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Strategic delegation in experimental duopolies with endogenous incentive contracts[*]

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Abstract

Often, deviations of firm behavior from profit maximization are the result of managerial incentive contracts. We study the endogenous emergence of incentive contracts used by firm owners to delegate the strategic decisions of the firm. These contracts are linear combinations either of own firm's profits and revenues, or own and rival firms' profits. A two- and three-stage game are studied depending on whether owners commit or not to a certain contract type before setting the managerial incentives and the level of output to produce in

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the market. We report experimental results which confirm some of the predictions of the model, especially those concerning owners' preference for relative performance incentives over profit-revenue contracts. Neglected behavioral aspects are proposed as possible explanation of some divergence between the theory and the experimental evidence, more specifically the relation between contract terms and managers' output choices

JEL: D43, L21

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

1 Introduction

Neoclassical economics consider firms as economic agents whose main objective is to maximize profits. However seminal papers such as Baumol's (1958) suggested a sales-maximization model of firms' objective function as a realistic alternative to the profit-maximization one. More recently, Fershtman and Judd (1987) argued that a proper analysis of the firm's objective function should be undertaken under the prism of separation between ownership and management.[1] They further argued that such an analysis should incorporate the structure of the incentives that owners offer to managers in order to motivate them.

The strategic use of managerial incentive contracts has been introduced in the Industrial Organization literature by Vickers (1985), Fershtman (1985), Fershtman and Judd (1987) and Sklivas (1987). In this line of research, each owner has the opportunity to delegate market competition decision and offer an incentive contract to his manager in order to direct him to a more aggressive behavior in the market, so as to force the competing manager to reduce output. When determining his manager's incentives each owner has an opportunity to obtain competitive advantage via delegation, provided that rival owners do not delegate any decisions to managers. Typically, in equilibrium, all owners act in the same way, engaging in a prisoners' dilemma.

In this context, the choice of contract terms determines whether the manager's reward will depend more on the firm's profits or some other alternative objective like for example the firm's sales. Incentive schemes which are combinations of profit and revenue have been extensively studied. On the contrary, other types of incentive contracts which reward the manager according to different objectives like relative performance in the market have received much less attention. Miller and Pazgal (2001, 2002, 2005) formalize the idea that each manager may be concerned with the competing firms' performance when making his decision, under the 'Relative Performance' type of dele-

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[1]Managerial theories of the firm and agency theory have emphasized that the aforementioned separation leads to inefficiencies due to asymmetric information and differing objectives of managers and owners (e.g., Williamson, 1964; Jensen and Meckling, 1976; Fama and Jensen, 1983).

gation schemes. The equilibrium outcome of the aforementioned model is similar to the one obtained under the one that includes a linear combination of profits and sales delegation schemes.

In this paper, we present and experimentally test an oligopoly delegation model in which firms' owners choose between incentive contracts which reward managers according to combinations of profit and revenue or profit and relative performance. In fact, in the presence of these two alternative incentive schemes, firms' owners decisions concern both the objectives that should be pursued by their managers as well as on the mixture of these objectives in the manager's final reward. Our theoretical results predict that owners will induce their managers the objective of maximizing their firm's performance relative to other firms.

To our knowledge, Huck et al. (2004) is the only previous experimental study on delegation of objectives in oligopoly. However, in their framework, the choice of firm owners is limited to the terms of an exogenously imposed profit-revenue incentive scheme. Therefore, ours is the first experiment allowing subjects to choose between two different incentive contract types independently and before the actual terms of the contract are chosen. Furthermore, contrary to the discrete strategy space used by these authors to implement a reduced form of the underlying game, we have used a finer grid for both output choices and contract term parameters.

Compared with Huck et al. (2004), our findings are far more supportive for the main theoretical prediction concerning the use of objectives other than mere profit maximization. Generally speaking, some of our model's predictions receive strong support by our experiments, while others receive much weaker support or are even rejected. First, the prevalence of the Relative Performance contract type over the Profit Revenue alternative is strongly confirmed. However, we are able to disentangle the two motives offered by the theoretical study for such prevalence. The explanation based on the selection of focal, Pareto superior points receives clear support against the alternative of strategic commitment on contract types before the terms of the incentives are fixed. Second, the predicted higher aggressiveness under Relative Performance incentives is observed only in asymmetric configura-

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tions involving co-existence of both types of contracts. Third, contrary to the theoretical predictions, output is not responsive either to contract type, or to contract terms.

The above experimental results indicate that the theoretical literature on strategic delegation in oligopoly may have ignored some important issues that matter in this context. The most prominent among the issues ignored in the aforementioned theoretical models seems to be fairness. Given that owners and managers are assumed to be absolute own utility maximizers, the latter are expected to accept any reward above their reservation salary no matter how unfair the split of the firm's profits may be. However, since the seminal ultimatum experiment by Güth et al. (1982), we know that an agent receiving an unequal proposal of sharing a given profit with another agent may prefer earning nothing than earning an unfairly low amount of money. Later, an influential strand of literature emerged on economic behavior which is driven by other motives than pure short-run own utility maximization.[2] Furthermore, in a principal-agent relationship, agents may have preferences on the competitiveness of the incentive scheme according to which they will be compensated. For example, it would be plausible to suspect that hyper-competitive incentive schemes may be negatively perceived by agents. This phenomenon has never been studied so far in the context of strategic delegation in oligopoly. This task is partially undertaken here, and this makes our study interesting for researchers working on the design of incentives and delegation of different levels of decision making within collective decision making entities like firms which then compete with other entities of a similar structure.

The paper is organized in the following way: Section II discusses the theoretical framework and presents the testable hypotheses. Section III presents the experimental design. Section IV reports the results and section V con-

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[2]A sample of representative contributions from a plethora of recent papers is Andreoni (1988, 1990), Andreoni and Croson (2008), Berg et al. (1995), Camerer and Thaler (1995), Charness (2004), Cochard et al. (2004), Croson (2000), Dufwenberg et al. (2001), Dufwenberg and Kirchsteiger (2004), Fehr and Gächter (1998), Fehr et al. (1998a,b), Fehr and Schmidt (1999), Gächter and Falk (2002), Gneezy et al. (2000), Güth et al. (1997, 2001), Hoffman et al. (1994, 1996), Levine (1998), McCabe et al. (2000, 2003), McCabe and Smith (2000) and Rabin (1993).

cludes.

2 The theoretical framework

We consider a homogenous 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, with $\{i, j\} = \{1, 2\}$, $i \neq j$, $A > 0$. Thus, firm i's profits are given by:

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

In this industry, each firm has an owner and a manager. Following Fershtman and Judd (1987), when we say owner, we mean a decision maker whose objective is to maximize the profits of the firm. This could be the actual owner, a board of directors, or a chief executive officer. Managers are agents hired by owners to make real time operating decisions. Each owner can choose one among two different types of incentive contracts to compensate his manager: the first is the Profit-Revenue (PR) type of contract. Following Fershtman and Judd (1987) and Sklivas (1987), under this type of contract, the incentive structure takes a particular form: each risk-neutral manager i is paid at the margin, in proportion to a linear combination of own profits and revenues. More formally, firm i's manager will be given incentives to maximize:

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

where Π_i and R_i are firm i's profits and revenues respectively and a_i^{PR} is the managerial incentive parameter that is chosen by owner i. From a theoretical point of view, since the manager's reward is linear in profits and sales, he is paid $A_i + B_i U_i^{PR}$ for some constants A_i, B_i, with $B_i > 0$. Since he is risk-neutral, he acts so as to maximize U_i^{PR} and the values of A_i and B_i are irrelevant. If $a_i^{PR} < 1$, firm i's manager should move away from strict profit-maximization towards higher sales, thus, becoming a more aggressive seller in the market.

The second type of contract is the Relative Performance (RP) one. Fol-

lowing Miller and Pazgal (2001; 2002; 2005), under this contract, each owner i compensates his manager putting a weight of $(1 - a_i^{RP})$ on own profits and a weight of a_i^{RP} on the difference between own profits and the profits of the rival firm, yielding a variable compensation to the manager of:

$$U_i^{RP} = a_i^{RP}\Pi_i + (1 - a_i^{RP})[\Pi_i - \Pi_j] \tag{3}$$

When the objective function is written in this manner, it becomes apparent that if $a_i^{RP} < 1$, manager i puts negative weight on rival firm's performance. If $a_i^{RP} = 1$ the manager's behavior coincides with standard own profit-maximization.

In order to examine which types of managerial incentive contracts prevail in equilibrium, we consider a two-stage game with the following timing: in the first stage, each owner chooses the type of contract to reward his manager and sets the corresponding managerial incentive parameter a_i. In contrast to the received literature, our postulate is that there is no ex-ante commitment over the type of contract that each owner will offer to his manager. The crucial, yet (due to the symmetric industry) reasonable assumption here is that the precise contract (the type of contract and the managerial incentive parameter) that owner i sets is not observable by the rival owner, before contract-setting is everywhere completed. Thus, we argue that each owner can independently shift from a Profit-Revenue (Relative Performance) contract, to a Relative Performance (Profit-Revenue) one. In the second stage of the game, given that the type of contract and the incentive parameter that each owner has chosen have become common knowledge and cannot be reset, managers compete setting quantities. An alternative assumption concerning the timing of the game and, thus, the strategic role of committing to a contract type is considered, according to which contract types are decided and observed before the terms of incentive contracts are chosen. This leads to a three stage game in which the choice of contract type precedes the choice of contract terms, with output decided in the third stage.

Subgame perfection is used as the equilibrium concept to solve these games by backward induction.

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First, the Universal Profit-Revenue scenario is investigated, in which both firms' owners choose a Profit-Revenue contract to compensate their managers. In this case, equilibrium managerial incentive parameter, output and profits are:

$$a_i^{PR*} = \frac{-A + 6c}{5c}; \quad q_i^{PR*} = \frac{2(A-c)}{5}; \quad \Pi_i^{PR*} = \frac{2(A-c)^2}{25}. \tag{4}$$

Second, the Universal Relative-Performance is examined. The corresponding equilibrium values are now given by:

$$a_i^{RP*} = \frac{1}{3}; \quad q_i^{RP*} = \frac{3(A-c)}{8}; \quad \Pi_i^{RP*} = \frac{3(A-c)^2}{32}. \tag{5}$$

Finally the Coexistence of the two types of contract is considered, in which, without loss of generality owner i is assumed to choose a Profit-Revenue contract, while his rival's choice is a Relative Performance one. The equilibrium outcome of the Coexistence scenario is given by:

$$a_i^{(pr-rp)*} = 1; \quad q_i^{(pr-rp)*} = \frac{A-c}{4}; \quad \Pi_i^{(pr-rp)*} = \frac{(A-c)^2}{16} \tag{6}$$

$$a_j^{(rp-pr)*} = 0; \quad q_j^{(rp-pr)*} = \frac{A-c}{2}; \quad \Pi_j^{(rp-pr)*} = \frac{(A-c)^2}{8} \tag{7}$$

We next summarize the main findings given in eq.(4), (5), (6) and (7), which yield the hypotheses which will be tested with our experimental design.[3]

First regarding the endogenous choice of managerial contracts, when owners commit to a contract before choosing the terms, a dominant strategy of both firms is to reward their managers under a Relative Performance type of contract. In the absence of commitment on contract type before the terms of incentive contracts are chosen, multiple equilibria exist corresponding to the universal adoption of either contract type. However, the Pareto criterion could be used to select the Relative Performance type as a focal equilibrium point. In terms of observable implications, this would lead to the following

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[3]Formal proofs and results obtained in this framework are presented and discussed in detail in Manasakis et al. (2007).

testable hypothesis:

TESTABLE HYPOTHESIS 1: (H1.1) *Relative Performance incentives will be preferred over Profit-Revenue incentive schemes and* (H1.2) *if the **focal point** motivation for the prevalence of Relative Performance incentives dominates over the **strategic commitment** alternative, the frequency of Relative Performance incentives will increase if firms commit to an incentive contract type before deciding on the terms of the contract.*

Given each one of these two equilibrium points, the terms of the corresponding equilibrium incentives should be such that Relative Performance-rewarding owners choose their managers' objectives closer to profit maximization, while in the alternative Profit-Revenue equilibrium managers are asked to deviate more from pure profit-seeking behavior.

TESTABLE HYPOTHESIS 2: *The terms of incentives under universal adoption of each type of contract are such that managers under Relative Performance contracts are induced to adopt a less aggressive behavior than under Profit-Revenue incentives. In asymmetric configurations the reverse ranking is expected to be observed.*

Regarding the consequences of this prediction for the corresponding equilibrium outputs, it is shown that Profit-Revenue contracts lead to a higher individual and total output than Relative Performance contracts, which also explains why the universal Relative Performance equilibrium is more profitable than its Profit-Revenue counterpart. Contrary to this comparison of equilibrium outputs across the two symmetric contract choices, in asymmetric contract configurations the firm using Relative Performance incentives produces higher output than its Profit-Revenue-oriented rival.

This can be summarized in the following testable hypothesis:

TESTABLE HYPOTHESIS 3: *Compared to the case of universal Relative Performance contracts, output is higher under industry-wide adoption of Profit-Revenue incentives, while the contrary ranking of individual outputs is predicted within a duopoly in which the two contract types coexist.*

It is worth noting that if both firms chose no delegation at all they would end up earning higher profits than in any of the delegation scenarios discussed above. The reason for the emergence of symmetric delegation equilibria is

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straightforward: by using an incentive contract strategically, an owner directs his manager to a more aggressive behavior in order to force the competing manager to reduce output. Because owners act in identical ways at the contract stage of the game, firms end up in a prisoners' dilemma situation. Naturally, the increase of market supply, in comparison to the no-delegation case, leads to lower profits and higher levels of social welfare.

The intuition behind the prevalence of the Relative Performance equilibrium is based on the results observed in eq.(**??**). More specifically, the owner who selects Relative Performance type of contract for his manager, obtains competitive advantage in the market, for any contract choice of the rival firm. This makes the selection of a Relative Performance managerial contract each owner's best response to whatever the rival owner's choice is. Hence, Relative Performance is the dominant owners' strategy.

3   Experimental design

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

A total of 144 subjects participated in the sessions. They were volunteers recruited among 2nd and 3rd course students enrolled in the Business and Human Resources degrees at the Universitat Jaume I according to standard protocols used in the *Laboratori d'Economia Experimental* (LEE) of the Universitat Jaume I (Castellón, Spain), where all the sessions reported here, were run. Real monetary incentives were used. Each session lasted approximately 100 minutes and average earnings per subject were slightly below 20 Euros.

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 *2-stage* game, owners choose simultaneously the type and the terms of their managers' incentive contracts before managers decide on their firms' output. In the second treatment, labeled as *3-stage*, the choice of contract type precedes the choice of contract terms and the corresponding decisions become public information before the contract terms are chosen by the owners and quantities are set by managers. The experiment was programmed using

the z-Tree toolbox (Fischbacher, 1999). At the beginning of the session, each subject was randomly assigned the role of an owner or a manager and written instructions specific to each role were distributed to them. All remaining questions were privately answered by one of the organizers.

Eighteen owner-manager pairs were randomly formed once at the beginning of each session. These intra-firm 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 pairs of firms were randomly formed in each period using a *strangers* matching protocol 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 would have a further 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.

Four independent sessions were run in two occasions on subsequent dates (18-19/12/2006 and 29-30/05/2007). The order between 2-stage and 3-stage treatment sessions was changed across the two occasions to control for any undesirable "social learning" across sessions creating misleading false treatment effects. Therefore, sessions 1 and 4 correspond to the 3-stage treatment, while sessions 2 and 3 belong to the 2-stage treatment.

The total cost for subject rewards was 2,739 euros which implies slightly above 19 euros per subject earnings, ranging between 7.3 and 29.6 euros

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(an owner subject in a three stage session and an owner-subject in a 2-stage session respectively). Subjects in the 2-stage treatment receive slightly higher payments than in the 3-stage one (19.3 and 18.7 euros respectively).

Given the experience from pilot sessions, the payment method was designed to yield similar earnings across player types.[4] Thus an equal split of the experimental earnings was observed in the overall sample and within each treatment.[5]

The model's parameter values implemented here are: $A = 1000$, $\gamma = 1$ (homogeneous product) and $c = 200$. To compensate for possible negative earnings, a show-up fee of 10 euros was given to each subject and it was uniformly distributed over the 50 periods in the form of a fixed amount $f = 20,000 ExCus$ (Experimental Currency Units) per period. Therefore, an exchange rate of 1 euro per $80,000$ ExCus was used.

Under this set of parameters the prediction for a non delegation Cournot equilibrium output is $q_i^{Cournot} = 266.66$. Given the prediction of the model concerning the contract choice stage, we move to the contract terms and outputs corresponding to the two aforementioned perfect equilibria. In the Universal Profit-Revenue equilibrium, both firms should choose $a_i^{PR*} = 1/5$ and managers should set the corresponding equilibrium output levels at $q_i^{PR*} = 320$. In the Universal Relative Performance equilibrium, both firms' owners set $a_i^{RP*} = 2/3$, leading to the corresponding equilibrium output level $q_i^{RP*} = 300$. Although the combination of firm i choosing a Profit-Revenue contract while j chooses Relative Performance incentives is not an equilibrium, it is worth mentioning that the corresponding equilibrium contract terms and outputs are respectively $(a_i^{PR}, a_j^{RP}, q_i^{PR}, q_j^{RP}) = (1, 0, 200, 400)$.

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, any experimentalist would immediately recognize the difficulties associated with such a strict test of the theory,

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[4]See instructions to the subject on this issue.

[5]That is owners' earnings were exactly 50% of total earnings in both the overall sample and the subsamples under treatments 1 and 2. Small variations of these percentages were observed across sessions (51% in session 1; 52% in session 2; 47% in session 3 and 48% in session 4.

given that, unlike the usual theoretical assumption of perfectly informed human decision makers with unlimited calculus capacity and perfect foresight, real subjects learn from trial-and-error strategies and often commit systematic mistakes due to a number of reasons.[6] Thus, we will focus on the test of the predictions provided in a qualitative form by the testable hypotheses H1-H3 stated in the previous section.

4   Results

Data analysis reveals two interesting results regarding the type of the contract that owners will choose for their managers. First, firms' owners will only rarely choose not to delegate any decisions to their managers.[7] This is in line with the theoretical prediction (See, Vickers (1985), Fershtman (1985), Fershtman and Judd (1987) and Sklivas (1987)), according to which owners will always choose strategic delegation in order to obtain competitive advantage in the market. Moreover this contradicts the experimental findings of Huck et al. (2004), according to which firms' owners' choice will in most cases be "No Delegation".

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[6]A vast literature has been dedicated to various factors that may be responsible for observed shortcomings of human behavior in complex environments, such as misperception of feedback (Paich and Sterman, 1993 and Sterman 1994), limitations in subjects' learning when exposed to strategic complexity (Richards and Hays 1998), or multitask 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 single-product symmetric benchmark is obtained in settings such as that outlined in Garcia-Gallego (1998), the introduction of a slightly more complex task in the multiproduct oligopolies in Garcia-Gallego and Georgantzis (2001) or the asymmetry in Garcia-Gallego et al. (2004) provide a sufficiently unfavorable environment for the hypothesis based on the corresponding theoretical prediction to be rejected.

[7]Only 6%(4%) of the contracts include No Delegation in the 2-Stage (3-stage) treatment.

Treatment	2-Stage		3-Stage		Both	
Variable	**Mean**	**Standard Deviation**	**Mean**	**Standard Deviation**	**Mean**	**Standard Deviation**
Quantity	357.00	97.99	354.43	91.97	355.72	95.02
Incentive Parameter (a)	.498	.261	.523	.285	.510	.274
Type of contract	1.733	.442	1.709	.454	1.721	.448
Profits	30802.09	19598.56	32213.03	19387.36	31507.56	19503.3

Table 1: Descriptive statistics (overall sample). Profit-Revenue Contracts=1, Relative Performance Contracts=2.

Table 1 provides descriptive statistics on individual quantities, contract types and incentive parameter choices. From this information we can see that quantities have been, on average, significantly higher than expected, even if we compared the average output obtained (approximately, 355 in the overall sample, 357 in the 2-stage game and 354 in the 3-stage one, with the most expansive theoretical output prediction (320 product units) corresponding to the simultaneous adoption of Profit-Revenue contracts by both owners. In fact, under our parameters, the other two scenarios (Universal Relative Performance and coexistence of both contract types) yield the same average output prediction (300 product units, although asymmetric contract configurations predict 400 for the Relative Performance-rewarding firm versus its Profit-Revenue oriented rival). Therefore, our subjects have behaved in an excessively pro-competitive way, far beyond the consequences predicted by the theoretical model for any of the scenarios studied. Given that the predictions of the model concerning the contract terms significantly vary across different scenarios, we will study the behavior of subjects with respect to the contract parameter choice contingent to each specific scenario. However, a first look at the overall sample reveals some not necessarily innocuous attraction to the focal value of 0.5, which lies between the predictions of both the two symmetric equilibrium configurations (1/5 and 2/3) and the predic-

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tions of the asymmetric contract configuration (0 and 1). As we said, we will discuss this in more detail in tables presenting contract term decisions contingent to different contract configurations. However, the attraction to "moderate" values of the parameter suggests that the deviation of the observed contract terms from their corresponding theoretical values towards more central attractors, such as the value of 0.5 which must be given special attention.[8]

		Type of Treatment		
		2-Stage	3-Stage	Total
Type of Contract	Profits-Revenues (PR)	.573 (.272) [480]	.616 (.287) [523]	.595 (.280) [1003]
	Relative Performance (RP)	.470 (.252) [1320]	.484 (.276) [1277]	.477 (.264) [2597]
	Total	.498 (.261) [1800]	.523 (.285) [1800]	.510 (.274) [3600]

Table 2: Means, (standard deviations) of a and [frequencies of contract types] for both the 2-stage and 3-stage treatments.

Let us move now to Table 2. Relative Performance contracts are more frequently used than Profit Revenue incentives under both treatments.[9] But what we are really interested to see is weather the combination of contract choices is as predicted by the subgame perfect equilibria discussed above. As sown in Table 3, in the 3-stage treatment, more than half of

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[8]See, for example, Sabater-Grande and Georgantzis (2002) where subjects offered a continuum of lotteries with winning probabilities ranging between 0 and 1 are found to have some non Expected Utility-compatible preference for probabilities near 0.5.

[9]480 vs. 1320 times in the 2-stage treatment and 523 vs.1277 times in the 3-stage treatment.

our experimental duopolies have taken place under universal Relative Performance incentive contracts ($932/1800 = 51.7\%$). Contrary to this equilibrium, the Universal Profit-Revenue equilibrium receives scarce, if any, support ($178/1800 = 9.8\%$) of all contract combinations observed.

		Firms' choise				
		i, j=PR	i, j=RP	i=PR, j=RP	i=RP, j=PR	Total
Type of Contract	Profit-Revenue	.610 (.278) [178]	. . 0	.619 (.291) [345]	. . 0	.616 (.287) [523]
	Relative Performance	. . 0	.484 (.276) [932]	. . 0	.484 (.276) [345]	.484 (.276) [1277]
	Total	.610 (.278) [178]	.484 (.276) [932]	.619 (.291) [345]	.484 (.276) [345]	.523 (.285) [1800]

Table 3: Means, (st.deviations) of a and [frequencies of contract types] for the 3-stage treatment.

In fact the frequency of Universal Profit Revenue contracts is approximately half the frequency of "out of equilibrium" coexistence of the two contract types in the same market.[10] This finding confirms the theoretical prediction according to which owners will reward managers under a Relative Performance type of contract. However, while this is a clear confirmation of our Testable Hypothesis 1 according to which Relative Performance contracts will be chosen more frequently due to the Pareto selection criterion as a focal equilibrium point, we find no evidence in favor of the second

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[10]A χ^2 test ($p = 0.0001$) 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.

part of the hypothesis (H2) concerning an increased likelihood of Relative Performance contracts in the 3-stage game. Specifically, against the aforementioned prediction, Table 1 indicates that the frequency of contract 2 is slightly higher (not significantly, though) in the 2-stage than in the 3-stage treatment. Therefore, we can state the following important finding:

RESULT 1: *Relative Performance contracts are significantly more frequent than Profit-Revenue ones (H1.1), but (opposite to H1.2) the result does not depend on whether owners commit on contract types before the contract terms are chosen.*

This result indicates that the selection criterion proposed in the theoretical findings in Manasakis et al. (2007) is more powerful than the 2-stage vs. 3-stage approach in explaining the prevalence of the Universal Relative Performance equilibrium over its Profit-Revenue counterpart. In other words, the strategic importance of committing on a specific contract type looses ground against a rational selection of the Pareto-dominant equilibrium.

Let us now present our findings regarding the managerial incentive parameter, α, for both contract types. First, under Profit-Revenue contracts, higher α's are chosen by owners than those chosen under Relative Performance incentives[11] indicating that under such an incentive scheme, owners' intentions to commit to a less competitive behavior is also expressed by the choice of a higher α, favoring behavior which is closer to standard profit maximization. However, the only prediction of the theoretical model which is supported by the observed contract terms is that, in asymmetric configurations, Profit-Revenue rewarding owners set higher α's than Relative Performance rewarding firms. On the contrary, symmetric configurations are such that owners rewarding their managers' Relative Performance set lower α's than owners in symmetric Profit Revenue reward configurations. Finally, taking into account the quantitative predictions under the set of the parameters implemented in the experiment (1/5 and 2/3 for Profit-Revenue and Relative Performance, respectively), we observe that owners have exhibited less aggressive behavior in symmetric configurations, setting on average

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[11]Yielding an average of 0.57 vs. 0.47 in the 2-stage treatment and 0.61 vs. 0.48 in the 3-stage treatment.

higher α's than predicted in the corresponding subgame perfect equilibria, while in the asymmetric case, less extreme α's have been adopted (0.61 and 0.48, respectively) than the predicted values (1 for Profit Revenue and 0 for Relative Performance contracts). The most striking pattern observed in our data on contract terms is that even after observing the other firm's contract type, owners set on average almost the same α independently of whether the other firm has committed to one or the other contract type. That is, the contract terms chosen by owners exhibit no differences in response to their rivals commitment on a given incentive scheme. We summarize this in the following result:

RESULT 2: 1. *The prediction of the model concerning a higher aggressiveness of Relative Performance-rewarding owners over their Profit-Revenue rivals is confirmed (partial confirmation of H2). On the contrary, the prediction concerning the ranking of α's across symmetric configurations is not supported by our data. 2. There is a systematic deviation of observed α's from the corresponding theoretical values (upwards for both symmetric configurations and Relative-Performance incentives in asymmetric situations and downwards for Profit Revenue in the asymmetric case). 3. Observing a rival's commitment on a given contract type does not affect the average a's used by either Relative Performance, or Profit Revenue rewarding owners.*

Finally we focus on the effects of contract type and incentive parameters (α's) on market outcomes. It is worth mentioning once more that output behavior has been excessively expansive far beyond any of our theoretical model's predictions. Several other theoretical predictions concerning output levels are partially or totally rejected. For example, the theoretical prediction of higher output under Profit-Revenue (Relative Performance) than in symmetric (asymmetric) configurations, is not verified by the experimental results. In fact, looking at Table 4 we can see that output has exhibited little if any responsiveness to variations in the contract structure, given that the only perceivable (though not statistically significant) difference is between the output averages of Relative Performance and Profit Revenue oriented managers. It has been already reported in the past that, contrary to Bertrand competition, learning in Cournot experimental markets exhibits modest de-

grees of convergence towards the corresponding theoretical predictions due to excessively competitive behavior and strategy volatility.[12] Our findings here extend this lack of predictive power of the Cournot model over to multi-stage games and specifically to the lack of output responsiveness to different delegation contracts.

Mean (st. deviation) of firms' quantity per contract type	Universal Profit-Revenue	Universal Relative Performance	Coexistence Scenario
Profit-Revenue	354.2 (33.5)		354.9 (21.6)
Relative Performance		355.2 (14.5)	348.1 (25.6)

Table 4: Mean and standard deviation of firms' quantity per contract type.

What is left is left now is to examine whether the terms of delegation contracts have produced the expected outcome on output. That is, whether a manager has responded in the expected way to his reward scheme. A simple test is to see if there is a negative relation between the α parameter and the output chosen. This can be done by examining specific patterns of individual manager's responses to their owner's contract term decisions. This can only be traced by looking at individual level data, and may be responsible for some apparent lack of response of outputs to delegation contract terms.

Below in table 5, we present the patterns of output responses to contract terms by contract configuration. Monotonic (M) responses are defined as those which imply a monotonic response, in the predicted direction of the average output per market with respect to increases in the contract term parameter. All other responses involving changes in the direction of the re-

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[12] See, for example, the sharp difference in the results obtained by Garcia-Gallego (1998) on learning in Bertrand oligopolies and those reported by Huck et al. (1999) on learning in experimental Cournot markets.

port or even persistence of a response direction opposite to that predicted by the model are defined as non monotonic (N) changes. We observe that the most frequent pattern, by far, is N, which implies that in most markets average output has exhibited at least one kink, revealing non linear patterns of individual managers' response to their owners behavior. That is, in each manager's history we identify that there is a threshold value of the contract term parameter beyond which the manager "counteracts" to the owner's pretended "advice" of an over-competitive behavior through extreme deviations from plain profit maximization.

Hence, the following result holds

RESULT 3: 1. *Output is not monotonically responsive (in the predicted direction) to the delegation contract type.* 2. *Moreover, output is not monotonically responsive (in the predicted direction) to contract terms.*

This finding is based on *individual* market data with at least one inconsistent tendency of output responses, paying special attention to this phenomenon as a qualitative fact, not as a tendency of aggregate output data.

Universal Profit-Revenue				Universal Relative Performance				Coexistence of both contract types scenario							
2-stage		3-stage		2-stage		3-stage		2-stage				3-stage			
								PR		RP		PR		RP	
M	N	M	N	M	N	M	N	M	N	M	N	M	N	M	N
1	8	1	8	2	7	3	6	1	8	2	7	2	7	0	9

Table 5: Number of markets (over 9) of patterns of average output response to contract terms. M="Monotonic" (as predicted by the theory); N="Non monotonic".

In most cases in which a non-monotonic pattern is observed, the latter is associated with extreme values of alpha like are those inducing complete deviation from plain profit maximization. In order to interpret this result, we must remember that manager subjects have no power to reply to their

owners once the latter have chosen a contract term parameter. That is, managers cannot renegotiate their contract, nor can they reject a given delegation scheme. Furthermore, they cannot express their opinion or preferences regarding the contract terms they are offered. In that sense, we must see our results in line with a more general set of findings from economic experiments on asymmetric bargaining situations like for example ultimatum games. There, it is usually found that subjects, rather than simply maximizing own earnings their behavior is affected by fairness considerations which can be explained as the result of other-regarding preferences. As a result, weaker agents tend to reject unfair offers, despite the fact that this leads them to lower (usually zero) payoffs.[13] This seems to be the case here, with managers receiving an overcompetitive contract leading often to a war with the other firm's manager aiming at winning the race of who is going to produce more. Managers engaged in such a warfare realize that the only negative signal they can send to their firm's owner concerning the imposition of such a contract is by producing an unprofitable output. Of course, this reduces their own profits too, but the message is clear: "I do not like overcompetitive incentive contracts". Such a loss of utility from excessively competitive environments has been reported in many different contexts, but, to our knowledge this is the first time it is being reported in the context of oligopoly delegation.

An alternative way to accommodate this finding into the other-regarding preferences framework is by considering managers' compliance with their owners' preferred objectives as reciprocal behavior[14] aiming at rewarding them for choosing a contract which does not put excessive pro-competitive pressure on them when deciding their output decisions. In any case, a seri-

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[13]See work on similar issues in different contexts by Camerer and Thaler (1995), Croson (1996) and, especially Fehr et al. (1998a), Gneezy et al. (2000) and the influential work by Fehr and Schmidt (1999) and Rabin (1993).

[14]An extensive literature exists on positive and negative reciprocity in many different contexts. Without pretending an exhaustive list, some representative examples are studies by Andreoni (1988 and 1990), Berg et al. (1995), Bolton and Ockenfels (2000), Boyd and Richerson (1989), Cochard et al. (2004), Dufwenberg et al. (2001), Dufwenberg and Kirchsteiger (2004), Engelmann and Fischbacher (2002), Fehr and Gächter (1998), Fehr et al. (1998b), Gächter and Falk (2002), Güth et al. (2001), McCabe et al. (2003). More similar to our intrafirm relations context is the study by Charness (2004).

ous but not surprising deviation of experimental results from the theoretical framework is the little if any incidence of symmetric strategy profiles (in contracts, contract terms, and output choices) which contrasts with the theoretical predictions of total symmetry. Therefore, one should have in mind that, for example, in all the occasions of a Universal Relative Performance configuration there is a subject which receives a penalization (negative variable compensation contingent on relative profits) that might trigger regret and feelings of loss to the looser of the output race. These considerations suggest several natural extensions of this work in the future. On one hand, a theoretical model with more behavioral consideration might be helpful in order to bring the theoretical framework closer to real world markets. Second, controlling for some of the behavioral factors described above could require designing a more complex environment, accounting for manager's willingness to sacrifice present earnings in order to cause their firms' owners to adopt more manager-friendly contracts. We will undertake this task in the future.

5 Conclusions

One of the most prominent theoretical paradigms predicting rational deviations from profit maximization is oligopoly models with delegation of firm objectives through managerial incentive contracts. So far, the experimental literature on strategic delegation is limited to a context of owners choosing the terms of an exogenously imposed profit-revenue incentive scheme.[15] Therefore, our experiment is, to our knowledge, the first to allow subjects to choose between two different incentive contract types independently and before the actual terms of the contract are chosen. Furthermore, contrary to the discrete strategy space used in the aforementioned experimental study, we have used a finer grid in both the output choice stage and the preceding one in which the contract terms are chosen.

We restrict our attention to three main testable hypotheses. The first regards the type of contracts that owners will endogenously choose to com-

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[15]Huck et al. (2004).

pensate their managers. The second refers to the relation between the contract type and the degree of aggressiveness chosen by owners. Finally the correlation of the contract type and managerial incentives to the market outcomes. Our main finding is that Relative Performance contracts are significantly more frequent than Profit-Revenue ones, but the result does not depend on whether owners commit on contract types before the contract terms are chosen. Thus the Pareto selection criterion is sufficient to explain the prevalence of Relative Performance incentives, while the role of strategic commitment on a contract type before the terms of the contract are chosen adds nothing to the reasons why owners prefer this type of incentive. Secondly, the prediction of the model concerning a higher aggressiveness of Relative Performance-rewarding owners over their Profit-Revenue rivals is confirmed for asymmetric contract configurations only. On the contrary, the prediction concerning the ranking of α's across symmetric configurations is not supported by our data. Additionally there is a systematic deviation of observed α's from the corresponding theoretical values (upwards for both symmetric configurations and Relative-Performance incentives in asymmetric situations and downwards for Profit Revenue in the asymmetric case). Furthermore, observing one's rival's commitment on a given contract type does not affect the average α used by either Relative Performance-rewarding owners, or Profit-Revenue ones. Finally, output is not monotonically responsive in the expected direction neither to the delegation contract type, nor to the contract terms which determine owners' choise for their manager's aggressiveness during the market competition stage.

A possible explanation of these deviations from the predicted theoretical outcomes may be the fact that managers often counteract to excessively pro-competitive incentive schemes as a means of punishing their owners for using them. In this way, the resulting loss of present earnings aims at increasing the probability of receiving more manager-friendly incentives in the future, in the same way in which rejections in an ultimatum game aim at increasing offers in the future. This is certainly an underinvestigated behavioral aspect of managerial incentives. Hopefully, this is the starting point for a re-consideration of oligopoly delegation towards frameworks inspired

on the rapidly growing behavioral economics literature on other-regarding preferences.

6 Appendix: Experimental 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 reward 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 monetary units (UMEX) as a fixed salary plus half of a linear combination between the firm's profits and the firm's revenues.

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 monetary units (UMEX) 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.

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.

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

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 ranging between 0 and 500 product units. You may change your manager's reward 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 UMEX you earn the higher will your payment in cash at the end of the session. We give you a fixed initial payment of 100.000 UMEX which will be added to your earnings from the experiment. The exchange rate is 1 euro for every 80,000 UMEX.

[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 alpha's 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 rewarded which you will have to take as given may be of either type:

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

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 reward.

Contract Type 2: 20.000 experimental currency units (UMEX) 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.

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 reward.

When receiving this information you should have in mind that the owner's earnings will be a fixed amount of 20.000 UMEX plus the firm's profit, minus the variable part of the owner's reward.

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 reward 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

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

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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