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STRATEGIC DELEGATION IN EXPERIMENTAL MARKETS

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Abstract

In this experiment, we analyze strategic delegation in a Cournot duopoly. Owners can choose among two different contracts which determine their managers' salaries. One contract simply gives managers incentives to maximize firm profits, while the second contract gives an additional sales bonus. Although theory predicts the second contract to be chosen, it is only rarely chosen in the experimental markets. This behavior is rational given that managers do not play according to the subgame perfect equilibrium prediction when asymmetric contracts are given.

Keywords: Strategic delegation, managerial incentives, experimental economics

JEL Classification: C72, C92, D21, D43

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1 Introduction

Coined by Schelling (1960), the term strategic delegation refers to a situation where a player uses a delegate as a "commitment device." In closely related models, Fershtman and Judd (1987), Sklivas (1987), and Vickers (1985) (henceforth FJSV), have formally shown how strategic delegation may serve as such a commitment device in oligopoly. Delegation of this type has received considerable attention in the theory of markets with separation of decision making and ownership. This paper provides an experimental investigation into the matter.

Consider a simple Cournot duopoly and imagine one firm employs a delegate to decide upon its supply while the other does not. In that case, the first firm can, by choosing an appropriate incentive contract for its manager, induce a Stackelberg outcome.[1] This increases the first firm's equilibrium profits. As FJSV have shown, markets become more competitive when firms use delegates whose incentives can depend on profits and sales. If both firms employ managers, they will choose equilibrium contracts with a sales bonus, inducing quantities that exceed the Cournot equilibrium quantities (which result if both firms take their decisions without delegates). Hence, firms' profits decrease. Firms face a dilemma situation.

The literature following FJSV has shown that the observability of contracts may be crucial for the results. Katz (1991) argues that unobservable contracts have no commitment value at all.[2] In contrast to that, Fershtman and Kalai (1997) analyze the conditions under which delegation, even when unobservable, may affect the outcome of an ultimatum game. In a recent experiment, these results were experimentally tested by Fershtman and Gneezy (1999). They show that unobservable delegation indeed matters—even if theory does not predict an effect of delegation. The main insight of Fershtman and Gneezy's study is that because of the introduction of a third player (the delegate) the ultimatum game is perceived more competitive which may drive behavior closer to the game–theoretic prediction.

[1]Technically speaking, the first firm can arbitrarily manipulate its manager's response function. Thus, it can "select" any quantity combination which lies on the second firm's response function.

[2]Bagwell (1995) shows that any noise associated with the observation of the first mover's choice (in a sequential game) eliminates the first–mover advantage. See Huck and Müller (2000) for experimental evidence.

In this paper, we report results from an experiment designed to test the FJSV prediction for markets. We study a simple Cournot duopoly framework matching the requirements of the FJSV theory. The main question is whether firm owners indeed provide contracts with sales bonuses, making their managers more "aggressive" and, thus, rendering the market outcomes more competitive.[3] In the experiment each firm has one owner and one manager. Owners simultaneously choose between two different contracts which determine their managers' possible salaries. One contract induces managers to maximize profits, while with the second contract managers' salaries are a convex combination of profits and sales. The chosen contracts become public information. Then managers simultaneously decide about quantities. Markets are repeated and an owner–manager pair always stays together.

This basic setup is varied in three treatments. All treatments implement "15 years" of market interaction. In two treatments, each year consists of four "quarters." While in these treatments owners only decide once a year about the contract, the managers have to make their choice in every quarter. This gives managers time for learning in the reached subgames. These two treatments differ with respect to the matching between firms. In one treatment two firms interact repeatedly over the complete course of the experiment. In the other treatment, firms are randomly rematched at the beginning of each year, but they stay together for four quarters. The third treatment differs from the first two in that there are no quarters. Here firms are also randomly rematched every year.

The theoretical prediction is identical for all these treatments: Owners should choose the contract entailing sales bonuses, and managers should, accordingly, produce above the Cournot level. The surprising result is, however, that owners rarely choose the equilibrium contract. Moreover, it turns out that—given managers' behavior in asymmetric subgames, i.e., in subgames in which they have different contracts—these choices are rational.

The remainder of the paper is organized as follows: Section 2 presents the underlying theory and the experimental design, Section 3 reports the experimental results, and

[3]See Dufwenberg and Güth (1999) for a comparison of the strategic delegation model and an evolutionary model of such "aggressive" preferences.

Section 4 concludes.

2 Theory and Experimental Design

In line with the FJSV model, we use linear demand and cost functions for our experiment. More specifically, inverse demand was

$$p(q_1, q_2) = \max\{60 - q_1 - q_2,\ 0\}$$

where q_i, $i = 1, 2$, denotes firm i's output. In order to avoid negative profits, we set constant marginal cost equal to zero. Manager i's incentives, g_i, are a combination of profits and sales:[4]

$$g_i(q_1, q_2, \lambda_i) = p(q_1, q_2) \cdot q_i + \lambda_i \cdot q_i = (\max\{60 - q_1 - q_2,\ 0\} + \lambda_i) \cdot q_i.$$

Straightforward computation shows that manager i chooses in equilibrium

$$q_i = \frac{60 + 2\lambda_i - \lambda_{-i}}{3},\ \ i = 1, 2.$$

Owners simultaneously decide about λ_1 and λ_2. Their objective is to maximize profits pq_i. Again it is straightforward to compute the equilibrium actions. Owners choose

$$\lambda_1^* = \lambda_2^* = 12$$

which induces $q_1^* = q_2^* = 24$. By contrast, if owners choose $\lambda_1 = \lambda_2 = 0$, both managers produce $q_1 = q_2 = 20$ (the Cournot quantities of the duopoly without delegation).

In an experimental market, strategic delegation is presumably of considerable complexity. For every (λ_1, λ_2)–combination, there is a different subgame with different equilibrium outputs in those subgames. Generally, subjects in multi–stage experiments do not play the subgame perfect equilibrium very well (see, for example, the literature on the ultimatum game which Fershtman and Gneezy (1999) study). Therefore, we simplified the design as far as possible.

We restricted the owners' strategy sets to only two choices which we labelled "Contract A" and "Contract B". Contract A corresponds to $\lambda_i = 0$, while Contract B

[4] With positive costs, one could also consider a combination of profits and revenue (see Sklivas, 1987).

corresponds to $\lambda_i = 12$, the equilibrium contract. In order to avoid a possible bias because of the labels "A" and "B", in five out of twelve sessions the labelling was reversed such that the equilibrium contract was Contract A. Since there were no significant differences between those treatments, we pooled the data and will henceforth refer to the equilibrium contract as Contract B.

We also restricted managers' strategy sets. More precisely, we let them choose from the set of quantities which are optimal in the four unrestricted quantity subgames. As noted above, if both owners choose Contract A, i.e., if $\lambda_1 = \lambda_2 = 0$, both managers optimally choose $q_1 = q_2 = 20$. If both owners choose Contract B, i.e., $\lambda_1 = \lambda_2 = 12$, managers' optimal choice is $q_1 = q_2 = 24$. Finally, the asymmetric Contract A/Contract B outcome with $\lambda_i = 12$ and $\lambda_j = 0$, leads to $q_i = 28$ and $q_j = 16$. Therefore, managers' strategy set was $\{16, 20, 24, 28\}$.

This reduced game was presented to subjects by payoff tables rather than by the model's parameters and payoff functions.[5] The payoff matrices are reproduced in Tables 1–3. They are, in principle, derived from the above linear model (see Appendix B). Analyzing these tables also shows that the game can be solved by iterated elimination of dominated strategies. For reasons of plausibility of the frame, owners' profits and managers' salaries were of different magnitudes. In order to equalize average payments of owners and managers, we used different exchange rates when converting the experimental payments into Deutsche marks (see below).

Table 1 is the profit table of an owner. If both owners choose Contract A, the payoff matrix of a manager is as in Table 2 (left). If both owners choose Contract B, the relevant manager matrix is the one in Table 2 (right). If one owner chooses Contract A while the other owner chooses Contract B, the matrix shown in Table 3 results. A fifth table given to subjects (not reproduced here) gave the payoffs in case the first manager had Contract B and the second manager had Contract A. This table is somewhat redundant but it might have helped subjects understanding the game. All five tables were given to all subjects before they knew which role they would play.

[5]Since the size of the quantities $\{16, 20, 24, 28\}$ is entirely meaningless to subjects (recall that they did not know the model), we labelled the strategies $\{1, 2, 3, 4\}$ instead. However, since the reader is familiar with the model and the equilibrium values, we will refer to quantities $\{16, 20, 24, 28\}$ throughout the paper.

	16	20	24	28
16	450, 450	380, 490	310, 480	260, 450
20	490, 380	400, 400	320, 380	240, 350
24	480, 310	380, 320	290, 290	200, 220
28	450, 260	350, 240	220, 200	110, 110

Table 1: Payoff table for owners

	16	20	24	28
16	58, 58	50, 64	40, 62	33, 58
20	64, 50	52, 52	42, 50	31, 46
24	62, 40	50, 42	37, 37	26, 29
28	58, 33	46, 31	29, 26	15, 15

	16	20	24	28
16	49, 49	41, 61	31, 65	24, 67
20	61, 41	49, 49	39, 53	28, 55
24	65, 31	53, 39	40, 40	29, 38
28	67, 24	55, 28	38, 29	24, 24

Table 2: Payoff table for managers given Contract A/Contract A (left) and given Contract B/Contract B (right)

	16	20	24	28
16	58, 49	50, 61	40, 65	33, 67
20	64, 41	52, 49	42, 53	31, 55
24	62, 31	50, 39	37, 40	26, 38
28	58, 24	46, 28	29, 29	15, 24

Table 3: Payoff table for managers given Contract A/Contract B

Subjects remained acting either as an owner or a manager for the entire course of the experiment. Also the owner–manager couples remained fixed over all periods.

The market lasted for 15 "years." At the beginning of each year, owners had to choose the contract for their managers. The contract decisions were made public to all four participants afterwards. Then managers had to choose outputs. In two treatments, each year consisted of four "quarters" and the managers had to make their choice in every quarter. Our motivation for the introduction of quarters was that subjects might need some time for learning within a certain subgame. To control for the effect of this design feature, there was a third treatment in which there were no quarters and managers had to decide only once in each year.

Our three treatments differed with respect to the form of interaction between firms. The above theory is of static nature. In the field, interaction in duopoly is in general repeated. Our first treatment, called FixFour, has fixed duopoly pairs playing over the 15 years consisting of four quarters each. In the second treatment, RandFour, duopolies were assembled randomly in every year, but managers interacted repeatedly over the four quarters of a year. Finally, in treatment RandOne, there was random matching and only a single course of manager interaction.[6]

For all treatments, we conducted three sessions with eight subjects participating in each session. In treatments with random matching, all eight participants interacted; with fixed matching, two groups of four subjects interacted but subjects could not tell with whom they were matched. Table 4 summarizes our treatments and the treatment variables.

Exchange rates were such that, in treatments FixFour and RandFour , owners got one Deutsche mark for every 600 "points" and managers got one Deutsche mark for every 80 "points." In treatment RandOne, this was changed to 300 and 40 points for owners and managers, respectively. Average earnings in treatments FixFour and RandFour (which lasted for about 90 minutes) were DM 37.67 and in treatment RandOne (which lasted for about 50 minutes) DM 16.50.

The experiments were conducted in the computer lab of Humboldt University. In

[6]Originally, we expected theory to perform well in treatment RandFour. When it turned out that this was not the case, we introduced the additional treatment RandOne, designed to give theory its best shot. However, the RandOne treatment only confirmed the robustness of our earlier results.

	FixFour	RandFour	RandOne
Owner interaction over years	fixed	random	random
Manager interaction over quarters	fixed	fixed	—
Number of subjects participating	24 (= 6 × 4)	24 (= 3 × 8)	24 (= 3 × 8)

Table 4: The treatments

total, 72 students, mainly of the department of business administration and economics, participated. For the computerized experiment we used the software tool kit *z-Tree*, developed by Fischbacher (1999). Translated instructions are provided in Appendix A.

3 Experimental Results

We will first present the contract choices of owners. Afterwards, we will analyze quantity choices of managers. Together with an analysis of ex–post realized payoffs for firm owners, this will yield an overall interpretation of the results.

Choice of contracts (1st stage). Recall that theory predicts firm owners to choose the contract that induces managers to care not only for firm profits but also for sales. That is, theoretically we would expect owners to choose Contract B, or at least learn to do so over time. Contrary to this prediction, we observe that in all three treatments the equilibrium Contract B is only rarely chosen. Out of 180 cases each, the number of Contract–B choices is 32 (17.8%), 29 (16.1%) and 48 (26.7%) in treatments FixFour, RandFour and RandOne, respectively. The data clearly do not support the theory. A binomial test even rejects the hypothesis that contracts are chosen equiprobably, that is, the hypothesis that Contract B is chosen with a probability of $p = 0.5$ is rejected.[7]

[7] We conducted two tests. For the first, we counted each contract choice as one observation. This test rejects the hypothesis at the 1% level. Since observations for individual owners might not be independent, we conducted a second test, in which we counted each owner as one observation: A dummy variable was 0 or 1 depending on whether the owner had a majority of A or B contracts. Using these data we can reject the hypothesis at the 5% level.

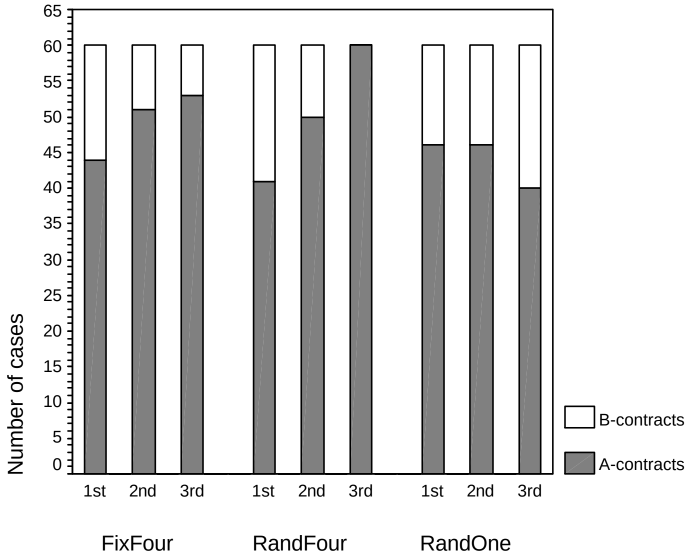

Figure 1: Number of contract choices in each third of the experiment (1st third: rounds 1-5; 2nd third: rounds 6-10; 3rd third: rounds 11-15)

Figure 1 shows for each treatment and for each third of the experiment the absolute frequencies of Contract–A and Contract–B choices.[8] A detailed analysis of the data shows that the frequency of Contract B choices significantly *decreases* in treatments FixFour and RandFour while the increase in treatment RandOne is not significant.[9]

With regard to the absolute frequency of Contract–B choices across treatments, we observe hardly any difference between treatments FixFour and RandFour (32 versus 29 out of 180 Contract–B choices). The difference between these two treatments and treatment RandOne (48) is somewhat larger. However, a statistical test based on the number of Contract–B choices as observed on the individual level over the whole experiment indicates that this difference is also insignificant.[10]

[8]See Table 7 in Appendix C for the corresponding values for each round separately.

[9]The correlation coefficients between the number of contract–B choices and time are $-.648$ at $p = .009$ for FixFour, $-.821$ at $p = .000$ for RandFour, and .430 at $p = .109$ for RandOne.

[10]For a test statistic, we determined the number of contract–B choices (a number between 0 and 15) for each firm owner separately. This generates 12 numbers for each treatment. Applying a two–tailed Mann–Whitney U test we get the following p-levels: $p = .887$ (FixFour vs. RandFour), $p = .266$

Subgame	THEORY	FIXFOUR	RANDFOUR	RANDONE
A/A	40	37.3 (3.6, $N = 62$)	37.0 (3.8, $N = 67$)	42.2 (6.2, $N = 45$)
A/B	44	47.3 (4.1, $N = 24$)	45.5 (4.8, $N = 17$)	46.9 (4.4, $N = 42$)
A/B (ind. quant.)	16 / 28	23.0 / 24.3 (2.3 / 2.8)	21.5 / 23.9 (2.4 / 3.0)	20.6 / 26.3 (3.7 / 2.7)
B/B	48	49.2 (2.4, $N = 4$)	48.2 (6.2, $N = 6$)	50.7 (2.3, $N = 3$)

Table 5: Average observed industry output in subgames (standard deviation and number of observations in parentheses)

Choice of quantities (2nd stage). Since firm owners could choose two different contracts, there are four different subgames that managers can play. Recall that the subgame–perfect equilibrium prescribes both managers to choose a quantity of 20 (24) in case both firm owners chose Contract A (B). If firm owners choose different contracts, the manager who has Contract A (B) chooses a quantity of 16 (28). Table 5 shows for each subgame both the theoretically predicted and the observed average industry output for all treatments. For the asymmetric subgames with different contracts, Table 5 also shows average individual quantities. Due to the behavior in the first stage, the majority of observations is made after both owners choose Contract A.

Inspecting Table 5 we observe that theory predicts average industry output quite well. Consider first symmetric subgames: In subgame A/A, FIXFOUR and RANDFOUR are somewhat collusive, while RANDONE is slightly more competitive than predicted. In subgame B/B, average industry output is in all treatments larger than predicted,

(FIXFOUR vs. RANDONE), and $p = .319$ (RANDFOUR vs. RANDONE).

but the predicted output is still within one standard deviation of the actual mean (note that we only have a few observations here).

The difference between RandFour and RandOne is explained by cooperation of the managers over the quarters: In treatment RandFour average industry output over the first three quarters is 38.5 while it is significantly larger (42.0) in the last quarter (across all subgames). In treatment FixFour there is no significant "end-quarter" effect.[11]

Concerning individual quantities in asymmetric subgames (A/B), theory does not predict well. In these cases, the manager with Contract B should choose a quantity of 28 while the manager with Contract A should theoretically choose a quantity of 16. Inspecting Table 5, we notice that the observed average quantity chosen by the manager with Contract B is lower than predicted, and the one chosen by the manager with Contract A is much higher than predicted. Thus, the pseudo–Stackelberg leaders with Contract B do not fully exploit their (theoretical) advantage while the pseudo–Stackelberg followers with Contract A do not adapt to the theoretically anticipated output of their competitors.

Overall interpretation. Of course, the behavior of managers in the subgames has a strong impact on the owners' game. Assuming subgame-perfect behavior by managers, the (truncated) owners' game is the 2×2 matrix game as shown in the upper-left corner of Table 6. The other matrices shown in this Table are the (truncated) owners' games given the empirical behavior of managers in the three different treatments.[12]

Note that in theory the (truncated) owner game is a prisoners' dilemma with Contract B being the dominant strategy. But, due to the observed behavior of managers in the experiment, entirely different payoff matrices emerge for owners: Given actual quantity choices in the subgames, Contract A becomes the dominant strategy in all treatments. The dilemma structure of the owner game disappears when managers'

[11]Significance levels of a two–tailed paired–sample T test were $p = .000$ for treatment RandFour and $p = .117$ for treatment FixFour.

[12]To construct these matrices, we computed average earnings of owners resulting from play in the subgames. Consider, for example, treatment FixFour when one owner chooses Contract A and the other Contract B. On average across all A/B outcomes, the owners received 272 and 293 points (rounded), respectively.

actual behavior is taken into account.[13]

As it is evident from Figure 1, owners start with a high proportion of contract A choices. It turns out that deviating from A/A does not pay since managers with Contract A punish managers with the "aggressive" Contract B.[14] Such punishments which violate the standard economic assumption of pure self–interest are frequently observed in experiments. Recently, Fehr and Schmidt (1999) and Bolton and Ockenfels (2000) have argued that such violations stem from an aversion against disadvantageous inequality. If individual utility depends not only on own material well being but also on the distribution of payoffs, the manager behavior can be rationalized.[15]

This, however, raises the question whether one would observe the same failure of theory in asymmetric markets where inequality is unavoidable due to different cost conditions. Possibly, a design with asymmetric firms could provide more favorable conditions for the theory of strategic delegation to prove successful.[16]

4 Conclusion

In this paper, we have investigated strategic delegation in a homogenous–goods duopoly experiment according to the models of Fershtman and Judd (1987), Sklivas (1987), and Vickers (1985) (FJSV). While the theoretical literature has pointed out that the FJSV prediction depends on intricate details of the model (the mode of competition, the observability of contracts, uncertainty, risk aversion, etc.), our results show that there is a weak point inherent even in the standard FJSV model. The prediction depends on subgame–perfect behavior of managers. In our experiment, managers did

[13]Note that the non–equilibrium contract, A, is in all treatments chosen with a relative frequency of more than 50% in almost all rounds. (The only exception is round 3 of treatment RandFour. See Appendix C.) Compared to standard 2×2 prisoners' dilemma experiments (see e.g. Cooper et al., 1996), we observe that owners in our experiment choose the cooperative strategy much more frequently.

[14]In Huck, Müller and Normann (1999) we analyze an experimental Stackelberg duopoly. There, empirically observed reaction functions of the Stackelberg followers were sometimes upward sloping.

[15]Inequality aversion cannot explain why managers behave more competitively than the standard theory predicts in the symmetric B/B subgames. However, note again that there are only very few obervations in which both owners choose Contract B.

[16]This argument has been suggested by Chaim Fershtman and we believe that it merits a fully blown follow-up study.

Theory

	A	B
A	400, 400	260, 450
B	450, 260	290, 290

FixFour

	A	B
A	416, 416	272, 293
B	293, 272	253, 253

RandFour

	A	B
A	414, 414	295, 332
B	332, 295	265, 265

RandOne

	A	B
A	358, 358	259, 343
B	343, 259	238, 238

Table 6: The theoretical and the empirical reduced owner games

not play the subgame–perfect quantities in subgames with asymmetric contracts. As a consequence, owners did not choose the equilibrium contract. Instead, they chose the contract which gave managers profit–maximizing incentives. In symmetric experimental duopoly markets, the theory of strategic delegation fails.

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A Translated Instructions

Welcome to our experiment!

Please read these instructions carefully. Do not talk to your neighbors, and stay quiet during the course of the experiment. Raise your hand in case you have any questions. We will come to your boot and answer the questions privately.

In this experiment you will have to make decisions repeatedly. Through these decisions you can earn money. How much you earn depends on your decisions and on the decisions of other participants. All participants receive the same instructions.

You will stay anonymous for us and for the other randomly chosen participants you get in touch with during the experiment.

You are in a market with two firms. Each firm has an owner and a manager.

[In treatment FixFour and RandFour:] The experiment runs over 15 rounds ("years"), each consisting of four periods ("quarters"). At the beginning of each year, the owners of the two firms decide on how to pay their managers. (The managers cannot reject their contract.) For each owner, there are two variants for the contract, contract A and contract B. These contracts are fixed for the entire year (4 quarters). At the beginning of the first quarter of the year, every participant (i.e., both managers and both owners) are informed about what contracts were chosen.

[In treatment RandOne:] The experiment runs over 15 rounds ("years"). At the beginning of each year, the owners of the two firms decide on how to pay their managers. (The managers cannot reject their contract.) For each owner, there are two variants for the contract, contract A and contract B. At the beginning of the year, every participant (i.e., both managers and both owners) are informed about what contracts were chosen.

Knowing their contracts, the managers decide on the quantity of the good they want to produce and sell. There are four possible quantities: 1, 2, 3 and 4. Dependent on the chosen quantity, owners get their profits and managers their payments according to their contracts.

All necessary information is included in 5 tables in the appendix.

The four payment tables for the managers result from the chosen contract, i.e. there is one table for the case that both owners choose contract A, one for the case that both choose B, one for the case that one owner chooses A and the other B, and finally one for the reverse case.

The payment tables for a **manager** have the following form: The beginning of each line shows his quantity decision (1, 2, 3, and 4), the head of each column shows the decision of the other manager. There are four possible quantities, so there are 16 different combinations, i.e. cells, in the table. Each of these cells contains two numbers. In the upper left corner, you will find your own payment according to the market result, the lower right corner gives the payment of the other manager.

The profit table of the **owners** are built the same way: The gain of the owners depends only on the decisions of the managers. The decision on the contract does not directly influence the gains of the owners.

[In treatment FixFour and RandFour:] Your earnings at the end of the experiment result from the cumulated payments/gains of the "15 years" or "60 quarters". The managers' payments and the owners' gains are summed up. For the payment in DM the exchange rate is for the managers 80 points = 1 DM, for the owners 600 points = 1DM.

[In treatment RandOne.] Your earnings at the end of the experiment result from the cumulated payments/gains of the "15 years". The managers' payments and the owners' gains are summed up. For the payment in DM the exchange rate is for the managers 40 points = 1DM, for the owners 300 points = 1 DM.

Consider once again the detailed course of the experiment. At the beginning of the first round, both owners have to decide on the contract for their managers. After that, all participants in the market are informed about the two decisions. [In treatment FixFour and RandFour:] Now, both managers (knowing their contract and the according payment table) have to decide upon their first quantity. [In treatment RandOne:] Now, both managers (knowing their contract and the according payment table) have to decide upon their quantity.

After that, again all participants are informed about the decisions, and everyone is told his/her payment resulting from these decisions. In the following, the managers have to decide again on the next amounts, and only after the forth quarter the owners can decide again about the contracts of their managers for the following "year". Now the second round ("year") starts. The following rounds proceed accordingly. Each participant keeps his/her role, and each manager stays with the same owner. [In treatment FixFour:] Also, the composition of the market, consisting of two owners and two managers, stays the same. [In treatment RandFour and RandOne:] The composition of the market, consisting of two owners and two managers, changes randomly in each of the 15 years [In treatment RandFour:] (but not in the quarters).

B How the payoff tables were derived

Deriving the payoff tables we had to face a number of conceptual problems. In theory, only managers' relative incentives (g_i) are important while absolute payments to managers are fixed and, therefore, do not affect equilibrium outcomes. The reason for this is that, assuming a competitive labor market for managers, managers will simply receive their reservation wage. Given standard rationality assumptions, firm owners and managers can rely on the equilibrium prediction and contracts can be adjusted accordingly—regardless of the relative incentives they provide. In an experiment this does not work as the equilibrium prediction may be violated. Hence, firm owners' payments to managers would become variable. And this, in turn, would change the equilibrium prediction. In order to reconcile the experiment with the FJSV theory, we decided to let owners' profits to be *independent* of the payments to managers. In other words, as in theory, owners' profits do not directly depend on the contracts they give to their managers, but only on the (induced) quantities the managers choose. For a particular combination of outputs, managers' salaries may differ depending on their contracts, while owners' profits are the same.[17]

The second problem is that Cournot games in matrix form exhibit multiple equilibria (Holt, 1985). In order to get unique best replies and to make the numbers more easily accessible for subjects, we slightly manipulated owners' payoffs which, in principle,

[17] In case a subject asked why owners get equal profits though managers' salaries differ, we were prepared to explain that managers' salaries were only a very small fraction of the firms' profit, not affecting the profits written down in the payoff matrix. No subject ever asked such a question.

were derived from $\Pi_i = \max\{60 - q_1 - q_2,\ 0\}\, q_i$, with $q_1, q_2 \in \{16, 20, 24, 28\}$. More specifically, we first rounded all entries to a multiple of 10, and then $2 \times 4 = 8$ entries of Table 1 were changed to lower or higher multiples of ten to get unique best replies.

Now turn to the managers' payoff tables. The matrix shown in Table 2 (left) is simply derived by multiplying (non-rounded) owner profits with 0.13 and then rounding the resulting values to integers.

If owners choose the contract with bonus, Contract B, another problem arises. If managers simply got the above share of profits plus a payment for sales, payments under the equilibrium contract would be always higher. Since owners' profits are independent of managers' salaries, owners might simply choose an equilibrium contract because their managers earn more. For this reason, we implicitly introduced a negative fixed payment as part of Contract B. This negative fixed payment was such that average payments with Contract B were just as high as with Contract A. Comparing the two payoff matrices in Table 2, the reader will realize that, when quantities 16 and 20 are chosen, payments are *c.p.* lower with Contract B, and, when quantities 24 and 28 are chosen, payments are *c.p.* higher with Contract B. That is, when $q_i \in \{16, 20\}$ there is actually a malus for too few sales, and when $q_i \in \{24, 28\}$ there is a bonus for larger sales. The functional form for the bonus is $(12q_i - 264) \times 0.13$, $q_i \in \{16, 20, 24, 28\}$. This explains how the matrices in Table 2 (right) and in Table 3 were derived.

C Further Data

Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
FixFour	8	9	9	10	8	10	11	11	9	10	11	11	10	10	11
RandFour	9	8	5	9	10	9	10	11	10	10	12	12	12	12	12
RandOne	11	9	9	7	10	11	9	7	10	9	9	7	7	9	8

Table 7: Number of contract–A choices across years (max.: 12)