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Discussion paper / Universität Erfurt, Staatswissenschaftliche Fakultät, No. 2006,001E

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Suggested citation: Gächter, Simon; Königstein, Manfred (2006) : Design a contract! : A simple principal-agent problem as a classroom experiment, Discussion paper / Universität Erfurt, Staatswissenschaftliche Fakultät, No. 2006,001E, http://hdl.handle.net/10419/23944

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Für den Inhalt des Diskussionspapiers sind die jeweiligen Autoren/innen allein verantwortlich.

ISSN 1610-9198 (Print)

ISSN 1610-918X (Internet)

Design a Contract! A Simple Principal-Agent Problem as a Classroom Experiment[§]

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15 March 2006

Abstract:

We present a simple classroom principal-agent experiment that can effectively be used as a teaching device to introduce important concepts of organizational economics and contracting. In a first part, students take the role of a principal and design a contract that consists of a fixed payment and an incentive component. In the second part, students take the role of agents and decide on an effort level. The experiment can be used to introduce students to the concepts of efficiency, incentive compatibility, outside options and participation constraints, the Coase theorem, and fairness and reciprocity in contracting.

JEL-Codes: A22, C92,

Keywords: Classroom experiments; post-contractual opportunism; incentive contracts; efficiency; reciprocity; Coase theorem.

[§] This paper is part of the EU-TMR research project ENDEAR (FMRX -CT98-0238). We are grateful to Christian Thöni for programming the software for the computerized version of this experiment.

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1. Introduction

The principal-agent framework is arguably the most important common paradigm in courses on organizational economics, personnel economics, and contract theory taught in economics departments and business schools. This is documented, e.g., in the textbooks by Milgrom and Roberts (1992), Lazear (1998), Baron and Kreps (1999) and Brickley, Smith and Zimmerman (2001) which appear on many syllabi of organizational economics courses. They all devote considerable space to the issue of contracting and the principal-agent paradigm. In the preface to their textbook Brickley et al. (2001) note: "A quiet revolution is occurring within business schools. (…) Armed with powerful theories and access to unprecedented data, we now have a rich set of managerial insights to teach about the workings of organizations and markets." One of these insights is certainly that work incentives are an important management issue and that the principal-agent framework is very useful for discussing these issues.

In this paper we present a simple classroom experiment on a two-person principal agent game that we have found very effective in introducing and illustrating the principal-agent framework and other important concepts of organizational economics and contracting.[1] First, the students take the role of a principal who may design a contract that is offered to an agent. Second, the students take the role of an agent who receives a contract and decides upon individual effort.

To motivate the principal's problem the students are asked to imagine being the "owner" of a company who lacks the expertise to run it him- or herself. Therefore an "expert" needs to be hired. The offered contract can specify two instruments of payment: A *fixed payment* or a *return share* or both. The fixed payment can be either positive or negative (it has to be between +700 and –700). If the fixed payment is positive, this is tantamount to a salary for the expert. If the fixed payment is negative, this is tantamount to a payment of the expert to the owner. The return share may be set between 0 and 100 percent (in multiples of 10 percent). It specifies the share of the return which the expert can pocket for him- or herself. For instance, if the return share is 100 percent, the expert will receive all of the return. Thus, contract design allows for a variety of contracts including pure fixed wage contracts and high powered incentive contracts.

[1] For those who want to conduct this experiment in a computerized laboratory, we also provide a program (called "design_a_contract.ztt") that runs under the experimental software z-Tree (Fischbacher 1999). z-Tree is a popular and easy to use toolbox for economic experiments. z-Tree does not require any programming skills. It is freely available (see http://www.iew.unizh.ch/ztree/index.php). z-Tree has to be installed first before our program can be used. Details can be found in Fischbacher (1999). z-Tree runs under Windows NT, 2000, and XP (but not under Windows 98). The program "design_a_contract.ztt" is available from the authors upon request.

In the second part of the experiment, all students decide in the role of the expert. They first have to decide whether they accept or reject the contract they are confronted with (we explain below how this is done). If the contract is rejected, the expert earns an outside wage of 100 while the owner earns nothing. If the expert has decided to accept the contract, he or she has to choose a costly effort level which determines the company's return. The return is split between owner and expert according to the terms of the contract; the expert has to bear the cost of effort.

There are ten effort levels (from 1 to 10) and costs are increasing and convex in the effort level. Efficiency requires that the expert chooses the highest effort level but, under standard assumptions of rationality and selfishness, the expert will choose the lowest effort level. Thus, to induce an opportunistic expert to exert the highest effort level, the owner has to give the expert a sufficiently large share of the return. Specifically, in the subgame perfect solution, if the owner him- or herself is rational and selfish, he will offer a return share of 100 percent and ask for the whole generated surplus minus 100 (the expert's outside wage).[2]

This teaching experiment is very simple and easy to implement. The role change in the two parts of the experiment simplifies procedures considerably, because the instructor does not have to match principals and agents (who are idle until their principal has reached a decision). Moreover, the design allows gathering data from all students in both roles, which also often results in interesting behavioral patterns and subsequent discussions.

In addition to introducing students to the principal-agent framework this simple game allows conveying the following theoretically and practically important concepts: (i) post-contractual opportunism (ii) efficiency, (iii) incentive compatibility, (iv) outside options and the "participation constraint", (v) the Coase theorem and (vi) fairness and reciprocity in contracting. The game can also be used to illustrate important principles of optimal behavior (like determining the optimal effort level by using a "marginal cost equals marginal benefit" analysis), the concept of the disutility of effort and when we need incentives, the necessity and difficulty of anticipating the behavioral reactions to the terms set in a contract, and recent insights from behavioral economics research.

[2] With our parameters return shares of 80 to 100 percent induce efficiency. Offering 100 percent is the trembling-hand perfect solution. See Anderhub et al. (2002).

2. Procedures

The experiment consists of two parts. In the first part, *all* students act in the role of the principal. In the second part, which we do not announce beforehand, *all* students decide in the role of the agent. Class size does not matter much for this experiment. We ran the experiment with classes of 20 to 40 students.

The experiment does not need much preparation. The instructor only needs to copy (i) the *instructions*, (ii) the *contract design sheet* of the principal and (iii) the *effort decision sheet* of the agent. We found it useful to put the instructions on *one* piece of paper, and the contract design sheet and the effort decision sheet of the agent on two separate sheets of paper. It is also helpful to use different colors for the three sheets. Also prepare transparencies of the instructions[3] and a *results sheet* on a transparency that will be helpful after the experiment in communicating the results and stimulating the discussion. The reader will find a copy of all materials that we use in the appendix of this paper.

The experiment is implemented as follows. First, distribute the instructions to all students and ask them to read them carefully and silently. Students will need 5-7 minutes for this. Second, after students have read the instructions, summarize the rules of the game by using the prepared transparencies and the overhead projector. After you have summarized the rules, take questions. Third, ask the students to design their contracts now. It is, of course, important that students do not talk to each other and make their choices privately. Students will typically need 5-7 minutes for designing their contracts. Fourth, after students have designed their contracts, collect all sheets, and announce that now all sheets will be shuffled and redistributed. Explain that all students will now act in the role of the expert. After you have shuffled the decision sheets, distribute them along with the decision sheet of the agent. Before students take the decisions, summarize the rules for the agents with the help of a transparency. Emphasize that the agents have to insert the contract they have received into their decision sheets. Then students will need about 3-5 minutes to reach their decision. The whole experiment will need about 30 minutes, including distributing and recollecting decision sheets. Ask a student to assist you, if you have large classes.

[3] The instructions we use are written in Microsoft Word in font size 20 pt, and comprise three pages in the original format. This has the following two advantages: First, you can print the instructions on one piece of paper by using the option of printing four pages on one page. Second, you can also print the same set of instructions on transparencies, which are very helpful in summarizing the basic rules.

3. Classroom Discussion

After you have collected the agent's decision sheets, ask one or two students to list them on the prepared transparencies (see appendix). We found it useful to present the results in two ways. The first results sheet ("Offered contracts and effort levels") just lists the offered contracts and the chosen effort levels. The second results sheet ("Optimal effort choice?") summarizes the actual effort choices according to the best reply effort levels. These transparencies are very helpful in the formal part of the discussion (see below).

We always find it useful to kick off the discussion informally. That is, while your assistant prepares the results, ask the students for their opinion on this experiment. Usually students are happy to give their impressions. Then proceed to ask questions like: "How did you come up with a contract in the first part?" "What kind of considerations did you have in mind?" "In the second part, when you were an expert, how did you decide?" Most likely, this part of the discussion will reveal that the students quickly got the *rules*, but found it very tricky to think about an optimal contract design. Naturally, they find it easier to decide on the effort level than on the contract. By the time you have collected some statements, your assistant will be ready with the results and students will be very curious to learn about them. We first put up the results sheet with the offered contracts.

A typical result is that many principals ask for a return share of 50 percent and pay a positive fixed wage. About 10 to 20 percent of the contracts, usually, specify return shares larger than 80 percent, and very few contracts offer a fixed wage only. Thus, people recognize the necessity to set incentives by offering a return share. There are a few contracts that ask for a negative fixed payment (typically those that offered a return share of 100%). When students are asked why they did not stipulate a negative fixed wage, and offered only 50 percent as a return share, many arguments were reminiscent of the endowment effect (see Kahneman, Knetsch and Thaler 1991): They do not want to part ownership, because they feel entitled to ownership.

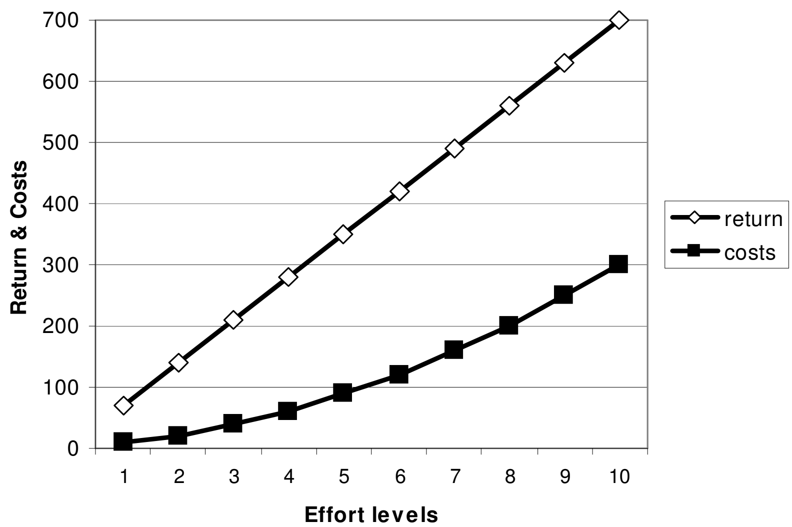
When students decide in the role of the expert (i.e., the agent), they often reject contracts (between 30 – 40 percent). Stated reasons for rejections often relate to the unfairness of the contract. The average effort level is usually between 5 and 6.

Putting up the results will satisfy the students' curiosity and further stimulate the discussion. Some of them will say that they did not think about the expert's likely effort level when they decided about the contract. Rather, they just thought about what in their opinion a reasonable contract looks like. Put differently, they did not think strategically. Others, however, thought about the expert's likely reaction and designed their contract accordingly. In the role of the expert they reject contracts they view as unfair and, if they accept the contract, they use a diversity of rules to decide on the effort level.

After this informal discussion that we always found to be quite lively, the ground is prepared for a more formal discussion. Students are eager to learn about the "correct" solution to this problem. A good starting point is putting up a graphical depiction of the return and cost schedule (Figure 1).

Figure 1 makes clear that the pie is largest at the effort level 10. The question is how to implement effort level 10. Before embarking on this question, it is useful to discuss the schedules first. While students quickly get the idea of an increasing return, some of them do not have an immediate intuition of the cost schedule being convex. It can be used to drive the idea home that incentive theory is about any productive activity that agents don't want to pursue *at the margin* (for instance, working long hours and thereby forgoing the opportunity to watch a movie or to spend the evening with one's spouse). If you have time, you can also use this to discuss theories of work motivation (working for money vs. job satisfaction and self-fulfillment, etc.).

Figure 1: *Returns and costs*



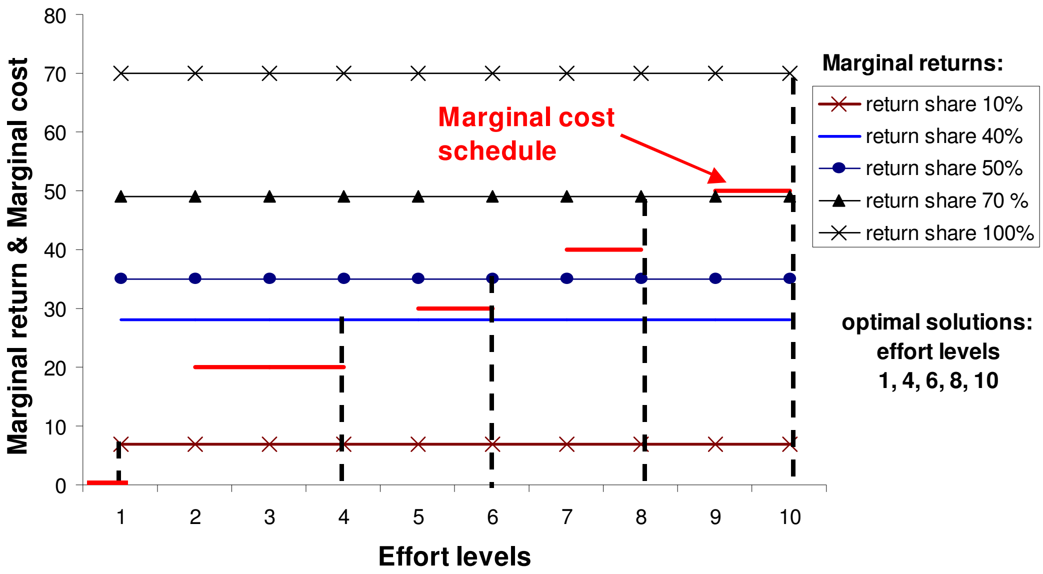
The next step in the discussion is the question how to achieve effort level 10. Before going into the derivation of the optimal result, it is useful to start with a discussion of incomplete contracts. If the principal could enforce a contract that stipulates a particular effort level, there would not be any need for an incentive contract. As Milgrom and Roberts (1992) put it (p. 127): "Motivation problems arise only because some plans cannot be described in a complete, enforceable contract."

The search for the optimal contract in this experiment starts with an argument on backward induction. The principal has to think about the agent's reaction to a contract. By assuming that the agent wants to maximize his or her monetary income, we can start with the analysis. Students usually remember the "marginal benefit equals marginal cost" principle of optimal choice. In this setup, the total marginal return from effort is constant and equals 70. The fixed payment is independent of the effort level and therefore does not influence the marginal benefit. The marginal benefit that belongs to the agent is determined by the return share. If the return share is zero, the marginal return for the agent is zero, but the marginal cost is always positive. Thus, an optimizing agent will always "shirk", i.e., work at the lowest effort level in this case. Incentives are needed to prevent this "post-contractual opportunism". The opposite case occurs when the return share is 100 percent. In this case the agent can pocket the whole return. A comparison of marginal cost and benefit quickly reveals that marginal cost are at most 50, but the marginal return is always 70. Thus, an agent who enjoys the full fruits of his or her labor has an incentive to work at the highest effort level. At this point students will probably realize that already a return share of 80 percent suffices to induce full effort of an optimizing agent.

Figure 2 conveys the logic of the "incentive compatibility constraint" for various return shares. The analysis reveals that only five effort levels can be optimal – levels 1, 4, 6, 8 and 10.[4] The main message of this argument is that economic theory predicts a positive correlation between return share and effort level.

[4] Effort level 1 is optimal for return shares 0, 10 and 20 percent; effort level 4 is optimal for return shares of 30 and 40 percent; effort level 6 is best for the return share of 50 percent; level 8 is a best response for the return shares of 60 and 70 percent; and return shares larger than 70 percent will induce the highest level.

Figure 2: *Deriving the solution*



A principal who understands the problem of post-contractual opportunism and the logic of the incentive compatibility constraint, will therefore offer a contract that gives the agent at least a return share of 80 percent. Since this return share induces an optimizing agent to provide the largest effort, the surplus will be maximized and amount to 400 (see Figure 1). Provided the agent is a money maximizer, the principal will therefore ask for a fixed payment of –299. The agent, who earns 100 if he or she rejects the contract, therefore enjoys a net earning of one money unit and will consequently accept the contract.

Of course, the data do not conform to this prediction. Agents, who receive a contract they view as unfair, are likely to reject it. The results are very similar as in the well-known ultimatum game.[5] Thus, you can drive home the point that the relevant "participation constraint" of the agent is not just his or her outside option, but what the agent is willing to accept.

The effort choices of accepted contracts conform by and large to economic theory. The correlation between return share and actual effort level is usually highly significantly positive. This message can be effectively conveyed by using the second results sheet ("Optimal effort choice?"). Students are usually quite impressed.

This theoretical discussion, combined with the results, can be very helpful to the students for getting the economic logic right. You can discuss the theoretical properties of fixed and variable payments, the importance of outside options, and the participation and incentive

[5] The survey papers by Camerer and Thaler (1995) and Güth (1995) summarize important results on the ultimatum game. See also Camerer (2003, Chap. 2) for a comprehensive treatment.

compatibility constraints. However, you can also discuss the relevance of fair sharing, and reciprocity in contracting. As in many other experiments we usually observe some students who reject unfair contracts or choose a suboptimal effort level for reciprocal reasons. Thus, if you have time, you can also briefly discuss recent advances in behavioral economics research that has documented the importance of fairness and reciprocity in principal-agent games and beyond.[6]

This experiment can also be used to discuss the economic concept of *efficiency*. Students easily see where the pie is maximized. They also understand that if the pie is not yet maximized there are arrangements where a least one party can be made better off, without making the other one worse off. From the concept of efficiency it is a small step to the "efficiency principle", "value maximization" and the "Coase theorem" as discussed, e.g., by Milgrom and Roberts (1992, Chap. 2). We therefore usually assign Chap. 2 in Milgrom and Roberts (1992) as compulsory reading and ask the students in a homework assignment to relate these concepts to the classroom experiment.

4. Further Reading

Ortmann and Colander (1997) also describe a principal-agent game used as a teaching device. Their game is a version of the prisoner's dilemma and can be used to illustrate the issue of moral hazard. Douglas (1997) proposes a simple analytical approach of teaching the principal-agent problem. Holt (1999) provides a general discussion of classroom experiments and a host of examples.

The experimental design of the present teaching experiment is inspired by research papers we were involved in (Anderhub, Gächter and Königstein 2002; Güth, Klose, Königstein and Schwalbach 1998; Königstein 2001). See Anderhub et al. (2002) for references to further principal-agent experiments. This paper can also be recommended to those students who want to learn more about this experiment.

The design of this classroom experiment is closest to Anderhub et al. (2002). The most important design differences are that in Anderhub et al. (2002) agents can choose among 21 effort levels and that the return shares are multiples of 1 percent. Moreover, the game is played repeatedly, in two sequences of six periods each. The results are that principals design work contracts that are incentive compatible and obey the participation constraint. Contracts are less

[6] Fehr and Gächter (2000) and Gächter and Fehr (2002) survey results on the economics of reciprocity and the relevance of fairness and reciprocity in various contracting situations. Camerer (2003) provides an extensive

unfair than predicted by standard arguments. Agents reject unfair contracts (similarly as in the ultimatum game) and respond to a very large degree optimally to the incentives set by the contract. Deviations from the optimal contract can be explained by reciprocity. In summary, the results typically observed in this classroom experiment are largely consistent with the observations in the underlying research experiment.

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Appendix: Instructions, decision sheets, and results sheet

Design a contract!

1. Imagine you are the owner of a firm but you lack the expertise to run your company properly. Therefore you decide to hire an expert.
2. Your task is to **design a contract** between you and the expert.
3. The expert can **accept or reject** your proposal. If the expert rejects the proposal, he will earn 100; you will earn nothing.
4. If the expert accepts the contract and is therefore willing to run your company, he/she chooses his/her **work effort**. For simplicity, we assume that there are **ten** work effort levels the expert can choose (1=expert works very little; 10=expert works very hard).
5. The work effort determines the **total return** that is generated as a result of the expert's work effort. The higher the expert's work effort the higher the total return, but also the cost the expert has to bear.

Your **contract** offer to the expert consists of two elements:

1. A **fixed payment,** which can be
   - *positive* (i.e., the expert gets a salary)
   - or *negative* (i.e., the expert has to pay this amount to you).
2. The **expert's return share,** in multiples of 10%, which states the share of the total return (in %) that belongs to the expert (the rest automatically goes to you).

Rules for contract offers to the expert:

For contract offers the following rules hold:

–700 ≤ *fixed payment* ≤ 700 (only integers!)

The *expert's return share*: between 0% and 100%
(0%, 10%, 20%,…,100%)

ALL combinations that obey these rules are feasible!

Payoffs if the expert *accepts* the contract:

The expert gets:

[*Expert's return share* in %]×(total return) + fixed payment – cost of the expert's work effort

The owner gets:

[100% – *Expert's return share* in %]×(total return) – fixed payment

Note: The expert's return share is a multiple of 10% (0% to 100%)
Example 1: Expert's return share = 0% ➔ the owner gets the whole return
Example 2: Expert's return share = 100% ➔ Expert gets the whole return
Example 3: Expert's return share = 50% ➔ Expert gets 50 %; the owner gets 50% of the total return

Payoffs if the expert *rejects* the contract:

The **expert** earns **100**
The **owner** earns 0.

The following table indicates the relationship between the expert's work effort and the generated total return from his or her work effort. The table also shows the costs of work effort the expert has to bear.

Work effort levels, total return from the expert's work effort and the expert's cost of the work effort:

Expert's work effort (1=lowest; 10=highest):	**Total return** from expert's effort: 70×(Work effort)	**Costs** of work effort for **expert**
1	70	0
2	140	20
3	210	40
4	280	60
5	350	90
6	420	120
7	490	160
8	560	200
9	630	250
10	700	300

Example:

You offer the following contract:

Fixed payment: +55
Expert's return share: 50%

The expert chooses effort level 3. The total return is therefore 210.

The expert earns: 50%×210 + 55 – 40 = 120.
You earn: 50%×210 – 55 = 50.

You can "simulate" payoff consequences of various contracts by using assumptions on the expert's work effort.

Contract design sheet for the principal

Design a contract!

I make the following contract proposal to the expert:

Fixed payment (between –700 and +700):	....
Expert's return share (in multiples of 10%, between 0% and 100%):	....

Effort decision sheet for the agent

Now you are an expert!

You have just received a contract offer! You now have to make two decisions.

1. Your first decision is to decide whether you *accept or reject* this contract.
2. If you accept the contract, you have to choose your *work effort*.

Please fill in the details of the contract proposal that you have just received from an owner:

The owner's proposed *fixed payment* for me:	....
The owner's proposed *return share* for me:	....

I accept this offer:

o No

o Yes

Only when "Yes":

I choose the work effort level (between 0 and 10): ....

First results sheet ("Offered contracts and effort levels")

no.	Fixed payment	return share %	accept (1="yes"; 0="no")	effort level
1				
2				
...				
total				

Second results sheet ("Optimal effort choice?")

Return share %	Payoff maximizing effort	Actual efforts	Average effort
0, 10, 20	1		
30, 40	4		
50	6		
60, 70	8		
80, 90, 100	10		