibited until payments in cash have been made at the end of the experiment.

6.2 Manager Instructions (both treatments)

Your decisions in this experiment will help us study human behavior in specific economic contexts. The experiment is financed by public research funds. Read these instructions carefully, taking into account that a better understanding of the decision making context will help you earn more money and generate more reliable and, thus, useful data.

You are the manager of one of the two firms selling a product in the market. The owner of the firm has hired you in order to delegate to you the decisions concerning the output of the firm.

The method with which you will be compensated which you will have to take as given may be of either type:

Contract Type 1: 20.000 experimental currency units (EXCUs) as a fixed salary plus half of a linear combination between the firm's profits and the firm's revenues.

$$C_1 = 20000 + \frac{1}{2} \cdot (\alpha \cdot \Pi + (1 - \alpha) \cdot Revenue)$$

By choosing the value of alpha, the owner can vary the weight given to each one of the two aforementioned objectives in the variable part of your compensation.

Contract Type 2: 20.000 experimental currency units (EXCUs) as a fixed salary plus half of a linear combination between the firm's profits and the difference between your firm's and the rival's profits.

$$C_2 = 20000 + \frac{1}{2} \cdot (\alpha \cdot \Pi + (1 - \alpha) \cdot [\Pi - \Pi_{other}])$$

By choosing the value of alpha, the owner can vary the weight given to each one of the two aforementioned objectives in the variable part of your compensation.

When receiving this information you should have in mind that the owner's earnings will be a fixed amount of 20.000 EXCUs plus the firm's profit.

The market will take place during 50 periods in each one of which you will have to make the decision of your firm's output. The contract concerning your compensation may be changed every three periods during the first 30 periods and every period after period 30.

You will be assigned to a firm's owner who will be randomly chosen once at the beginning of the experiment. This matching will be kept constant throughout the session. The firm with which your firm will be matched to form a market will be determined randomly in each period among the rest of the firms formed by the participants in this session in the same way as your firm.

Your objective is to maximize your cumulative compensation. The more EXCUs you earn the higher will be your payment in cash at the end of the session. We give you a fixed initial payment of 100.000 EXCUs which will be added to your earnings from the experiment. The exchange rate is 1 euro for every 80,000 EXCUs.

Thank you for your participation and remember that, once these instructions are read, any communication or action which is not controlled by the organizers is prohibited until payments in cash have been made at the end of the experiment.

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