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Incentive Effects of Funding Contracts: An Experiment *

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Abstract

We examine the incentive effects of funding contracts on entrepreneurial effort decisions and allocative efficiency. We experiment with four types of contracts (standard debt contract, outside equity, non-monotonic contract, full-subsidy contract) that differ in the structure of investor repayment and, therefore, in the incentives for entrepreneurial effort provision. Theoretically the replacement of a standard debt contract by a repayment-equivalent non-monotonic contract reduces effort distortions and increases efficiency. We test this non-monotonic-contracts hypothesis in the laboratory as well.

Our results reveal that the incentive effects of funding contracts need to be experienced before they reflect in observed behavior. With sufficient experience observed behavior is consistent with the theoretical predictions and supports the non-monotonic-contracts hypothesis: we find that the replacement of a standard debt contract by a repayment-neutral non-monotonic contract increases entrepreneurial income by 170% and total surplus by 30% in our setting.

Keywords: hidden information, funding contracts, incentives, experiment, standard debt contract, non-monotonic contract

JEL codes: C91, D82, G21

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1 Introduction

There are many real-life instances of individuals facing the opportunity of conducting a "project" that yields risky returns. Cases in point range from starting entrepreneurship to students aiming for a University degree. Typically project execution requires fixed setup costs that exceed the available funds of the project's owner-manager (henceforth entrepreneur) and are financed by outside investors, e.g. the market for loans, the market for equity, or government subsidy programs.

The specified terms of repayment to the investor form an integral element of outside financing and can differ considerably; e.g., 1) government agencies subsidizing unemployed workers to start entrepreneurship may require no repayment at all; 2) an entrepreneur may take out a loan requiring the repayment of either a constant amount or all of the available assets in case of bankruptcy; 3) student loan programs may ask students to repay less if more successful in their studies than their fellows; 4) all potential returns to entrepreneurship may be divided at a specified share between entrepreneur and investor.

Since the entrepreneur can improve the prospects of higher returns by exerting more effort, the division of yet uncertain returns between entrepreneur and investor that is fixed in the funding contract potentially affects the entrepreneur's effort choice. This raises the question of how the incentives inherent in funding contracts shape the entrepreneurial outcome. The purpose of this paper is to investigate experimentally how funding contracts influence entrepreneurial behavior and to inquire into their implications for allocative efficiency.

This setting of external finance with hidden effort and limited liability is analyzed theoretically in the seminal paper by Innes (1990). He shows that standard debt contracts induce inefficiently low effort, thus leading to substantial efficiency losses. In contrast, non-monotonic contracts can overcome this problem under a wide range of parameter choices. If designed accordingly, they can induce efficient effort choices. In our experiment we set out to test this non-monotonic-contracts hypothesis and compare behavior with a standard debt contract to that observed with a non-monotonic contract yielding the same expected repayment to the investor. To obtain a more complete picture of the incentive effects of funding contracts we also study behavioral responses to outside equity and no-repayment[1] contracts since these contracts are also frequently used in real life.

We find that the incentive effects of funding contracts are too subtle to be grasped by introspection alone. At the beginning of the experiment we find no differences in entrepreneurial behavior across contract conditions at all. This is of particular importance in the studied setting since many real-life entrepreneurs are similarly inexperienced when relying on external finance for the first, and possibly only, time. Nevertheless the differential theoretical predictions strongly attract behavior over the course of the experiment.

[1] For simplicity we refer to all cases where the entrepreneur can always keep the entire return to the project as cases with a no-repayment contract, even if no explicit repayment contract was written; for example, if the entrepreneurial project is fully subsidized or if entrepreneurs do not rely on external finance and self-finance their projects instead.

With accumulating experience behavior moves closer to the theoretical point predictions and the comparative statics predictions across funding contracts apply. With sufficient experience, behavior is consistent with the theoretical point predictions.

This paper contributes to the growing experimental literature on credit markets since, to the best of our knowledge, this is the first study that inquires into the incentive effects of funding contracts and investigates the non-monotonic-contracts hypothesis. An experimental study related to our setting is Serra-Garcia (2010) that explores the effects of collateral. She observes a positive relationship between collateral and entrepreneurial effort which, in contrast to standard theory, emerges only if the repayment to the investor is sufficiently low. Other experimental studies of credit markets include Brown and Zehnder (2007, 2010) investigating the effect of information dissemination of loan defaults on repayment behavior and Fehr and Zehnder (2006) studying the role of reputation in credit markets.

Our findings also complement the literature on moral hazard.[2] In this literature it is natural to model the principal-agent relationship such that the residual claimant owns the project (principal) and–to execute the project–requires someone else (agent) to provide an unobserved input (effort). Our setting, in contrast, allows us to explore the diametral case in which the residual claimant owning the project is the same contract party as that providing the unobservable input (effort). This assumption is natural in our setting since the entrepreneur owns the project and executes it. A second party (investor) is needed here since the execution of the project requires the provision of an indispensable input (external funding) that the entrepreneurs lacks.

The paper is organized as follows. Section 2 provides the theoretical foundation of our experimental research, section 3 summarizes the experimental design, section 4 reports our experimental results, and section 5 concludes.

2 Theoretical considerations

This section first outlines a simple model of entrepreneurial external financing that serves as the foundation for our experimental investigation. Second, it reviews the non-monotonic-contracts hypothesis that compares entrepreneurial effort under a standard debt contract to that under a non-monotonic contract. Third, the entrepreneur's optimal effort decision is related to outside equity contracts.

[2]E.g., DeJong, Forsythe and Lundholm (1985) demonstrate the relevance of moral hazard with flat wage employment contracts. Fehr, Kirchsteiger, and Riedl (1993) and Irlenbusch and Sliwka (2005) show that agents' effort increases in the generosity of flat wages. Fehr, Klein, and Schmidt (2007), on the other hand, report that bonus contracts outperform flat wage contracts while Brandts and Charness (2004) investigate the impact of competitive imbalances and minimum wages. Contract design has been show to also affect behavior in the field, e.g., Lazear (2000) finds that replacing flat rate hourly pay by piece rates for windshield installers increases productivity while Shearer (2004) reports a similar effect for workers in tree-planting.

2.1 A simple model of funding

The outlined model is a discrete variant of Innes (1990). Consider an entrepreneurial project with random return Z. The underlying probability function is such that greater entrepreneurial effort increases the likelihood of outcomes with high returns. There are n states. The project return in state i is denoted by $z_i \geq 0$. Return states are numbered in ascending order, i.e. $z_i < z_j$ if $i < j$. The probability of state i depends on entrepreneurial effort $x \in [0, \overline{x}]$ and is given by $p_i(x) \geq 0$ where $p_i(x)$ is twice-differentiable. For a proper probability distribution assume $\sum_i p_i(x) = 1$ and $\sum_i p_i'(x) = 0$. To model that greater effort increases the probability for higher return states to occur, suppose that the monotone likelihood ratio property is satisfied, ie. for all $z_i < z_j$ we have $p_i'(x)/p_i(x) < p_j'(x)/p_j(x)$ implying $\partial E[Z|x]/\partial x > 0$, cf. Milgrom (1981). To ensure an interior solution, suppose marginal benefit of effort does not grow to infinity, i.e. $\lim_{x \to \overline{x}} \partial E[Z|x]/\partial x$ is finite.

The project requires start-up cost $\Gamma > z_1$.[3] The entrepreneur is endowed with wealth W. The amount of external finance required to start the project is $D \equiv \Gamma - W$. Since we inquire into the effects of external financing schemes on entrepreneurial activity, $D > 0$. For simplicity, let $W = 0$. We assume the entrepreneur is subject to limited liability such that the realized project return constrains repayment in low return states. A feasible repayment contract $\vec{t}$ is characterized by $\vec{t} = (t_1, t_2, ..., t_n)$ such that $t_i \leq z_i$ due to limited liability, where t_i denotes the contracted amount of repayment in state i.

The preferences of the entrepreneur are additively separable in income y and effort cost $c(x)$

$$u(x, y) = y - c(x)$$

where $c(0) = 0$, $c'(x) > 0$, $c''(x) > 0$ and $\lim_{x \to \overline{x}} c'(x) = \infty$. Since the entrepreneur's income in state i is the difference of realized project return and contracted repayment, the entrepreneur's maximization problem for any given contract $\vec{t}$ is given by:

$$\max_x \quad EU(x, \vec{t}\,) = \sum_{i=1}^{n} p_i(x)\,(z_i - t_i) - c(x).$$

Expected utility is maximized by effort level $\widetilde{x}(\vec{t}\,)$. For ease of exposition, let $c(x)$ be sufficiently concave to always guarantee strict concavity of the objective function. Then, the first order condition of the maximization problem characterizes a unique global maximum of entrepreneurial expected utility:[4]

$$\sum_{i=1}^{n} p_i'(\widetilde{x})\, z_i = c'(\widetilde{x}) + \sum_{i=1}^{n} p_i'(\widetilde{x})\, t_i. \tag{1}$$

[3] If the start-up cost is not larger than the lowest project return z_1, the financing problem is trivial.

[4] Due to the generality of feasible contracts and revenue distributions, it is possible to find contracts that imply a strictly negative marginal entrepreneurial income net of repayment even with zero effort (e.g., a contract that always requires full repayment except for the lowest state where no repayment is required.) Then, it is impossible to satisfy the first-order condition (1) and a boundary solution emerges such that $\widetilde{x}(\vec{t}\,) = 0$.

The LHS of (1) gives the marginal expected project return of additional effort. The first term of the RHS is marginal effort cost.

The key to understanding how entrepreneurial incentives are related to funding contracts lies in the second term on the RHS: the marginal expected repayment to the lender, $\mathrm{MR}(x) \equiv \sum p_i'(x)\, t_i$. If the repayment contract implies that the marginal expected repayment vanishes from (1), the entrepreneur finds it optimal to supply first-best effort x^* that prevails in the absence of external financing ($t_i = 0\ \forall i$); hence, any flat contract ($t_i = \tau\ \forall i$) induces first-best effort.[5]

If the funding contract is designed such that the marginal expected repayment, however, does not sum up to zero, the funding contract distorts the entrepreneur's effort choice and leads to inefficient effort provision and a loss of economic surplus. Specifically, the entrepreneur's optimal effort $\widetilde{x}$ decreases in the marginal expected repayment as the application of the implicit function theorem to $\widetilde{x} = f(\mathrm{MR})$ implicitly defined by (1) shows:

$$\frac{d\widetilde{x}}{d\mathrm{MR}} = \frac{1}{\sum_{i=1}^{n} p_i''(\widetilde{x})\, z_i - c''(\widetilde{x}) - \mathrm{MR}'(\widetilde{x})} < 0.$$

The denominator is the maximization problem's second-order condition so that a strictly positive marginal expected repayment implies $\widetilde{x} < x^*$ resulting in lost economic surplus.

Since the incentive effects of funding contracts are reflected in the marginal expected repayment to the investor, they are influenced by the structure of the funding contracts. A contract that does not require any repayment induces the entrepreneur to exert first-best effort. In the following two subsections we discuss the incentive effects of three other contract structures, standard debt contracts, non-monotonic contracts, and outside equity contracts.

2.2 The standard debt contract and the non-monotonic-contracts hypothesis

A widely applied funding contract is the standard debt contract that essentially reduces the repayment structure to a flat repayment claim τ independent of the realized return state. Due to binding limited liability, the actual repayment to the lender is smaller than τ whenever the realized project return falls short off the flat repayment claim. Using our contract notation, a standard debt contract $\vec{t}^{\,\mathrm{SDC}}$ is given by

$$t_i^{\mathrm{SDC}} = \begin{cases} z_i & \text{if } z_i < \tau, \\ \tau & \text{otherwise.} \end{cases}$$

Under a standard debt contract, the entrepreneur shares with the lender the benefit of increased expected project return created by additional effort while bearing total marginal effort cost. A key characteristic of this type of contract is that the implied marginal

[5] Recall that $\sum p_i'(x) = 0$ otherwise probability would sum up to more or less than unity with variations of effort.

expected repayment is strictly positive, so that the standard debt contract is inherently inefficient. To see this, note that the expected repayment to the lender under any standard debt contract is given by $\sum_{i=1}^{m-1} p_i(x)\, z_i + \sum_{i=m}^{n} p_i(x)\, \tau$ where m is the smallest payoff state that allows the entrepreneur to fully repay the fixed payment of the standard debt contract. Rewriting the expected repayment and differentiating it with respect to effort yields marginal expected repayment as

$$\mathrm{MR}^{\mathrm{SDC}}(x) = z_i \sum_{i=1}^{n} p_i' + (z_2 - z_1) \sum_{i=2}^{n} p_i' + \ldots + (z_{m-1} - z_{m-2}) \sum_{i=m-1}^{n} p_i' + (\tau - z_{m-1}) \sum_{i=m}^{n} p_i'.$$

By definition of a proper distribution function, the sum of marginal probabilities equals zero, $\sum_{i=1}^{n} p_i' = 0$, so that the first summation vanishes. All other summations differ from the first one in that marginal probabilities for low revenue states are not part of the summation. The fact that higher effort reduces the probability of low states and increases that of high states implies that the lowest payoff states are assigned negative marginal probabilities, so that, when omitting them, all remaining summations are strictly positive. It follows that the marginal expected repayment under any standard debt contract is always strictly positive and, henceforth, the induced entrepreneurial effort choice is suboptimal.

Nevertheless it is possible to design Pareto-improving contracts that can overcome the inefficiency inherent to standard debt contracts. These contracts are characterized by a non-monotonic repayment structure in the sense that repayment in some higher-return states is lower than repayment in some lower-return states. By decreasing repayment in high-return states, marginal repayment to the lender - being strictly positive under standard debt contracts - is reduced while the expected repayment to the lender can be preserved. It follows that the deviation from first-best effort and the implied efficiency loss with non-monotonic contracts are smaller than under standard debt contracts due to better incentives provided by the former. If designed accordingly, non-monotonic contracts can even lead the entrepreneur to exert first-best effort and eliminate any efficiency loss (Proposition 1b).

Proposition 1. *(Non-monotonic-contracts hypothesis)*
There exist non-monotonic contracts that are superior to standard debt contracts in terms of entrepreneurial profit and allocative efficiency due to a smaller deviation from first-best effort.

Proof. See appendix A. □

A numerical example that illustrates the potential magnitude of welfare gains through non-monotonic contracts which we experimentally investigate is provided in section 3.

2.3 Outside equity contracts

Outside equity contracts are a special case of monotonic contracts where the repayment to the investor is higher if the entrepreneur's revenue realization is higher, $t_i < t_j$ if $i < j$. For outside equity contracts, the share of investor repayment in revenue is the same in any state. We denote the share of investor repayment by $\sigma \in (0, 1]$ and also refer to it as the equity share. Then any outside equity contract $\vec{t}^{\,\text{Equi}}$ is defined by

$$t_i^{\text{Equi}}(\sigma) = \sigma\, z_i \qquad (i = 1, ..., n)$$

3 Experimental design

3.1 Model parametrization, treatments, and theoretical predictions

In the experiment, we implement the model introduced in section 2 with three states and linear probability functions. Project revenues and probability functions for states 1, 2, and 3 to occur are as follows:

$$\begin{array}{ll} z_1 = 500 \text{ ECU} & \text{with } p_1(x) = 0.6 - 0.6\frac{x}{100}, \\ z_2 = 9,000 \text{ ECU} & \text{with } p_2(x) = 0.4, \\ z_3 = 10,000 \text{ ECU} & \text{with } p_3(x) = 0.6\frac{x}{100}, \end{array}$$

where effort $x \in [0, 100]$. By increasing effort, probability is shifted from the low project return of 500 ECU to the high project return of 10,000 ECU. This can be thought of as probability mass being shifted from the low to the intermediate return to the same extent as from the intermediate to the high return.

The entrepreneur faces effort cost $c(x) = 0.5\, x^2$. The start-up investment of the project is fixed at $\Gamma = 3,120$ ECU. The rate of return an outside lender requires to finance the project is $r = 0.25$.

We investigate four treatments that differ in the specification of the repayment contract only. To minimize confounding effects that could emerge from social preferences or strategic uncertainty, we use an individual-choice experiment where incentive structures are set exogenously by the experimenter and are not affected by the actual choice behavior of the subjects in the experiment. This aspect of our design captures the anonymous setting in much of the financial markets since funding contracts are frequently offered through financial institutions like banks where social preferences seem less relevant.[6] We investigate four treatments that differ in the specification of the exogenously chosen repayment contract only: As a benchmark we run a self-financing treatment (NoRepay), in which there is no repayment at all. Furthermore, we study a standard-debt-contract condition (SDC), a non-monotonic-contract condition (NMC), and an equity condition

[6] Reiss and Wolff (2011) endogenize the selection of repayment contracts and study the structures of subject-selected repayment contracts and their effects on entrepreneurial effort choice.

(EQUI), in which subjects are exposed to the respective kind of repayment contract. The required expected repayment to the lender, $(1 + r)\,\Gamma$, determines the state-contingent repayments under the standard debt contract and the non-monotonic contract. Importantly, both contracts lead to the same expected repayment of 3,900 ECU. In contrast, state-contingent repayments under equity are chosen such that the effort prediction equals the effort prediction prevailing under the standard debt contract of 15.7. This requires that the state-independent equity share is 72.5%. Table 1 summarizes all repayment contracts. Evidently, the standard debt contract and the equity contract lead to a loss

Repayment	SDC	NMC	NoRepay	EQUI (72.5%)
t_1 (z_1=500)	500.00 ECU	500.00 ECU	0.00 ECU	362.50 ECU
t_2 ($z_2 = 9000$)	7,383.30 ECU	9,000.00 ECU	0 ECU	6,525.00 ECU
t_3 ($z_3 = 10000$)	7,383.30 ECU	500.00 ECU	0 ECU	7,250.00 ECU
Effort prediction	15.7	57.0	57.0	15.7
Total surplus	1,551.66 ECU	2,404.50 ECU	2,404.50 ECU	1,551.66 ECU
Exp. Repayment	3,900.00 ECU	3,900.00 ECU	0.00 ECU	3,476.30 ECU
Entrepreneur's EU	769.93 ECU	1,624.50 ECU	2,404.50 ECU	1,195.35 ECU
Investor's EU	780.00 ECU	780.00 ECU	0.00 ECU	356.20 ECU

Table 1: Repayment contracts by treatment

in total surplus. Additionally, the entrepreneur's payoff is substantially smaller. If the standard debt contract is replaced by a repayment-equivalent non-monotonic contract, total surplus increases by 55%, while the surplus accruing to the entrepreneur more than doubles.[7]

Behavior in the laboratory that deviates from our theory-based predictions which assume risk-neutrality may be attributable to the effects of individual risk preferences such as various degrees of risk-aversion. To address this concern, we reduce the risk in subjects' payoffs by paying them the average payoff over 50 different projects, with outcomes determined by independent draws from the probability distribution determined by effort choice instead of using the payoff realized for a single project. This method was successfully introduced by Kirchkamp, Reiss, and Sadrieh (2006) in an auction setting.

3.2 Procedures and other details

The experiment was programmed using z-tree (Fischbacher, 2007) and run at the Erfurt Laboratory for Experimental Economics (eLab). Subjects were recruited for each session using ORSEE (Greiner, 2004). No subject participated in more than one session. We ran one session for each treatment, obtaining twelve independent observations per treatment.

On the day, subjects were welcomed and randomly assigned to private cabins. Written instructions were handed to them before being read aloud by the experimenter. Subse-

[7] The exact numbers are 54.96% and 110.99%.

quently, subjects entered their cubicles and had some time to go over the instructions again and ask any questions they might have. Questions were answered individually.

Subjects played 15 repetitions of the game and were paid according to their individual performance. The experimental sessions lasted for one hour or less, average earnings being € 9.65 ($\approx$ US$ 12.50). Payments were settled individually to ensure subjects' anonymity.

3.3 Testable hypotheses

We derive the hypotheses that we test in the experiment from the theoretical predictions summarized in Table 1. At the least demanding level we expect that effort choices are influenced by the contract condition in a systematic way. In particular, we hypothesize that observed behavior is qualitatively consistent with the comparative statics of changing the funding contract. This leads to our first and most basic hypothesis:

Hypothesis 1 *Observed effort choices are influenced by contract conditions and share the ordinal rank across contract conditions with the theoretical ranking prediction*:
$x^{\text{NoRepay}} \approx x^{\text{NMC}} > x^{\text{SDC}} \approx x^{\text{EQUI}}$.

Hypothesis 1 is weak in the sense that it is a qualitative one that disregards the quantitative nature of the theoretical point predictions. Since the precise optimal effort values allow us to predict behavior also quantitatively we strengthen the first hypothesis by hypothesizing that behavior is also consistent with the point predictions:

Hypothesis 2a *Observed effort choices on average match the theoretical point predictions of effort.*

A particular strength of the model is its parsimony. It provides a single equation, equation (1), that predicts the effort level for any repayment contract. Although hypothesis 2a relates to the optimal effort equation, it hypothesizes on the comparisons of observed effort to predicted effort for each contract condition separately. This allows for some flexibility as the point prediction of some contract condition may fit the data for some repayment contract better than for another repayment contract. To strengthen our hypothesis on the theory's predictive power, hypothesis 2b supposes that the optimal effort prediction holds for *all* repayment contracts at the same time:

Hypothesis 2b *The optimal effort function (1) explains observed effort choices well in all contract conditions simultaneously.*

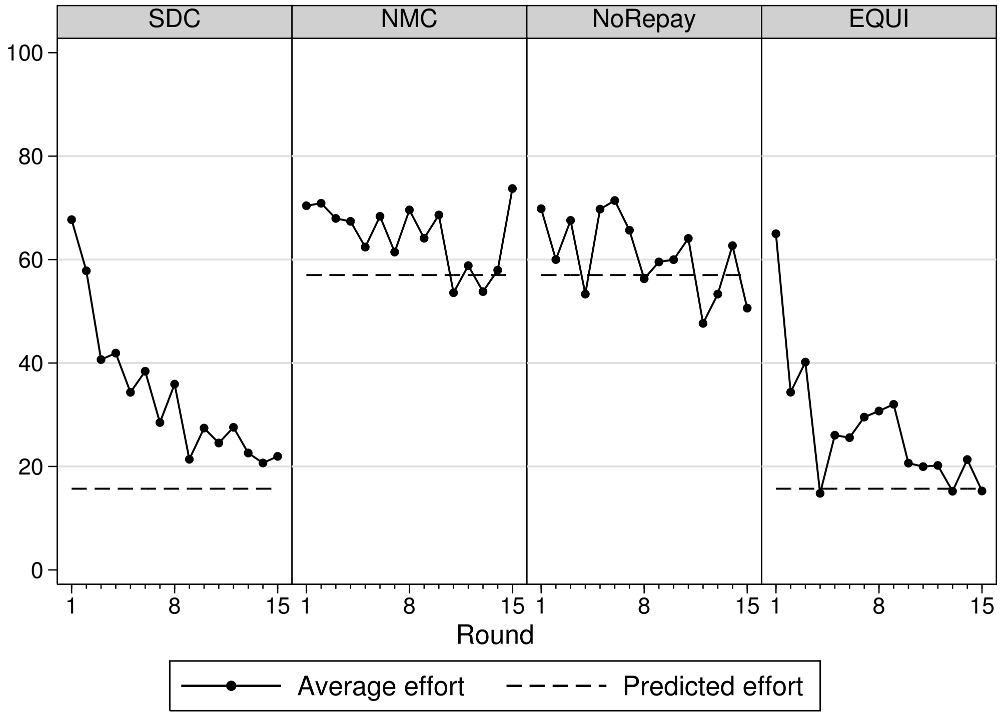
The non-monotonic-contracts hypothesis compares allocative efficiency and profits obtained under the non-monotonic contract to that under a standard debt contract yielding the same expected investor repayment theoretically.

Hypothesis 3 *(Non-monotonic-contracts hypothesis) Allocative efficiency and entrepreneurial profits are higher under the non-monotonic contract than under the standard debt contract.*

4 Experimental results

First we investigate if incentives matter, then we explore learning dynamics and finally, we examine the non-monotonic-contracts hypothesis.

4.1 Effects of funding contracts on effort choice



The figure depicts average effort (solid lines) over rounds under the standard debt contract (left), the non-monotonic contract (second-left), if there is no repayment (second-right), and under outside equity (right). The theoretical effort prediction is indicated by dashed lines.

Figure 1: Average effort and predicted effort by round

Let us begin by addressing the fundamental question if funding contracts affect behavior at all and, if so, see to what extent it is consistent with the theoretical predictions. In the experiment, any incentive effect of funding contracts should be reflected directly in the observed effort choices. Figure 1 depicts average effort by treatment and by round. The patterns of the average effort paths across the contract types show that funding contracts embody incentives strongly affecting behavior. Strikingly, hypothesis 1 on comparative statics seems to be confirmed entirely. The paths of average effort, $\{\overline{x}_t, t = 1, ..., 15\}$, seem similar when they are supposed to be similar, $\overline{x}_t^{\mathrm{SDC}} \approx \overline{x}_t^{\mathrm{EQUI}}$ and $\overline{x}_t^{\mathrm{NMC}} \approx \overline{x}_t^{\mathrm{NoRep}}$ and seem to differ in the hypothesized direction when they are supposed to differ, $\overline{x}_t^{\mathrm{NMC}}$, $\overline{x}_t^{\mathrm{NoRep}} > \overline{x}_t^{\mathrm{SDC}}$, $\overline{x}_t^{\mathrm{EQUI}}$. This impression is formally confirmed by testing for differences in average effort among any pair of contract conditions, separately for each round, using two-tailed t-tests,[8] see Table 5 for a summary. The table shows the number of significant

[8] We also checked for treatment differences using the Mann-Whitney U test and essentially find the

Contract condition	NMC	NoRepay	EQUI
SDC	$x^{\mathrm{SDC}} < x^{\mathrm{NMC}}$	$x^{\mathrm{SDC}} < x^{\mathrm{NoRepay}}$	$x^{\mathrm{SDC}} = x^{\mathrm{EQUI}}$
No. of sign. diffs.	13 ($p \leq 0.028$)	12 ($p \leq 0.066$)	2 ($p \leq 0.034$)
No. of insign. diffs.	2 ($p \geq 0.229$)	3 ($p \geq 0.290$)	13 ($p \geq 0.167$)
NMC		$x^{\mathrm{NMC}} = x^{\mathrm{NoRepay}}$	$x^{\mathrm{NMC}} > x^{\mathrm{EQUI}}$
No. of sign. diffs.		1 ($p = 0.028$)	14 ($p \leq 0.011$)
No. of insign. diffs.		14 ($p \geq 0.123$)	1 ($p = 0.590$)
NoRepay			$x^{\mathrm{NoRepay}} > x^{\mathrm{EQUI}}$
No. of sign. diffs.			14 ($p \leq 0.047$)
No. of insign. diffs.			1 ($p = 0.661$)

The table reports, for any pair of treatments, the results of roundwise t-tests. The null hypothesis is that there is no difference in the average effort observed in the paired treatments. The alternative hypothesis is that there is a difference. For any comparison of treatments, the theoretical comparative statics effort prediction and the number of significant and insignificant differences out of all of the 15 roundwise tests are reported together with the obtained highest and lowest p-values in parenthesis.

Table 2: Summary of t-tests comparing average effort across contract conditions.

and insignificant differences of average effort that we find for each pair of contract conditions. The test results indicate that we observe significant differences in average effort in almost all of the rounds for all cases where theory predicts differences in average effort between contract conditions. Similarly, for all cases where theory predicts that average effort does not differ across contract conditions, in almost all of these rounds we do not observe significant differences. Hence, there is strong support for hypothesis 1.

Comparing the paths of average effort to the theoretical predictions, as indicated by the dashed lines in Figure 1, illustrates that observed behavior is, however, much richer than predicted by theory. For example, in contrast to the static prediction for the contract condition SDC, $x^{\mathrm{SDC}} = 15.7$, observed average effort changes considerably over the course of the experiment as can be seen in the left panel of the figure. The graph for the contract condition SDC (left panel) shows that nevertheless, the static prediction turns out to be rather useful as it attracts observed average effort over time. Overall, the standard debt contract leads subjects to implement inefficiently low levels of effort consistent with theory most of the time but not in the beginning of the experiment: In the first two rounds of the experiment average effort does not differ from the first-best level of $x^* = 57$ ($p > 0.185$), inconsistent with the theoretical prediction for the SDC condition. For all of the remaining 13 rounds, the t-test indicates significant differences between average effort and first-best effort (two-tailed, $p < 0.075$).[9] Comparing the data to the theoretical point prediction of inefficient effort, $x^{\mathrm{SDC}} = 15.7$, shows that average effort mostly differs from this prediction except for the end of the experiment: According to the t-test, average effort

same results. [Referees: Please see the referee's appendix on p.30 for a summary of the MWU test results.]

[9]Similarly, the sign test reveals significant differences between observed median effort and first-best effort in 10 of 15 rounds (two-tailed, $p < 0.007$); for the remaining five rounds at the beginning of the experiment (rounds 1-4 and 8), observed differences are insignificant ($p > 0.145$).

is not significantly different from the predicted effort level in 6 of 15 rounds (two-tailed, $p > 0.110$) that happen to be at the end of the experiment (rounds 11-15 and round 9). It identifies significant differences for all other rounds ($p < 0.069$).[10] We explore the learning of funding contract incentives in more detail in subsection 4.2.

Next, let us consider the outside equity contract in more detail. It is designed to induce the same level of effort as the standard debt contract, $x^{\mathrm{EQ}} = x^{\mathrm{SDC}} = 15.7$. Though average effort observed in the outside equity condition (right panel) evolves very similar to that observed in the SDC condition (left panel), one subtle difference between both paths of average effort is, perhaps, that the convergence behavior towards the theoretically predicted effort level seems slightly faster under the outside equity contract. This is consistent with the results of roundwise comparisons of average effort to its prediction since deviations from the prediction fade away later in the SDC condition. In the EQUI condition, the t-test finds significant differences in the first three rounds only (two-tailed, $p < 0.012$ for rounds 1-3 and $p > 0.104$ for any other round), while it finds a significant difference in each of the first eight rounds in the SDC condition.[11]

In contrast to converging average behavior under the standard debt contract and under the outside equity contract, there is neither converging nor diverging behavior under the non-monotonic contract or under the no repayment contract. In the treatment conditions NMC and NoRepay, first-round average effort is close to the theoretical prediction of $x^{\mathrm{NMC}} = x^{\mathrm{NoRepay}} = 57$ and seems to fluctuate in its neighborhood over time as can be seen in Figure 1. In fact roundwise comparisons of average effort to the predicted level do not suggest a systematic trend over time. There are only a few significant differences that seem arbitrarily distributed over the course of the experiment in either treatment. Specifically the t-test reveals significant differences in six rounds (1-2, 6, 8, 10, and 15, $p < 0.081$) in condition NMC and significant differences in four rounds (1 and 5-7, $p < 0.099$) in condition NoRepay.[12]

Result 1. *Funding contracts strongly influence the choice of effort in a way that is consistent with the comparative statics predictions except for the beginning of the experiment (support for hypothesis 1). Behavior adjusts to the theoretical point predictions through repeated exposure to incentives over time (partial support for hypothesis 2a).*

To quantify the extent to which the incentives of funding contracts influence the effort choice once incentives have been absorbed, we estimate first-order condition (1) with data from the second half of the experiment, i.e. rounds 9-15. In our parametrization, the

[10] The sign-test finds no significant differences in rounds 7-15 and round 3 (two-tailed, $p > 0.146$) and reveals significant differences in all other rounds ($p < 0.039$).

[11] The sign test indicates significant differences in rounds 1-2 and round 7 (two-tailed, $p < 0.065$) in the EQUI treatment and five of the first six rounds ($p < 0.039$ for rounds 1-2 and 4-6 and $p = 0.146$ for round 5.)

[12] The sign test finds significant differences in rounds 4 and 15 ($p \leq 0.039$) in the NMC condition and significant differences in rounds 5 and 7 ($p \leq 0.039$) in the NoRepay condition.

	coefficent	robust σ	t	p-value	95% conf	interval
I) Unrestricted model (3)						
(Intercept)	57.98	3.916	14.81	0.000	50.14	65.82
$\widetilde{t}_1$	35.99	52.329	0.69	0.494	-68.76	140.73
$\widetilde{t}_2$	-1.28	3.01	-0.43	0.671	-7.311	4.743
$\widetilde{t}_3$	-5.98	0.622	-9.31	0.000	-7.037	-4.545
II) Restricted model (4)						
(Intercept)	59.16	2.876	20.57	0.000	53.41	64.92
Marg. Repayment	0.89	0.090	9.94	0.000	0.71	1.07

Note: State-contingent repayments are normalized such that $\widetilde{t}_s = t_s/1000$.

Table 3: Estimation results of equations (3) and (4).

first-order condition can be explicitly solved for optimal effort and simplifies to

$$x^* = 57 - \frac{6\,(t_3 - t_1)}{1\,000}. \tag{2}$$

First, we estimate[13] the unrestricted model

$$x_{it} = \beta_0 + \beta_1\,\widetilde{t}_1 + \beta_2\,\widetilde{t}_2 + \beta_3\,\widetilde{t}_3 + u_{it} \tag{3}$$

The dependent variable x_{it} is the effort choice of participant i in round t, $\widetilde{t}_s$ is the repayment in state s measured in thousands of ECU (i.e., $\widetilde{t}_s = t_s/1\,000$), and u_{it} is the residual. The unrestricted model does not impose any restriction derived from theory on the specification apart from the linearity assumption. This allows us to explore if the repayment in state 2, t_2, affects effort choice though theoretically irrelevant and to check if the repayments in states 1 and 3 influence behavior similarly strong.

If observed behavior is fully consistent with theory, then we expect to estimate coefficients such that the optimal effort function (2) is reproduced by specification (3), i.e. $\widehat{\beta_0} = 57$, $\widehat{\beta_1} = 6$, $\widehat{\beta_2}$ not significantly different from zero, and $\widehat{\beta_3} = -6$. Table 3 presents regression results that are broadly consistent with theory. Although the estimates reproduce essential features of the optimal effort function, the joint hypothesis that the estimated coefficients satisfy the theoretical point predictions precisely is rejected at 5.5%.[14]

In our parametrization, the additional repayment to the investor arising if the entrepreneur devotes one more unit of effort to the project, i.e. the marginal repayment, is constant for any repayment contract and given by

$$\mathrm{MR} = \frac{6\,(t_3 - t_1)}{1\,000}.$$

[13]We estimate this and the next model by OLS such that the computation of standard errors takes into account that observations of the same individual might be correlated across time (Rogers, 1993).

[14]An F-test of the joint hypothesis I) $\widehat{\beta_0} = 57$, II) $\widehat{\beta_1} = -\widehat{\beta_3}$, III) $\widehat{\beta_1} = 6$, IV) $\widehat{\beta_2} = 0$ with $F_{4,58} = 2.47$ yields $p = 0.055$.

It depends on the funding contract through the repayments in states 1 and 3 only. Comparing marginal repayment MR to the optimal effort function (2) shows that optimal effort is simply given by first-best effort, $x^* = 57$, reduced by the amount of marginal repayment. To quantify the effect of a funding contract's marginal repayment on effort, we regress observed effort on marginal repayment using the following restricted specification:

$$x_{it} = \gamma_0 - \gamma_1 \, 6 \, (\widetilde{t}_3 - \widetilde{t}_1) + u_{it} \tag{4}$$

In this regression equation, coefficient γ_1 indicates the effect of marginal repayment on effort. Theoretically we expect to find on estimate of $\widehat{\gamma}_1 = 1$. Any positive estimate, $\widehat{\gamma}_1 > 0$, would indicate that reducing effort would be correlated with changes in the repayment contract that require greater repayment if the entrepreneur exerts additional effort. If we found an estimate of $\widehat{\gamma}_1 > 1$, then observed effort would respond excessively strong to contractual changes that lead to changes of marginal repayment. In this case a replacement of the standard debt contract (with strictly positive marginal repayment) by a non-monotonic contract (with zero marginal repayment) would increase effort by an amount that is larger than predicted theoretically. Table 3 reports the estimation results. It turns out that the coefficient on marginal repayment is not significantly different from one (two-tailed t-test, $p = 0.239$). Therefore, on average, marginal repayment captures the incentives provided by funding contracts on effort choice as theoretically predicted. Before moving on to study the learning of contract incentives in more detail, we summarize our result on effort choice behavior as compared to optimal choice:

Result 2. *Observed average behavior is largely consistent with the theoretical point predictions given by the optimal effort choice function (1) once sufficient experience accumulates (partial support for hypothesis 2b).*

4.2 Learning incentives

The fundamental differences in the incentives provided by the experimentally studied funding contracts seem not to be reflected in the observed effort choices at the beginning of the experiment according to a comparison of first-round effort choices across contract conditions, see the left panel of Figure 1. It may be unsurprising that the differences in funding contract incentives do not induce behavior that is in line with the point predictions precisely– but it is striking that there seem to be no differences across contract conditions in the first round at all. To look at this aspect in more detail we compare the distributions of first-round effort choices. The left panel of Figure 2 depicts the empirical cumulative distributions and shows that they are rather similar and independent of the contract condition. In fact the Kolmogorov-Smirnov test applied to any pair of first-round distributions fails to reject the hypothesis of identical distributions of observed effort choices at any reasonable level of significance ($p \geq 0.777$).

The failure of finding significant differences in first-round effort behavior across these contract conditions where it should matter, e.g. SDC as compared to NoRepay, is important. It suggests that the incentives provided by funding contracts are too weak or too subtle to be grasped by *ex ante* introspection. The result that effort choices change over the course of the experiment towards the theoretical prediction reveals that repeated experience is required for contract incentives to take effect. Only after sufficiently-repeated exposure to contract incentives is average behavior consistent with the theoretical predictions, as suggested by Figure 1 and by the corresponding statistical tests.

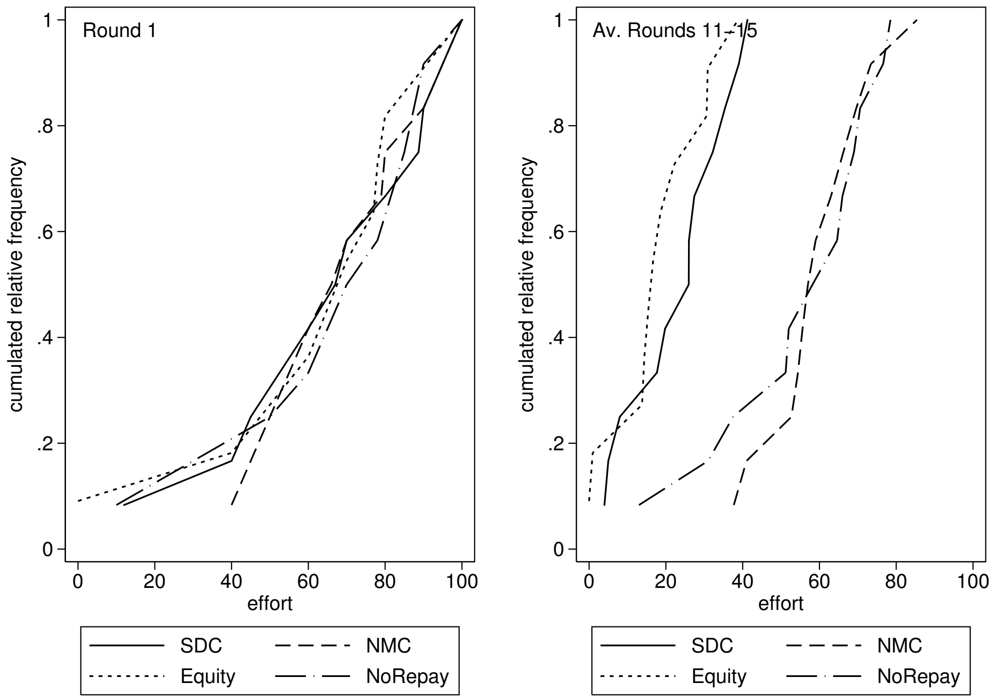


Figure 2: Cumulative distribution functions of effort observed in the first round (left panel) and averaged over the last five rounds (right panel) of the experiment.

To further our understanding of how the incentives of funding contracts are learned and to see if the shape of funding contracts affects the way of learning incentives, we estimate two learning models that have been applied in the previous literature, the experience-weighted attraction learning model (EWA; see Camerer and Ho, 1999), and a reinforcement learning model (RI; e.g., Roth and Erev, 1995).

4.2.1 Implementation of EWA and RI models

For details about the experienced-weighted attraction learning model, see Camerer and Ho (1999), Ho, Xin, and Camerer (2008), or Feri, Irlenbusch, and Sutter (2010). In brief, the EWA model describes a decision maker's choice by mapping state variables associated with actions, referred to as 'attractions', into a probability distribution of choice variables. EWA assumes that the attraction value A_t^x of choosing action x at the end of period t– after experiencing (or imagining) the payoff $\pi_t(x)$ from choosing (or potentially choosing) action x in period t–is a weighted average of its past attractions and its payoff, specifically,

$$A_t^x = \frac{\phi\, N_{t-1}\, A_{t-1}^x + \widetilde{\pi}_t(x)}{N_t}$$

where the experience process is governed by $N_t = \phi(1-\kappa)\, N_{t-1} + 1$ and the payoff to action x is

$$\widetilde{\pi}_t(x) = \begin{cases} \pi(x) & \text{if } x \text{ is chosen action in } t \\ \delta\, \pi(x) & \text{otherwise.} \end{cases}$$

The parameter ϕ discounts past attractions and the parameter κ indicates the importance of accumulated experience measured as the number of times the choice situation was experienced. An important difference between EWA and RI models is that EWA allows for attraction updating not only through experiencing payoffs via the actually chosen action but also through imagining payoffs to unchosen actions. It captures any potential difference between the actual payoff experience and its imagination by discounting imagined payoffs at δ.

For mapping attractions into choice probabilities we use the logistic form so that the probability of choosing action x in period $t+1$ is given by

$$\mathrm{Pr}_{t+1}^x = \frac{e^{\lambda\, A_t^x}}{\sum_{a=1}^m e^{\lambda\, A_t^a}}$$

where m is the number of actions. The parameter λ indicates the sensitivity of choice probabilities to attractions. E.g., there emerges random choice for $\lambda = 0$ and with increasing λ choice converges to the payoff-maximizing choice.

Before applying EWA to our setting we have to overcome two obstacles. First, the choice variable of our interest, effort, is continuous while EWA is designed for describing discrete choice. We address this issue by discretizing the effort space analogously to Capra, Goeree, Gomez, and Holt (1999). In particular we round observed effort to the nearest integer so that there are $m = 101$ effort choices, i.e. the discretized effort space is $\{0, 1, ..., 100\}$. Second, unlike with discrete choice under certainty, in our setting payoff information is only partially available due to unknown realizations of project outcomes that would have resulted from any unchosen effort level: our participants are informed about their actual payoffs implied by the actual set of project realizations for the chosen effort levels, but they do not know the payoffs that would have emerged for any unchosen effort level. Following Ho, Wang, and Camerer (2008) we replace the unknown payoff by the average over the set of possible forgone payoffs from the unchosen effort level which is the expected payoff in our case.[15] For consistency, we also replace the actual payoff by the expected payoff conditional on the actually chosen effort level. In our case this is a minor change as the entrepreneur's payoff in our experiment is the average payoff over

[15] Ho, Wang, and Camerer (2008) provide an extension of EWA to partial payoff information and apply it to centipede game data.

50 project realizations.[16]

Following Camerer (2003) and Ho, Camerer, and Chong (2007) we impose the restriction $N_0 = 1$. For specifying the levels of initial attraction, A_0^x, we use the approach of Ho, Wang, and Camerer (2008, fn 16), also followed by Feri, Irlenbusch, and Sutter (2010), to calibrate them such that the choice probabilities approximately[17] imply the distribution of relative frequencies as observed in the first round of the experiment. When obtaining the frequency distribution of first-round data we pool the data across contract conditions as first-round choices do not significantly differ. In particular, the initial levels of attraction satisfy the equation system ($j = 1, ..., m$):

$$A_0^j - \frac{1}{m}\sum_j A_0^j = \frac{1}{\lambda}\ln(\widetilde{f}^j)$$

where $\widetilde{f}^j = f^j/\Pi_k f^k)^{1/m}$ and f^j is the frequency of observing action j in the first round.

We investigate the reinforcement learning model as a special case of the EWA model. For that we impose the restrictions $\delta = 0$, so that non-experienced payoffs do not influence attractions, and $\kappa = 1$, so that the count of experienced choices is irrelevant. With these restrictions attraction levels simplify to the reinforcement levels of the RI model with gradual forgetting as studied in Roth and Erev (1995). Unlike Roth and Erev (1995) we continue using the logistic form for mapping the reinforcement levels into the choice probabilities to facilitate parameter comparisons.[18]

4.2.2 Estimation results

We use maximum-likelihood estimation to quantify the parameters of the EWA and RI learning models. Table 4 reports the estimation results. The significant estimates of λ in any contract condition and any learning model show that subjects do not randomly choose effort levels over the course of the experiment. Rather payoff differences substantially govern effort choice behavior. The fit of the learning models as summarized by the BIC shows that the EWA model explains the the data better than the RI model in any contract condition.[19]

An important reason why the EWA model fits the data better than the RI model lies in the fact that EWA also allows for the updating of attractions if the corresponding levels of effort were not chosen. The significantly positive estimates of the introspection discount factor δ show, consistently across contract conditions, that our participants not

[16]In each treatment, the difference between expected payoff and actual payoff is smaller than 0.5% of the expected payoff on average. [Referees: More detailed descriptive data is provided in table 6 in the referee's appendix D.2.]

[17]It is only possible to approximately reproduce the frequency distribution of first-round choices since some effort levels were not chosen in the experiment and it is infeasible to calibrate the attraction level for the corresponding strategy such that the corresponding choice probability is zero.

[18]Roth and Erev (1995) employs the power form, i.e. $\Pr_{t+1}^x = A_t^x / \sum_a A_t^a$.

[19]Note that the BIC corrects for increasing the number of parameters so that it is not simply the larger number of parameters under EWA explaining the improved fit.

Contract types	λ	δ	ϕ	κ	BIC
1) EWA					
Standard debt contract	0.440***	0.132***	0.849***	0.432***	-709.25
	(0.097)	(0.023)	(0.038)	(0.139)	
Equity	0.538**	0.147***	0.928***	0.163**	-584.21
	(0.120)	(0.025)	(0.040)	(0.075)	
Non-monotonic contract	0.198***	0.235***	0.940***	0.277***	-744.51
	(0.036)	(0.057)	(0.032)	(0.072)	
No repayment	0.066***	0.411***	0.884***	0.503***	-686.88
	(0.012)	(0.087)	(0.026)	(0.106)	
2) Cum. Reinforcement					
Standard debt contract	0.330***	0	0.683***	1	-758.90
	(0.030)		(0.036)		
Equity	0.222***	0	0.707***	1	-626.98
	(0.017)		(0.034)		
Non-monotonic contract	0.091***	0	0.773***	1	-767.26
	(0.011)		(0.027)		
No repayment	0.029***	0	0.816***	1	-695.69
	(0.003)		(0.019)		

Table 4: Parameter estimates of the EWA and the RI learning models

Standard errors are reported in parentheses. There is no standard error reported if the parameter is not estimated but exogenously restricted to a value to obtain the RI model. BIC = LL $-$ $0.5k\log(NT)$ where k is the number of estimated parameters, N is the number of subjects, and T is the number of periods. Levels of significance: *** significant at 1%, ** significant at 5%, * significant at 10.%.

only responded to the actually experienced payoffs through choosing some effort level but also take into account non-experienced payoffs through introspection.

If participants took into account, through introspection, all non-chosen effort levels in the same way as they are using chosen effort, then the introspection discount factor δ would be equal to one. There would be no discounting of payoffs and all attraction levels would be updated in the same way independent of the actual effort choice. In contrast, the estimates of δ show that introspection is limited as the estimates are much smaller in magnitude than one for any contract condition (Table 4). Therefore, experiencing the implications of the actual effort choice is essential in all contract conditions including NMC and NoRepay where average behavior starts out in the vicinity of the optimal value (Figure 1). We summarize our findings on learning incentives as follows.

Result 3. *Experiencing the implications of effort choice is essential for incentive effects of funding contracts to take effect. Incentive effects are learned through experience in all contract conditions and affect behavior increasingly with the accumulation of prior exposure.*

4.3 Standard debt contract vs non-monotonic contract

In this section we take a closer look at the non-monotonic-contracts hypothesis. Would the replacement of a standard debt contract by a repayment-equivalent non-monotonic contract reduce efficiency losses and increase entrepreneurial income as predicted? Figure 3 shows the average incomes obtained under both contracts for each round. It is easy to see that entrepreneurial income in the NMC condition is much greater than in the SDC condition. Using data of the last part of the experiment, rounds 11-15, we find that NMC income exceeds SDC income by 170%.[20]

Result 4. *Observed entrepreneurial income (net of effort cost and repayment) under the non-monotonic contract is on average 170% greater than under the standard debt contract (support for hypothesis 3).*

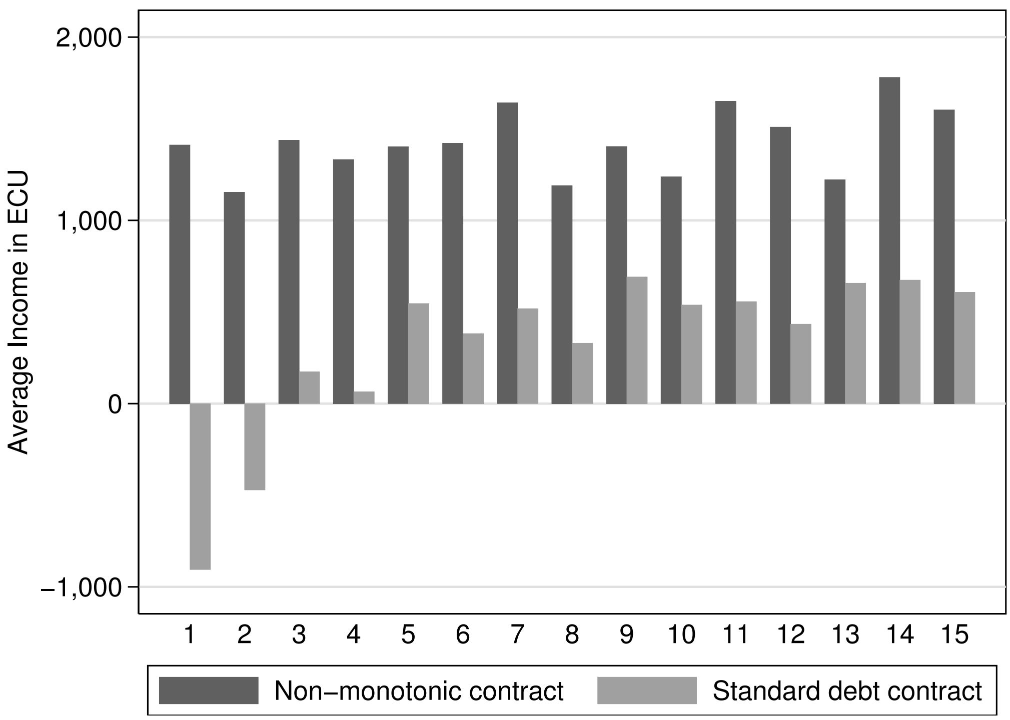


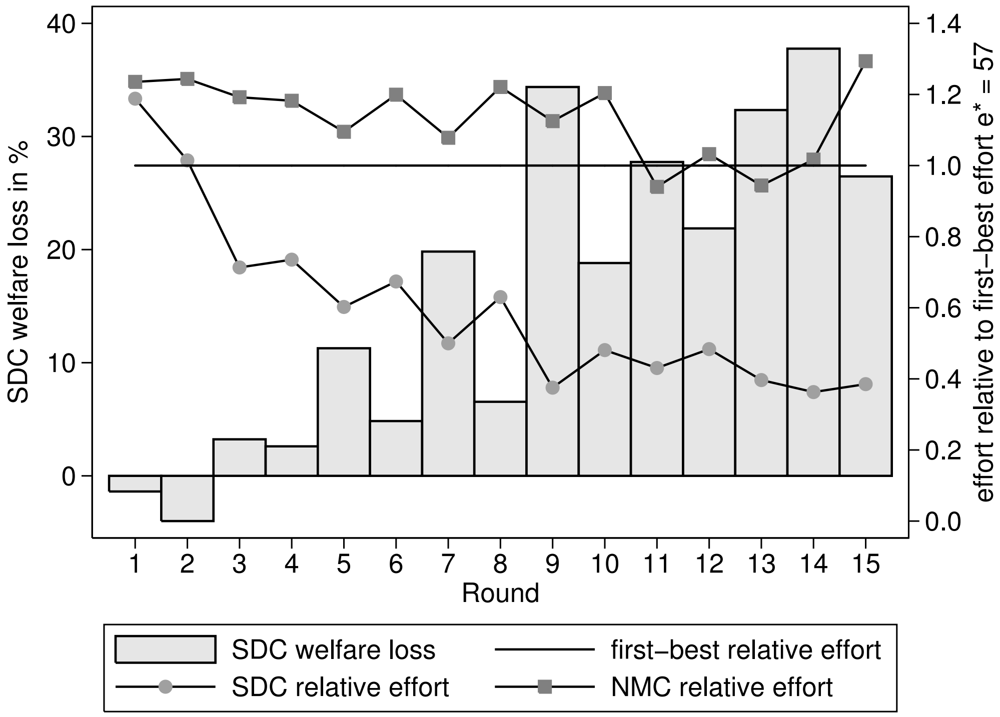
Figure 3: Average round income of entrepreneurs under NMC and SDC

Using the two-tailed t-test for roundwise comparisons of entrepreneurial income (net of agency costs and repayment) formally confirms that the income difference is significant in all fifteen rounds ($p < 0.033$) and highly significant in 13 out of 15 rounds ($p < 0.006$).[21]

Figure 4 illustrates how much additional total surplus would have been created in the SDC treatment if, instead of the standard debt contract, a non-monotonic contract had been used. The figure reveals that in the first four rounds of the experiment, there is

[20] If earlier rounds are included, non-monotonic contracts perform even better, e.g. NMC income tops SDC income by 360% on average if data for rounds 3-15 is used.

[21] Similarly the two-tailed Mann-Whitney U test indicates highly significant income difference in 12 of 15 rounds ($p < 0.007$); for the remaining three rounds we find $p < 0.065$.



The figure depicts the additional total surplus (in %) that is created on average if the SDC is replaced by the corresponding NMC, given average effort levels observed under both contract conditions. This measure of welfare loss is shown as a series of bars (left scale). Furthermore, the figure illustrates average effort observed in both contract conditions relative to first-best effort (right scale). Eg., in round 5, NMC average effort exceeds first-best effort by roughly 10% while SDC average effort falls short off it by 40 %. Finally, the first-best effort benchmark (where total surplus is maximized) is represented by a horizontal line at unity (right scale).

Figure 4: Welfare loss with a standard debt contract, but eliminable by a non-monotonic contract

essentially no welfare disadvantage of the standard debt contract.[22] Clearly, these initial effort levels are suboptimal and yield negative round incomes, as is obvious from figure 3. In the course of the experiment, subjects in the SDC treatment reduce their effort choices towards the optimal level. As effort levels in the SDC treatment decrease, the inefficiency of the standard debt contracts grows sharply. Restricting attention to data from the last part of the experiment (rounds 11-15) where effort choices under SDC have stabilized (see figure 4), we find that the use of the non-monotonic contract would have increased total surplus in the SDC treatment by approximately 30%. Total surplus in the NMC treatment is significantly greater than in the SDC treatment in all of these five rounds (t-test, $p < 0.058$, two-tailed).[23]

[22]In the first two rounds, SDC welfare is even slightly higher than NMC welfare. This is due to the fact that quite large effort levels are initially chosen in the SDC treatment, similar to those effort levels observed in the NMC treatment, but somewhat closer to first-best effort which is indicated by the horizontal line in the Figure.

[23]Mann-Whitney U test, $p < 0.057$, two-tailed.

Result 5. *Standard debt contracts lead to allocative inefficiencies that can be eliminated by using repayment-equivalent non-monotonic contracts (support for hypothesis 3).*

5 Concluding remarks

We examined the incentive effects inherent to funding contracts experimentally. Surprisingly, at the beginning of the experiment we found no incentive effects at all: effort is the same independent of the contract condition. This shows that there are limits to grasping incentive effects through mere introspection. As experience with the contract condition accumulates, incentive effects increasingly govern behavior. With sufficient experience behavior is largely consistent with the theoretical predictions so that the differential incentive effects of funding contracts apply in the long run. As a consequence we also find support for the non-monotonic-contracts hypothesis.

The finding that experience crucially determines how the incentives of funding contracts affect behavior is of particular importance in our setting as real life entrepreneurs, who are endowed with all sorts of "projects", differ in their experience. For example, any entrepreneur requiring external finance to start a project is inexperienced with the implications of funding contracts at the beginning of the entrepreneurial career. Our results suggest that no efficiency loss arises with standard debt or equity in these cases due to limited introspection. The inexperienced entrepreneurs, however, suffer from their inexperience as they receive lower incomes than predicted due to filing for bankruptcy less often and repaying to the investor more often than is expected. Depending on the individual entrepreneur and the particular project(s), there are entrepreneurs who accumulate experience with the incentive effects of funding contracts over the course of their careers. In contrast to the inexperienced ones, we provide evidence that inefficiencies arise with the experienced entrepreneurs under the standard debt contract and the equity contract. Replacing these contracts by non-monotonic contracts would mitigate the losses in allocative efficiency. One possibility of setting up non-monotonic contracts is to combine a standard debt contract with bonus payments of the investor to the entrepreneur conditional on reaching relatively high return states.

Interestingly our data allows us to see if the learning of incentives applies not only globally but also locally. The estimation of the EWA model revealed that exposure to experience matters if behavior starts out far away from the optimal effort choice as in the SDC and Equity conditions. This type of global learning should be expected as the rewards from learning, that is the payoffs when moving into the direction of optimal choice, increase in the distance of actual choice to optimal choice. If actual choice begins in the neighborhood of optimal choice, it might be less obvious if exposure would matter. The EWA estimates show, however, that increasing exposure to incentives also matters if choice behavior starts out in the neighborhood of the optimal effort level as in the NMC and NoRepay conditions.

References

Brandt, Jordi and Gary Charness (2004): Do Labour Market Conditions Affect Gift Exchange? Some Experimental Evidence. *Economic Journal*, 114, 684-708.

Brown, Martin and Christian Zehnder (2007): Credit Registries, Relationship Banking and Loan Repayment. *Journal of Money, Credit, and Banking*, 39(8), 1883-1918.

Brown, Martin and Christian Zehnder (2010): The Emergence of Information Sharing in Credit Markets. *Journal of Financial Intermediation*, 19(2), 255-278.

Camerer, Colin F. (2003): *Behavioral Game Theory: Experiments in Strategic Interaction.* Princeton, NJ: Princeton University Press.

Camerer, Colin and Teck H. Ho (1999): Experience-weighted attraction learning in normal-form games. *Econometrica*, 67(4), 827-874.

Capra, C. Monica, Goeree, Jacob K., Gomez, Rosario, and Charles A. Holt (1999): Anomalous Behavior in a Traveler's Dilemma? *American Economic Review*, 89(3), 678-690.

DeJong, Douglas V., Forsythe, Robert, and Russell J. Lundholm (1985): Ripoffs, Lemons, and Reputation Formation in Agency Relationships: A Laboratory Market Study. *Journal of Finance*, 40(3), 809-820.

Fehr, Ernst, Kirchsteiger, Georg, and Arno Riedl (1993): Does Fairness prevent Market Clearing? An Experimental Investigation. *Quarterly Journal of Economics*, 108(2), 437-460.

Fehr, Ernst, Klein, Alexander, and Klaus M. Schmidt (2007): Fairness and Contract Design. *Econometrica*, 75(1), 121-154.

Fehr, Ernst and Christian Zehnder (2006): Reputation and Credit Market Formation. *NCCR Finrisk Working Paper No.* 179.

Feri, Francesco, Irlenbusch, Bernd, and Matthias Sutter (2010): Efficiency gains from team-based coordination. *American Economic Review*, 100(4), 1892-1912.

Fischbacher, Urs (2007): z-Tree: Zurich toolbox for ready-made economic experiments. *Experimental Economics*, 10, 171-178.

Greiner, Ben (2004): The Online Recruitment System ORSEE 2.0 - A Guide for the Organization of Experiments in Economics. *Working Paper Series in Economics*, No. 10, University of Cologne.

Ho, Teck H., Camerer, Colin F., and Juin-Kuan Chong (2007): Self-tuning experience weighted attraction learning in games. *Journal of Economic Theory*, 133, 177-198.

Ho, Teck H., Wang, Xin, and Colin F. Camerer (2008): Individual differences in EWA learning with partial payoff information. *Economic Journal*, 118, 37-59.

Knoepfle, Daniel T., Wang, Joseph Tao-yi, and Colin F. Camerer, (2009): Studying learning in games using eyetracking. *Journal of the European Economic Assocciation*, 7(2-3), 388-398.

Innes, R.T. (1990): Limited liability and incentive contracting with ex ante action choices. *Journal of Economic Theory*, 52, 45-67.

Irlenbusch, Bernd and Dirk Sliwka (2005): Transparency and reciprocal behavior in employment relations. *Journal of Economic Behavior and Organization*, 56(3), 383-403.

Kirchkamp, Oliver, Reiss, J. Philipp, and Karim Sadrieh (2006): A pure variation of risk in first-price auctions. *METEOR Research Memorandum* 06/058.

Lazear, Edward. (2000): Performance pay and productivity. *American Economic Review*, 90(5), 1346-1361.

Milgrom, Paul R. (1981): Good news and bad news: Representation theorems and applications. *Bell Journal of Economics*, 13, 369-378.

Reiss, J. Philipp and Irenaeus Wolff (2011): Funding of entrepreneurs: An experimental approach. *Working paper*, Maastricht University.

Rogers, W.H. (1993): Regression standard errors in clustered samples. *Stata Technical Bulletin*, 13, 19-23. Reprinted in Stata Technical Bulletin Reprints 3, 88-94.

Roth, Alvin E. and Ido Erev (1995): Learning in extensive form games: Experimental data and simple dynamic models in the intermediate term. *Games and Economic Behavior*, 8, 164-212.

Serra-Garcia, Marta (2010): Moral hazard in credit markets: The incentive effect of collateral. *Working Paper*, Tilburg University.

Shearer, Bruce (2004): Piece rates, fixed wages and incentives: Evidence from a field experiment. *Review of Economic Studies*, 71(2), 513-534.

Appendix

A Proof of Proposition 1

Proof.
Consider any standard debt contract $\vec{t}$ such that $t_{n-1} < z_{n-1}$. It follows feasibility of small changes of the contract structure such that $dt_{n-1} = -p_n(\widetilde{x})/p_{n-1}(\widetilde{x})\,dt_n > 0$. The resulting contract structure is non-monotonic since under the SDC repayments in the two highest revenue states are the same while under the modified contract repayment in the highest revenue state is smaller than that in the second-highest. Examining the effect of the contract modification on optimal effort yields, by (1),

$$\left.\frac{d\widetilde{x}}{dt_{n-1}}\right|_{dt_{n-1}/dt_n=-p_n/p_{n-1}} = \frac{p_{n-1}(\widetilde{x})}{\mathrm{SOC}} \cdot \left[\frac{p'_{n-1}(\widetilde{x})}{p_{n-1}(\widetilde{x})} - \frac{p'_n(\widetilde{x})}{p_n(\widetilde{x})}\right] > 0,$$

where the first factor is negative by strictly positive probability in state n and second order condition $\mathrm{SOC} \equiv \sum_{i=1}^{n} p''_i(\widetilde{x})\,z_i - c''(\widetilde{x}) - \sum_{i=1}^{n} p''_i(\widetilde{x})\,t_i < 0$, and the second factor is negative by MLRP. Therefore, the modified repayment structure induces the entrepreneur to exert more effort than exerting under the considered SDC.

The increase of effort implies greater total surplus due to the fact that total surplus is strictly increasing in effort on $[0, x^*]$ and effort under any SDC satisfies $\widetilde{x} < x^*$. Since marginal repayment under any SDC is strictly positive, the expected repayment, denoted by $R(\widetilde{x}(\vec{t}))$, is greater than that under the modified repayment contract:

$$\left.\frac{dR(\widetilde{x}(\vec{t}))}{dt_{n-1}}\right|_{dt_{n-1}/dt_n=-p_n/p_{n-1}} = \left[\sum_{i=1}^{n} p'_i(\widetilde{x})\,t_i\right] \cdot \left.\frac{d\widetilde{x}}{dt_{n-1}}\right|_{dt_{n-1}/dt_n=-p_n/p_{n-1}} > 0.$$

Evidently, expected repayment can be reduced to the level prevailing under the considered SDC by decreasing repayment in every state by the same amount so that optimal effort and total surplus do not change. Therefore, there exist non-monotonic contracts that are superior to the considered SDC in terms of total surplus and entrepreneurial profit. □

B Instructions (Translation from German)

[Part I:] **General explanations for participants**
You are now participating in an economic experiment that is financed by METEOR. If you carefully read the following explanations, you can earn a substantial amount of money, contingent on your decisions. Therefore, it is very important that you read these explanations carefully.

The instructions handed out to you are for your private information only.During the experiment there is a strict prohibition of any kind of communication. If you do not abide by this rule, you will be excluded from the experiment as well as any payments. If you have any question, please, raise your arm. We will then answer your question COMING TO YOUR CUBICLE.

During the experiment we will not count in Euros but in ECU (Experimental Currency Units). Therefore, your total earnings will first be calculated in ECU. The total amount of ECU you attain during the experiment will be converted to Euros at the end of the experiment and paid in cash.

[Part II:] **Information regarding the experiment**
The experiment today is divided into separate rounds. In total, there will be 15 rounds. The following elaborations explain the course of action of the experiment for each round.

Each round, you undertake a new project and decide on how much effort you want to invest into the project. By choosing your effort level, you determine the probabilities of the project to attain a low, intermediate, or high revenue. At the same time, a higher effort choice leads to higher costs. Undertaking the project requires start-up costs of ECU 3 120. [*The next two sentences were only included in the instructions for the SDC condition, the NMC condition, and the EQUITY condition:* As you do not dispose of the start-up capital needed for the start-up investment, you have to raise the capital on the capital market. You are acting under limited liability: in case your project revenue does not cover the fixed repayment to the capital provider, only your project revenue will be used for repayment, the remainder will be waived.] [*The next two sentences were only included in the instructions for the NoRepay condition:* Undertaking the project requires start-up costs of ECU 3 120. You dispose of the necessary start-up capital and you do not have to raise the capital on the capital market.]

Course of action At the beginning of each round, you are asked to set the effort level X for this round's project. The effort level cannot be negative or exceed 100, and may only exhibit one decimal place.
The costs arising from your effort are $\frac{1}{2}X^2$. The project revenue is random and may take on a low, intermediate, or high level. By choosing your effort level X, you can influence the probabilities for a low or a high project revenue. The higher your effort level, the lower the probability of a low revenue and the higher the probability of a high revenue. In particular:

- probability of the low revenue of 500 ECU: $60\% - \frac{X}{100} \cdot 60\%$
- probability of the intermediate revenue of 9,000 ECU: 40%
- probability of the high revenue of 10,000 ECU: $\frac{X}{100} \cdot 60\%$

To ease calculating probabilities and effort costs, on the input screen (see figure 1 [*Please see the first screenshot in the next section*]) you may enter any number of values into the effort entry field and have the according probabilities and effort costs displayed by clicking on the button "calculate probabilities". By clicking on the button "confirm choice", you make your decision in this round irrevocable.

[*The following paragraph was only included in the instructions for the SDC condition:*
Fixed repayment to the capital provider Out of the project revenue, the capital provider receives ECU 7 383.30 as fixed repayment for financing the project. In case the project revenue does not cover the fixed repayment to the capital provider, you will only repay the project revenue, the remainder will be waived.]

[*The following paragraph was only included in the instructions for the NMC condition:*
Fixed repayment to the capital provider Out of the project revenue, the capital provider receives ECU 500 in case of a low revenue, ECU 9 000 in case of an intermediate revenue, and ECU 500 in case of a high revenue as a fixed repayment for financing the project.]

[*The following paragraph was only included in the instructions for the EQUITY condition:*
Fixed repayment to the capital provider Out of the project revenue, the capital provider receives ECU 362.50 in case of a low revenue, ECU 6 525 in case of an intermediate revenue, and ECU 7 250 in case of a high revenue as a fixed repayment for financing the project.]

[*The following paragraph was only included in the instructions for the SDC condition:*
Your project income Your project income equals the project revenue minus repayment costs and minus effort costs, i.e.:

- in case of a low revenue: $500 - 500 - \frac{1}{2}X^2 = -\frac{1}{2}X^2$ ECU.
- in case of an intermediate revenue: $9,000 - 7,383.30 - \frac{1}{2}X^2 = 1,616.70 - \frac{1}{2}X^2$ ECU.
- in case of a high revenue: $10,000 - 7,383.30 - \frac{1}{2}X^2 = 2,616.70 - \frac{1}{2}X^2$ ECU.]

[*The following paragraph was only included in the instructions for the NMC condition:*
Your project income Your project income equals the project revenue minus repayment costs and minus effort costs, i.e.:

- in case of a low revenue: $500 - 500 - \frac{1}{2}X^2 = -\frac{1}{2}X^2$ ECU.
- in case of an intermediate revenue: $9,000 - 9,000 - \frac{1}{2}X^2 = -\frac{1}{2}X^2$ ECU.
- in case of a high revenue: $10,000 - 500 - \frac{1}{2}X^2 = 9,500 - \frac{1}{2}X^2$ ECU.]

[*The following paragraph was only included in the instructions for the EQUITY condition:*
Your project income Your project income equals the project revenue minus repayment costs and minus effort costs, i.e.:

- in case of a low revenue: $500 - 362.50 - \frac{1}{2}X^2 = 137.50 - \frac{1}{2}X^2$ ECU.
- in case of an intermediate revenue: $9.000 - 6,525.00 - \frac{1}{2}X^2 = 2,475.00 - \frac{1}{2}X^2$ ECU.
- in case of a high revenue: $10,000 - 7,250.00 - \frac{1}{2}X^2 = 2,750.00 - \frac{1}{2}X^2$ ECU.]

[*The following paragraph was only included in the instructions for the NoRepay condition:*
Your project income Your project income equals the project revenue minus effort costs, i.e.:

- in case of a low revenue: $500 - \frac{1}{2}X^2$ ECU.
- in case of an intermediate revenue: $9,000 - \frac{1}{2}X^2$ ECU.
- in case of a high revenue: $10,000 - \frac{1}{2}X^2$ ECU.]

Number of projects and round income In each round, you will undertake 50 identical projects. That is to say, by choosing your effort level you do not determine the revenue probabilities and effort costs of a single project only, but those of 50 independent projects. To this effect, each project's revenue will be determined by a random draw under the probabilities determined by your effort choice. All random draws are independent of each other. You will be shown the number of projects with low, intermediate, and high revenue as well as the project incomes on an informational screen (see figure 2 [*Please see the second screenshot in the following section*]). Your round income will be determined as follows:

Your round income = average revenue of the 50 projects.

Payment At the end of the experiment you will be paid [*in SDC, NMC, and EQUITY:* EUR 0.0004] [*in NoRepay:* EUR 0.00005] for each ECU on your ECU account. At the beginning of the experiment, an initial endowment of [*in SDC, NMC, and EQUITY:* ECU 12 500] [*in NoRepay:* ECU 100 000] will be credited to your account to cover potential losses. Each round, your round income will be added to your account, so that your account balance either increases (in case of a positive round income) or decreases (in case of a negative round income). You can avoid losses with certainty by making decisions accordingly. In case your account balance falls below [*in SDC, NMC, and EQUITY:* ECU 2 500] [*in NoRepay:* ECU 20 000], you may not continue the experiment.

If you have any questions, please, let us know by raising your hand.

C Screenshots

Figure 5 shows an input screen with hypothetical data for the SDC treatment. In the screenshot used in the set of instructions given to subjects, there was no data available.

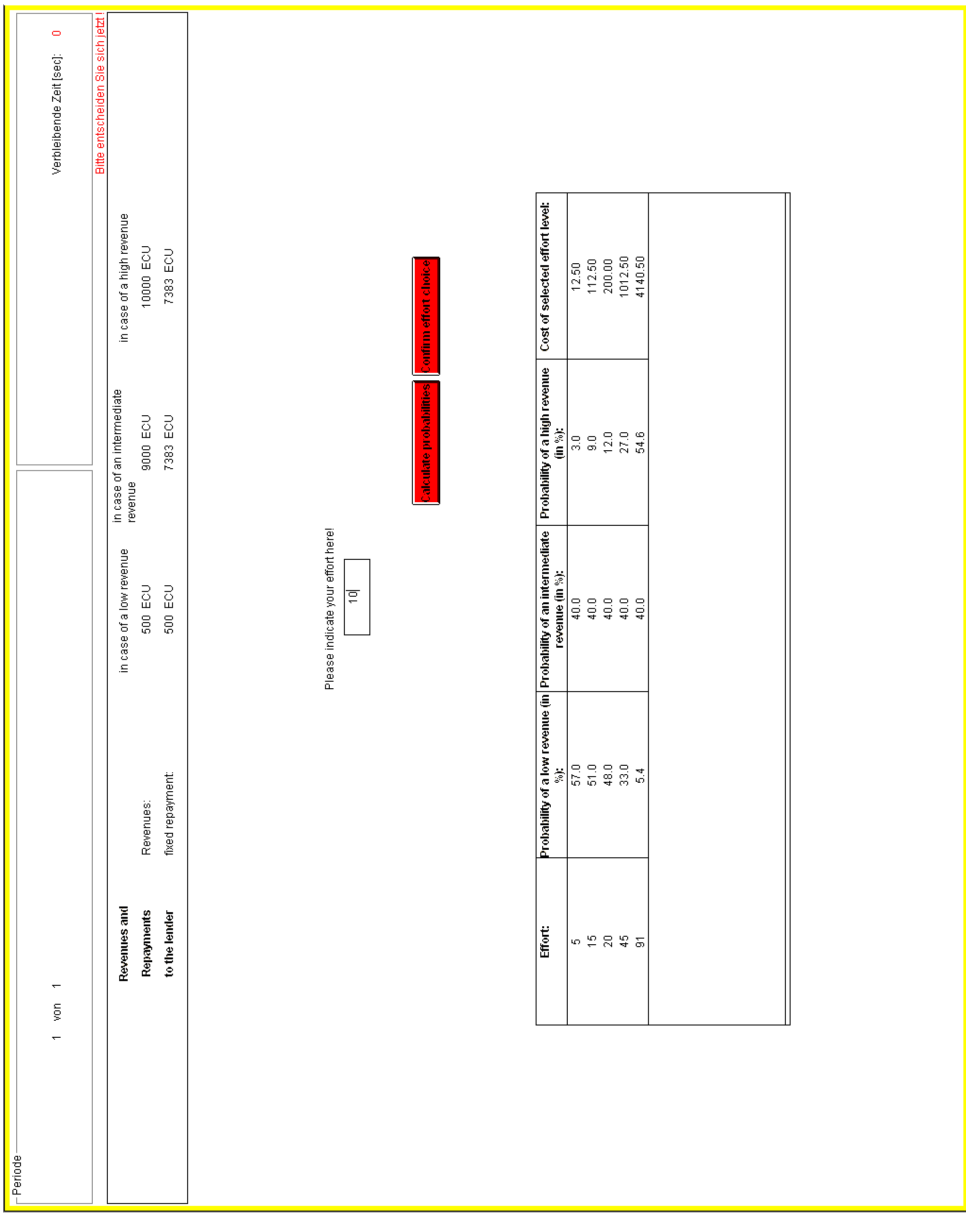


Figure 5: Input screen in the SDC treatment with hypothetical data (translation)

Figure 6 shows the feedback screen with information about project outcomes and round income. A similar screenshot, also with data substituted by letters ”XXX”, was used in the set of instructions give to subjects.

Figure 6: Feedback screen from instructions in SDC treatment with erased data (transl.)

D Referee's Appendix

D.1 Results of the Mann-Whitney U test on treatment differences

Contract condition	NMC	NoRepay	EQUI
SDC	$x^{\mathrm{SDC}} < x^{\mathrm{NMC}}$	$x^{\mathrm{SDC}} < x^{\mathrm{NoRepay}}$	$x^{\mathrm{SDC}} = x^{\mathrm{EQUI}}$
No. of sign. diffs.	13 ($p \leq 0.026$)	12 ($p \leq 0.074$)	3 ($p \leq 0.090$)
No. of insign. diffs.	2 ($p \geq 0.229$)	3 ($p \geq 0.191$)	12 ($p \geq 0.185$)
NMC		$x^{\mathrm{NMC}} = x^{\mathrm{NoRepay}}$	$x^{\mathrm{NMC}} > x^{\mathrm{EQUI}}$
No. of sign. diffs.		1 ($p = 0.088$)	14 ($p \leq 0.025$)
No. of insign. diffs.		14 ($p \geq 0.133$)	1 ($p = 0.829$)
NoRepay			$x^{\mathrm{NoRepay}} > x^{\mathrm{EQUI}}$
No. of sign. diffs.			14 ($p \leq 0.060$)
No. of insign. diffs.			1 ($p = 0.600$)

The table reports, for any pair of treatments, the results of roundwise Mann-Whitney U-tests. The null hypothesis is that there is no difference in the central location of average effort observed in the paired treatments. The alternative hypothesis is that there is one. For any comparison of treatments, the theoretical comparative statics effort prediction and the number of significant and insignificant differences out of all of the 15 roundwise tests is reported together with the obtained highest and lowest p-values in parenthesis.

Table 5: Summary of Mann-Whitney U-tests comparing average effort across contract conditions.

D.2 Descriptive statistics on actual profits and expected profits

NoRepay	Mean	Std Dev	Min	Max
E[profit]	5288.94	658.68	3417.50	7022.00
Actual profit	5289.96	658.74	3417.50	7022.00
E[profit]−Actual profit	1.01	6.88	-30.88	41.88
(E[profit]−Actual profit)/E[profit]	0.0002	0.001	-0.0051	0.0089
SDC	Mean	Std Dev	Min	Max
E[profit]	319.24	759.46	-2843.30	980.52
Actual profit	319.74	759.07	-2843.30	980.52
E[profit]−Actual profit	0.51	3.59	-12.35	26.66
(E[profit]−Actual profit)/E[profit]	0.0009	0.009	-0.0287	0.0709
NMC	Mean	Std Dev	Min	Max
E[profit]	1423.98	756.05	-74.50	3487.50
Actual profit	1426.12	756.19	-74.50	3487.50
E[profit]−Actual profit	2.15	8.51	-19.85	46.88
(E[profit]−Actual profit)/E[profit]	0.0024	0.0126	-0.011	0.1412
EQUI	Mean	Std Dev	Min	Max
E[profit]	780.82	752.99	-2338.00	1559.50
Actual profit	781.32	753.29	-2338.00	1559.50
E[profit]−Actual profit	0.50	2.39	-9.95	16.38
(E[profit]−Actual profit)/E[profit]	0.0004	0.0021	-0.0090	0.0166

The table reports descriptive statistics of each subjects actual profits and expected profits in each round of the experiment. All reported data are given in ECU except for the relative difference. The data shows that actual profits are very close to the expected profits conditional on chosen effort.

Table 6: Descriptive statistics on actual profits and expected profits.

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