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Petra Nieken, University of Bonn
Patrick W Schmitz, University of Cologne and CEPR

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Centre for Economic Policy Research
77 Bastwick Street, London EC1V 3PZ, UK
Tel: (44 20) 7183 8801, Fax: (44 20) 7183 8820
Email: cepr@cepr.org, Website: www.cepr.org

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ABSTRACT

Repeated moral hazard and contracts with memory: A laboratory experiment *

This paper reports data from a laboratory experiment on two-period moral hazard problems. The findings corroborate the contract-theoretic insight that even though the periods are technologically unrelated, due to incentive considerations principals may prefer to offer contracts with memory.

JEL Classification: D82 and J33
Keywords: laboratory experiment, repeated moral hazard and sequential hidden actions

Petra Nieken
Department of Economics
University of Bonn
Adenaueralle 24-42
53113 Bonn
GERMANY

Email: petra.nieken@uni-bonn.de

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Patrick W Schmitz
Department of Economics
University of Cologne
Albertus-Magnus-Platz
50923 Köln
GERMANY

Email: patrick.schmitz@uni-koeln.de

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1 Introduction

This note presents a laboratory experiment that investigates the role of long-term contracts with and without memory in a repeated hidden action framework.[1] In a pioneering paper, Rogerson (1985) analyzed a two-period moral hazard problem and showed that in an optimal long-term contract, the second-period incentives depend on the first-period outcome (i.e., the contract exhibits memory), even though the periods are technologically independent.

While Rogerson's result was driven by the consumption-smoothing motive of agents,[2] similar findings can also be obtained in frameworks in which this motive is absent, so that memory in the optimal long-term contract is due to incentive considerations only. Specifically, consider the following problem.

There are two players, a principal and an agent. In period $i \in \{1, 2\}$, the agent chooses an unobservable effort level $e_i \in \{0, 20\}$. If the agent chooses $e_i = 20$, then the outcome of period i will be a success. If the agent shirks (i.e., chooses $e_i = 0$), then the outcome of period i will be either a success or a failure, each with probability $1/2$. In case of a success, the principal's return in period i is given by 70, otherwise it is zero.

outcome period 1	outcome period 2	wage scheme A $z_A \in \{25, 30, 35, 40\}$	wage scheme B $z_B \in \{50, 60, 70, 80\}$
failure	failure	0	0
success	failure	z_A	0
failure	success	z_A	0
success	success	$2z_A$	z_B

Table 1. The principal can choose one of the four type-A wage schemes (contracts without memory) or one of the four type-B wage schemes (contracts with memory).

[1] For surveys on the theory of repeated moral hazard, see Chiappori et al. (1994), Laffont and Martimort (2002, ch. 8), and Bolton and Dewatripont (2005, ch. 10).

[2] Cf. Malcomson and Spinnewyn (1988), Fudenberg, Holmström, and Milgrom (1990), and Rey and Salanié (1990).

Before the first period starts, the principal chooses one of the eight wage schemes shown in Table 1. There are two different types of wage schemes. According to a type-A wage scheme, the agent gets a payment z_A in each period in which there is a success and zero otherwise. Hence, type-A wage schemes are contracts without memory. In contrast, in a type-B wage scheme, the agent gets a payment z_B if and only if both periods were successful, otherwise the payment is zero. Thus, type-B wage schemes are contracts with memory.

The contract-theoretic analysis under standard assumptions (i.e., common knowledge of rationality, self-interested and risk-neutral preferences) is as follows. If the principal chooses a type-A wage scheme, the agent will exert high effort in period i whenever $z_A - 20 \geq z_A/2$. Hence, the agent is willing to choose high effort whenever the principal has set $z_A \geq 40$, otherwise the agent will shirk.[3] The best admissible type-A contract for the principal is thus $z_A = 40$, leading to the profit $140 - 80 = 60$.[4] Now consider a type-B wage scheme. The agent will shirk in the second period if the first period was a failure. Yet, if the first period was a success, the agent chooses high second-period effort whenever $z_B - 20 \geq z_B/2$, which is the case for all admissible values of z_B. The agent thus chooses high effort in the first period whenever $z_B - 40 \geq (z_B - 20)/2$. Thus, the agent is willing to exert high effort in the first period if and only if the principal has set $z_B \geq 60$, otherwise the agent will shirk in the first period. The best type-B contract for the principal is $z_B = 60$, leading to the profit $140 - 60 = 80$.[5] Overall, the principal clearly prefers to offer the optimal contract with memory, $z_B = 60$.

[3] In contract theory it is usually assumed that an agent exerts high effort when the incentive compatibility constraint holds with equality. Note that if in the present context the agent were slightly risk averse, he would unambiguously prefer high effort when $z_A = 40$.

[4] If the principal implemented low effort, she would set $z_A = 25$ and her expected profit would be 45 only (note that she would prefer to implement low effort and make the expected profit 70 if a zero bonus were admissible).

[5] Indeed, if the principal implemented low effort in the first stage by setting $z_B = 50$, her expected profit would be $(140 - 50)/2 + 70/4 = 62.5$ only.

Guided by the analysis, our predictions are that (i) principals should prefer type-B wage schemes and (ii) make the largest profit when $z_B = 60$. Moreover, (iii) given type-A contracts, agents should exert considerably more effort (in both periods) when $z_A = 40$ than when z_A is smaller. Finally, given type-B contracts, (iv) agents should exert considerably less first-period effort when $z_B = 50$ than when z_B is larger, and (v) they should exert much more second-period effort following a first-period success than following a first-period failure.

Our example captures the main features of the more general framework investigated by Ohlendorf and Schmitz (2008). In particular, also when effort is a continuous variable, renegotiation cannot be ruled out, and the only restriction put on the admissible contract space is limited liability (cf. Innes, 1990; Pitchford, 1998), the principal's optimal contract typically exhibits memory,[6] despite the fact that the periods are technologically unrelated.[7]

2 Experimental design and results

We have tested the contract-theoretic predictions in an experiment which was conducted at the Cologne Laboratory of Economic Research.[8] At the beginning of the experiment, the subjects were randomly assigned to the roles of principals (employers) and agents (employees). Each principal was randomly and anonymously matched with one agent. We implemented a one-shot design to prevent reputation effects and to ensure a large number of independent observations. Altogether 358 students of the University of Cologne participated in the 12 sessions of the experiment. Each session took about 45 minutes. At

[6] In the present example, note that the optimal contract ($z_B = 60$) is renegotiation-proof. After a first-period success the agent would not accept a wage cut, while after a first-period failure, the principal would not be willing to implement high effort.

[7] See Schmitz (2005) for the case in which the periods are technologically related.

[8] We used the online recruitment system by Greiner (2004) for the recruitment of the players. The experiment was programmed using the experimental software z-tree by Fischbacher (2007).

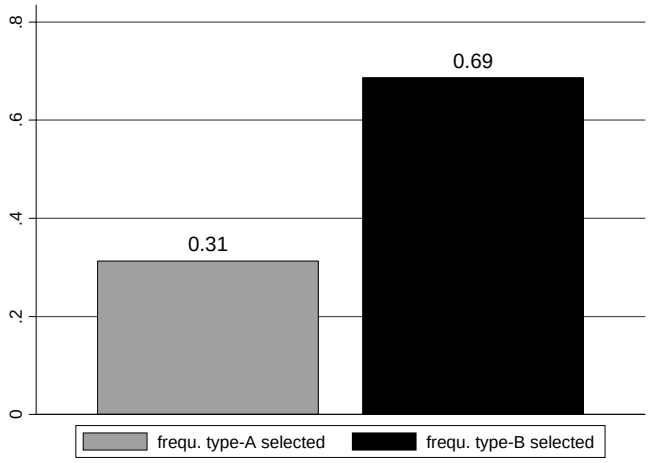

Figure 1. Fraction of principals who selected type-A or type-B wage schemes.

the end of the experiment the subjects answered a questionnaire containing open questions where they could explain their decisions as well as questions regarding risk attitudes and demographic details.[9] We used the fictitious currency "taler," which were later converted into euro. On average, the subjects earned 9.15 euro.

wage scheme		absolute frequency	relative frequency	average profit
A	25	15	8.38	51.00
A	30	12	6.70	56.67
A	35	16	8.94	37.19
A	40	13	7.26	46.15
B	50	36	20.11	65.56
B	60	22	12.29	71.82
B	70	40	22.35	68.25
B	80	25	13.97	56.40

Table 2. Principal's choice of a wage scheme and the average profit of the principal.

[9] We measured risk attitudes with the ten paired lottery-choice decisions from Holt and Laury (2002).

Figure 1 shows the behavior of the principals. 31% of the principals chose type-A wage schemes, while 69% chose type-B wage schemes. The choices were significantly different from a random selection ($p = 0.000$, two-sided binomial test). Hence, the data of our experiment support prediction (i), stating that principals would select type-B rather than type-A schemes. However, as can be seen in Table 2, only 12.29% of the principals preferred $z_B = 60$, which is the optimal contract in theory. The majority selected $z_B = 70$. At the end of the experiment, the players could explain their decisions. Many of the principals claimed that offering half of the return of two successful periods constitutes a "fair" offer.

The average profit of the principal was highest with 71.82 taler for $z_B = 60$. The differences between the profits given $z_B = 60$ and the profits given alternative wage schemes were statistically significant for five of the seven alternatives ($p = 0.054$ for a comparison of $z_B = 60$ with $z_A = 30$, and $p = 0.000$ for comparisons of $z_B = 60$ with $z_A = 35, z_A = 40, z_B = 70$, or $z_B = 80$, according to two-sided Mann-Whitney U tests). The finding that principals made the largest profits if they selected $z_B = 60$ is in line with prediction (ii).

wage scheme		first-period effort		second-period effort			
				first period failure		first period success	
		average	obs.	average	obs.	average	obs.
A	25	1.33	15	2.50	8	0	7
A	30	3.33	12	0	5	2.85	7
A	35	3.75	16	8.57	7	2.22	9
A	40	9.23	13	0	3	14.00	10
B	50	5.56	36	1.25	16	11.00	20
B	60	14.55	22	0	4	15.56	18
B	70	19.00	40	10.00	2	16.84	38
B	80	16.80	25	0	3	18.18	22

Table 3. Average efforts of the agents for each period.

The reactions of the agents for given wage schemes are reported in Table 3 as well as in Figures 2 and 3. If the agent was confronted with a type-A wage scheme, chosen effort (pooled over both periods) was significantly higher when $z_A = 40$ than when z_A was smaller (the p-values are 0.001, 0.006, and 0.030 for a comparison of $z_A = 40$ with $z_A = 25$, $z_A = 30$, and $z_A = 35$, respectively, according to two-sided Fisher exact tests). Hence, our findings are in favor of prediction (iii).

Given a type-B wage scheme, the first-period effort level was significantly smaller for $z_B = 50$ than when z_B was larger ($p = 0.001$ for a comparison of $z_B = 50$ with $z_B = 60$, and $p = 0.000$ for a comparison of $z_B = 50$ with $z_B = 70$ or $z_B = 80$; two-sided Fisher exact tests). This is in line with prediction (iv).

As can be seen in Table 3 and Figure 3, the average effort exerted in type-B wage schemes depended on the outcome of the first period. Except for $z_B = 70$,[10] if the first period had been a success, the second-period effort was significantly higher than if the first period had been a failure ($p = 0.004$ for $z_B = 50$, $p = 0.010$ for $z_B = 60$, $p = 0.004$ for $z_B = 80$; two-sided Fisher exact tests). Probit regressions show that a success in the first period had a significant positive effect on second-period effort for type-B wage schemes, but no significant effect for type-A wage schemes.[11] Hence, the agents' second-period effort was sensitive towards the outcome of the first period given type-B wage schemes, which corroborates prediction (v).

[10] Note that we have only two observations for a failure in the first period if $z_B = 70$, where one agent selected $e_2 = 0$ and the other $e_2 = 20$.

[11] The results of the regressions can be found in Appendix A.

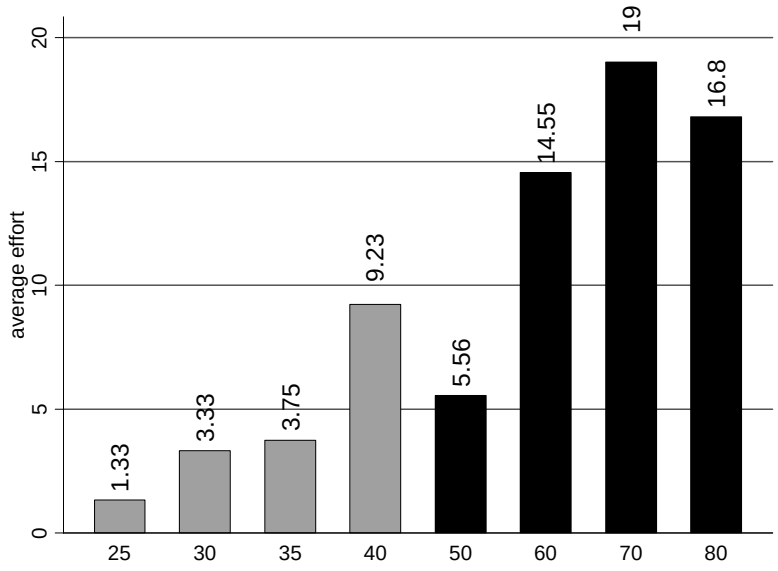

Figure 2. Average first-period effort for each wage scheme.

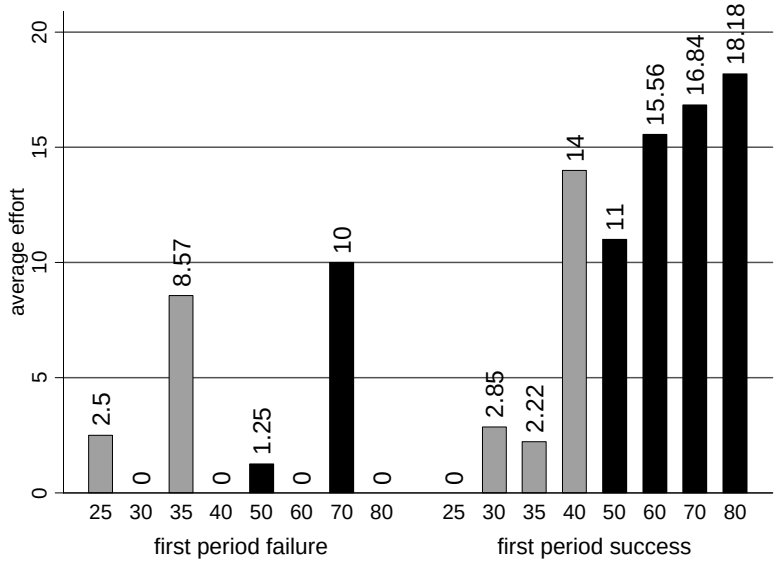

Figure 3. Average second-period effort for each wage scheme if the first period was a failure or a success.

3 Concluding remarks

We have found experimental support for the contract-theoretic insight that, due to incentive considerations, a principal can gain from offering long-term contracts exhibiting memory, even if the periods are technologically unrelated.

To our knowledge, Huck et al. (2010) is the only other experiment exploring the intertemporal allocation of wages. They test Lazear's (1979) theory of deferred compensation (i.e., wage profiles that are increasing over a worker's lifetime; cf. Lazear, 1981; Akerlof and Katz, 1989). While the models motivating the experiments are quite different,[12] Huck et al. (2010) also find that agents respond strongly to monetary incentives and provide support for Lazear's idea that deferred compensation can be used to elicit effort.[13]

Taken together, the findings of Huck et al. (2010) and the results reported in the present note suggest that more experimental work on the incentive effects of long-term contracts guided by contract-theoretic research might be very promising.

[12] In the deferred compensation model, the principal can always deduce effort from output (so that with full commitment the first-best solution could be implemented with a Maskin mechanism; see Maskin, 1999; Maskin and Sjöström, 2002). Moreover, the wage in a given period does not depend on the output of that period, but the agent is dismissed with a certain probability after a period in which she exerted low effort.

[13] Yet, in their experiment only a sizable minority of principals actually decided to make no payment for the first period; which might be due to the fact that the principals' task was quite complex, as they had to set three wages.

Appendix A

	type-A wage schemes		type-B wage schemes	
	(1)	(2)	(3)	(4)
first period success	0.0048	0.0029	0.0314***	0.0344***
	(0.0055)	(0.0061)	(0.0056)	(0.0068)
age		−0.0030		0.0207
		(0.1020)		(0.0341)
gender		−0.6130		0.4060
		(0.4860)		(0.2980)
dummy field of study		0.1790		−0.0645
		(0.5020)		(0.3320)
dummy participation		−0.4340		−0.3650
$6-10$ times		(0.5270)		(0.3700)
dummy participation		−0.3390		0.8170**
more than 10 times		(0.5570)		(0.3940)
# of safe choices (H&L)		0.1400		−0.0902
		(0.1210)		(0.0932)
constant	−0.9390***	−0.8780	−1.4050***	−1.9660**
	(0.3080)	(2.6110)	(0.3650)	(1.0010)
observations	56	50	123	113
(pseudo) R^2	0.0125	0.0650	0.2783	0.3611

Standard errors in parentheses.

***p < 0.01, **p < 0.05, *p < 0.1

Table 1. Probit regression with second-period effort as dependent variable (zero denoting $e_2 = 0$ and one denoting $e_2 = 20$). The dummy variable "field of study" is one if the subjects were enrolled in economics or business administration, otherwise it is zero. We measured risk aversion by implementing the ten paired lottery choice decisions from Holt and Laury (2002), the variable "# of safe choices (H&L)" indicating the number of safe choices

of a subject in this lottery. Additionally, we controlled for the number of times subjects have participated in laboratory experiments before (variables "participation"), with zero to five times as the reference category. For one session (16 subjects in the role of the agent) we have no information regarding demographics and risk attitude due to technical problems with the questionnaire.

Appendix B

B1. Instructions

You are participating in an experiment on economic decision-making. All decisions are anonymous, that means that none of the other participants learns the identity of someone having made a certain decision. The payoffs are also anonymous; none of the participants learns how much the others have earned. Please read these instructions carefully.

If you have any questions please look again at the instructions. If you still have questions please give us a signal by raising your hand.

Overview

In this experiment you and another participant who is chosen by a random generator are assigned to one group. Each group consists of an employer and an employee. At the beginning you are informed whether the role of the employer or the role of the employee has been assigned to you.

All of the payments occurring in the experiment are calculated in a fictitious currency called taler. Your payoff will be converted into euro at the end of the experiment. The exchange rate is 7 taler for one euro.

First, the employer chooses a wage scheme. After that, there are two periods. In each period the employee makes a decision that affects whether the group is in State X or Y. If the group is in State X, the employer receives a return of 70 taler from which he will make a previously fixed wage payment to the employee. If the group is in State Y, the employer receives zero taler and the employee does not receive any payment.

Choice of the wage scheme

The employer can choose between different wage schemes. If he chooses a wage scheme of type A, he pays z_A taler to the employee **in each period** in which State X is reached.

If the employer chooses a wage scheme of type B, he pays z_B taler to the employee once, provided that State X is reached **in both periods**.

The employer determines the amount of the payment Z for each wage scheme bindingly. He can choose from the following alternatives:

Alternative	**Wage scheme A**
	(Payment when reaching State X in the resp. period)
1	$z_A = 25$ taler
2	$z_A = 30$ taler
3	$z_A = 35$ taler
4	$z_A = 40$ taler
	Wage scheme B
	(Payment when reaching State X in both periods)
5	$z_B = 50$ taler
6	$z_B = 60$ taler
7	$z_B = 70$ taler
8	$z_B = 80$ taler

The employee is informed about the alternative the employer has chosen.

First period

In the first period the employee chooses between two strategies.

- If he chooses Strategy 1, State X or State Y occur with a probability of 50%, respectively. Choosing Strategy 1 does not impose any costs on the employee.

- If he chooses Strategy 2, State X emerges with a probability of 100%. Choosing Strategy 2 costs the employee 20 taler, which will be subtracted from his payoff.

After the employee has chosen his strategy the software determines (in case of Strategy 1 randomly) if State X or State Y is reached in this period. Both players are informed about the result.

Second period

In the second period the employee chooses again between Strategy 1 and Strategy 2:

- If he chooses Strategy 1, State X or State Y occur with a probability of 50%, respectively. Choosing Strategy 1 does not impose any costs on the employee.
- If he chooses Strategy 2, State X emerges with a probability of 100%. Choosing Strategy 2 costs the employee 20 taler, which will be subtracted from his payoff.

After the employee has chosen his strategy the software determines (in case of Strategy 1 randomly) if State X or State Y is reached in this period. Both players are informed about the result and about the total payoffs in the experiment.

Overview of possible results and payments:

Result		Employer	Employee	
Period 1	Period 2	Return	Wage scheme A	Wage scheme B
State Y	State Y	0	0	0
State X	State Y	70	z_A	0
State Y	State X	70	z_A	0
State X	State X	140	$2z_A$	z_B

Please note that the employer's payoff is calculated from the obtained returns minus the employee's wage. The employee's payoff is calculated from his wage minus the respective costs for choosing Strategy 2 if it was chosen. Additionally, you receive a show-up-fee of 3 euro.

Finally, we ask you to carefully answer a short questionnaire appearing on the screen at the end of the experiment.

When all players have finished this questionnaire they will receive their payoffs. Please stay seated at the end of the experiment until we call your cabin number.

Good luck!

B2. Quiz to check the understanding of the subjects before the experiment started

- What is the return of the employer at the end of one period if the group is in state X?
- What is the return of the employer at the end of one period if the group is in state Y?
- If the employer selects wage scheme A, the employee receives z_A if
  - State X has been reached in the respective period.
  - State X has been reached in both periods.
- If the employer selects wage scheme B, the employee receives z_B if
  - State X has been reached in the respective period.
  - State X has been reached in both periods.
- State X is reached with a probability of 50% if
  - Strategy 1 is chosen.
  - Strategy 2 is chosen.

- State X is reached with a probability of 100% if
  - Strategy 1 is chosen.
  - Strategy 2 is chosen.

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